SIPROTEC

Time-Overcurrent, Overload, and Motor Protective Relay with Bay Controller

7SJ61

V4.0/V4.1

Instruction Manual

C53000-G1140-C118-1

Preface

Purpose of This Manual

This manual describes the functions, operation, installation, and placing into service of the device. In particular, one will find:

- General information regarding operation of SIPROTEC$^{®}$ 4 devices → Chapter 4.
- Information regarding customizing of the device → Chapter 5.
- Descriptions of device functions and settings → Chapter 6.
- Instructions for operation while in service → Chapter 7.
- Instructions for mounting and commissioning → Chapter 8.
- Compilation of technical specifications → Chapter 10.
- As well as a compilation of the most significant data for experienced users in the Appendix.

Target Audience

Protection engineers, commissioning engineers, personnel concerned with adjustment, checking, and service of selective protective equipment, automatic and control facilities, and personnel of electrical facilities and power plants.

Applicability of This Manual

This manual is valid for SIPROTEC$^{®}$ 4 7SJ61 Time-Overcurrent, Overload, and Motor Protective Relay with Bay Controllers; firmware version 4.0/4.1.

$C\!E$

Indication of Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the member states relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within certain voltage limits (Low-voltage Directive 73/23/EEC).

This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 50081 and EN 50082 for EMC directive, and with the standards EN 60255–6 for the low-voltage directive.

The product conforms with international standards of series IEC 60255 and the German standard DIN 57435 /Part 303 (corresponds to VDE 0435/Part 303).

Y2k Compliance

The tests made by Siemens EV S show no indications of any problems of the year 2000 compliance for the relays. Neither the performance nor the functionality of the protection relays become negatively affected through input of a date, which will before, during or after the year 2000. The tests were made according the recognized rules of the British Standards Institute (BSI). Because of the complexity of the application, a residual risk regarding the data function may not be totally excluded.

ANSI	ˌThis product has been designed according to ANSI C37.90.* standards.

The product is according to UL (refer to Section 10.1):

	69CA IND. CONT. EQ. TYPE 1		E194016 IND. CONT. EQ. TYPE 1

Additional Support   For questions regarding SIPROTEC® 4 devices, please contact your Siemens representative.

Training Courses   Individual course offerings may be found in our Training Catalog, or questions can be directed to our training center. Please contact your Siemens representative.

Instructions and Warnings   The following indicators and standard definitions are used:

DANGER
means that death, severe personal injury, or considerable equipment damage will occur if safety precautions are disregarded.

WARNING
means that death, severe personal injury, or considerable equipment damage could occur if safety precautions are disregarded.

Caution
means that light personal injury or equipment damage may occur if safety precautions are disregarded. This particularly applies to damage to the device and to resulting damage of the protected equipment.

Instruction
is an important piece of information regarding the product or the part of the manual that deserves special attention.

Warning!

During operation of electrical equipment, certain parts of these devices are under high voltage. Severe personal injury or significant equipment damage could result from improper behavior.

Only qualified personnel should work on this equipment or in the vicinity of this equipment. These personnel must be familiar with all warnings and service procedures described in this manual, as well as with safety regulations.

Prerequisites to proper and safe operation of this product are proper transport, proper storage, setup, installation, operation, and maintenance of the product, as well as careful operation and servicing of the device within the scope of the warnings and instructions of this manual.

In particular, the general facility and safety regulations for work with high-voltage equipment (e.g. ANSI, IEC, EN, or other national or international regulations) must be observed. Noncompliance may result in death, injury, or significant equipment damage.

QUALIFIED PERSONNEL

Within the meaning of safety precautions of this manual and the instructions, qualified personnel are those persons who are qualified to set up, install, place into service, and operate this device, and who possess the following qualifications:

❑ Training and instruction (or other qualification) for switching, grounding, and designating devices and systems.

❑ Training or instruction in accordance with safety standards for care and use of certain safety equipment.

❑ First aid training.

Typographic and Graphical Conventions

The following text formats are used to identify concepts giving device information described by the text flow:
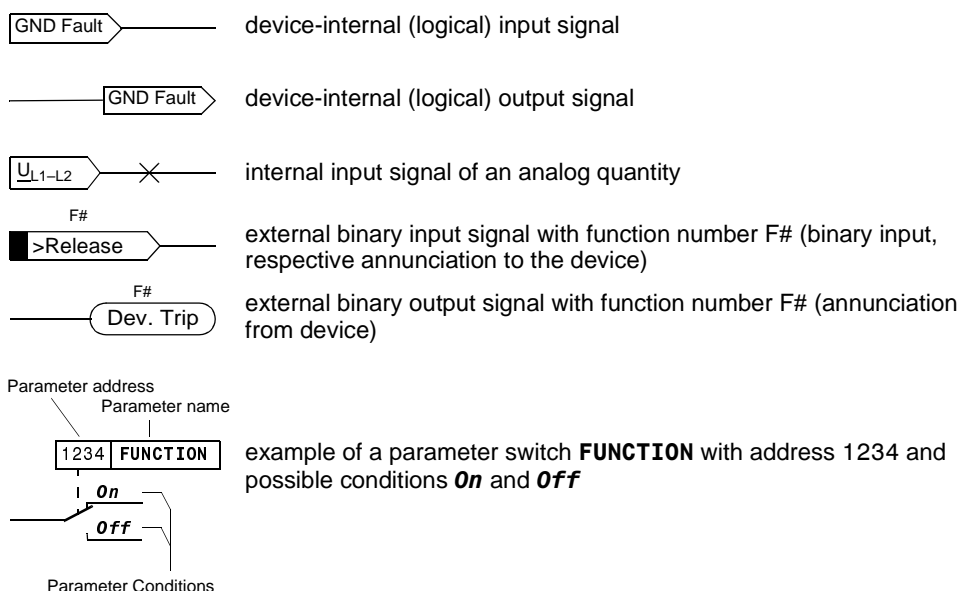
`Parameter names`, or identifiers for configuration or function parameters that appear in the device display or on the screen of a PC (with DIGSI® 4) are shown in mono-script (same point size) bold text. This also applies to header bars for selection menus.

`Parameter conditions,` or possible settings of parameters that appear in the device display or on the screen of a PC (with DIGSI® 4), are additionally shown in italic style. This also applies to selection items for selection menus.

"`Annunciations`", or identifiers for information produced by the device or required by other devices or from the switch-gear is shown in mono-script (same point size) and placed into quotation marks.

For diagrams in which the identifier type results from the representation itself, text conventions may differ from the above-mentioned.

The following symbols are used in diagrams:

GND Fault ⟩	device-internal (logical) input signal
⟨ GND Fault ⟩	device-internal (logical) output signal
$\underline{U}_{L1-L2}$ ⟩—✕—	internal input signal of an analog quantity
F# ▉ >Release ⟩	external binary input signal with function number F# (binary input, respective annunciation to the device)
F# (Dev. Trip)	external binary output signal with function number F# (annunciation from device)

Parameter address
Parameter name

| 1234 | **FUNCTION** |

⌐ *On*
Off

Parameter Conditions

example of a parameter switch **FUNCTION** with address 1234 and possible conditions *On* and *Off*

Liability Statement

We have checked the text of this manual against the hardware and software described. Exclusions and deviations cannot be ruled out; we accept no liability for lack of total agreement.

The information in this manual is checked periodically, and necessary corrections will be included in future editions. We appreciate any suggested improvements.

We reserve the right to make technical improvements.

Table of Contents

Introduction 1

The SIPROTEC® 4 7SJ61 devices are introduced in this section. An overview of the devices is presented in their application, characteristics, and scope of functions.

1.1   Overall Operation

The SIPROTEC® 4 7SJ61 is a numerical, multi-functional, protective and control device equipped with a powerful microprocessor. All tasks, such as the acquisition of the measured quantities, issuing of commands to circuit breakers and other primary power system equipment, are processed in a completely digital way. Figure 1-1 illustrates the basic structure of the 7SJ61.

Analog Inputs   The measuring inputs (MI) section consists of current transformers. They convert the signals from the measuring transducers to levels appropriate for the internal processing of the 7SJ61.

Four current inputs are available in the MI section. Three inputs are used for measuring of the phase currents. The use of the fourth input depends on the version of the device ordered. The fourth input can be used for measuring the ground current as the residual of the phase current transformers (In), or for measuring the ground current from a separate current transformer ($I_{Ns}/3I_0$). The latter is used in a highly sensitive ground fault protective scheme (I_{Ns}) or as a polarizing $3I_0$ current to determine the fault direction.

The 7SJ61 does not have AC voltage inputs.
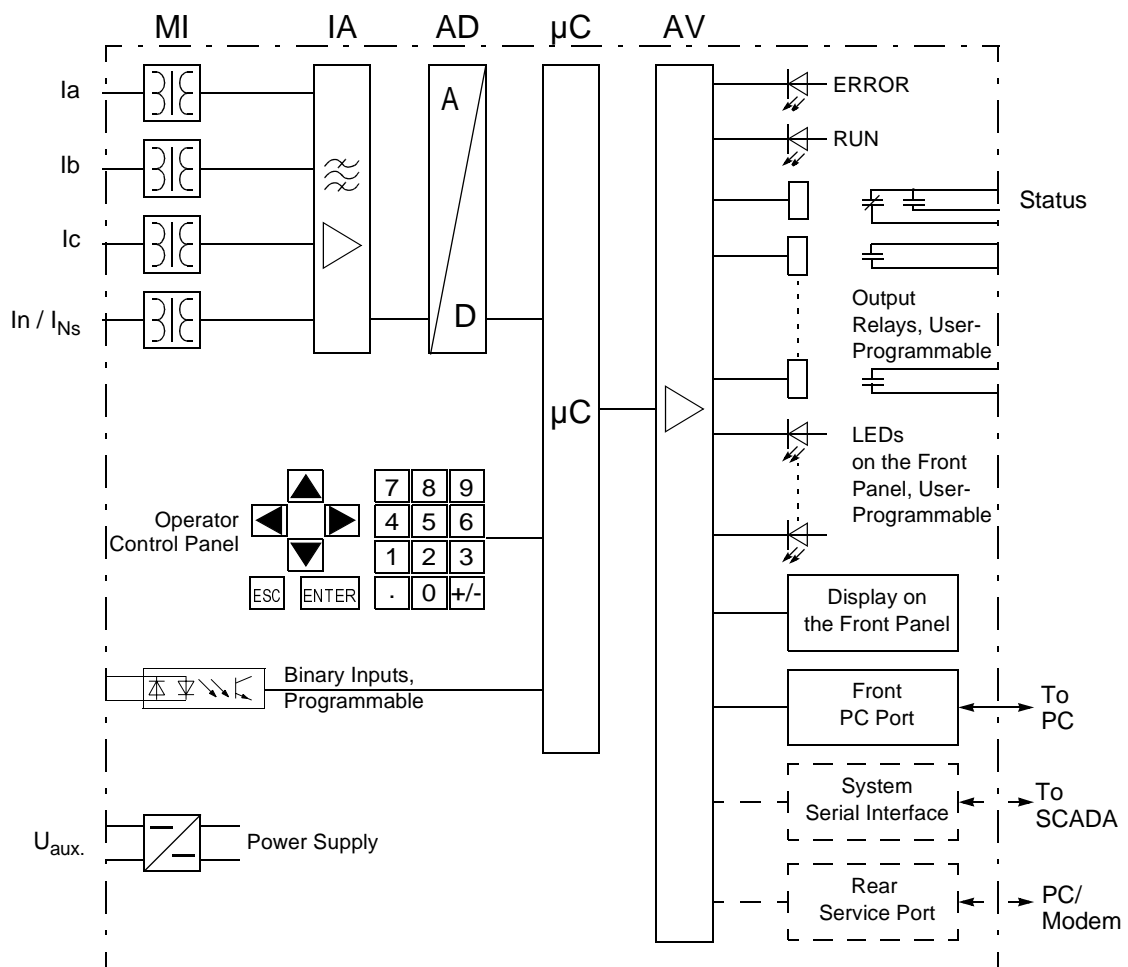
Figure 1-1   Hardware Structure of the Numerical Device 7SJ61 (Maximum Configuration)

The analog input quantities from the MI stage are passed on to the input amplification (IA) stage, which provides high-resistance terminations for the analog quantities. The IA stage consists of filters for processing the measured values. The filters are optimized with regard to bandwidth and processing speed.

The analog-to-digital (AD) stage consists of memory components, a multiplexer, and an analog-to-digital (A/D) converter. The A/D converter processes the analog signals from the IA stage. The digital signals from the converter are input to the microcomputer system where they are processed as numerical values in the residing algorithms.

Microcomputer System

The actual protection and control functions of the 7SJ61 are processed in the microcomputer system (µC). In addition, the µC controls the measured quantities. Specifically, the µC performs:

− Filtering and preparation of the measured quantities

− Continuous monitoring of the measured quantities

− Monitoring of the pickup conditions for the individual elements and functions

− Evaluation of limit values and sequences in time

− Control of signals for the logic functions

− Decision for trip, close, and other control commands

− Output of control commands for switching devices (output contacts)

− Recording of messages and data for events, alarms, faults, and control actions, and provision of their data for analysis

− Management of the operating system and the associated functions such as data recording, real-time clock, communications, interfaces, etc.

Binary Inputs and Outputs

The µC obtains external information through the binary inputs such as blocking commands for protective elements or position indications of circuit breakers. The µC issues commands to external equipment via the output contacts. These output commands are generally used to operate circuit breakers or other switching devices. They can also be connected to other protective devices, annunciators, or external carrier equipment for use in Pilot-Relaying schemes.

Front Elements

Light-emitting diodes (LEDs) and a display screen (LCD) on the front panel provide information such as targets, metering quantities, messages related to events or faults, status, and functional status of the 7SJ61.

Integrated control and numeric keys in conjunction with the LCD facilitate local interaction with the 7SJ61. All information of the device can be accessed using the integrated control and numeric keys. The information includes protective and control settings, operating and fault messages, and metering values (see also Chapter 7). The settings can be modified; the procedures are discussed in Chapter 6. In addition, control of circuit breakers and other equipment is possible from the 7SJ61 front panel.

Serial Interfaces

A serial **PC Port on device** is provided for local communications with the 7SJ61 through a personal computer. Convenient operation of all functions of the device is possible. The SIPROTEC® 4 operating program DIGSI® 4 is required.

A separate **Service Port** can be provided for remote communications via a modem, or substation computer. The SIPROTEC® 4 operating program DIGSI® 4 is required.

All 7SJ61 data can be transferred to a central control and monitor system (RTU/SCA-DA) through the **Scada Port**. Various protocols and physical interfaces are available to suit the particular application.

Power Supply The 7SJ61 can be supplied with any of the common power supply voltages from 24 VDC to 250 VDC. The device can also be supplied with 115 VAC or 230 VAC. Momentary dips of the supply voltage up to 50 ms are bridged by a capacitor (see Technical Data, Sub-section 10.1). Voltage dips can occur, for example, if the voltage supply system (substation battery) becomes short-circuited or experiences a severe variation in load.

1.2   Applications

The numerical, multi-functional SIPROTEC® 4 7SJ61 is a versatile device designed for many applications. The 7SJ61 can be used as a protective, control, and monitoring device for distribution feeders and transmission lines of any voltage in networks that are grounded, low-resistance grounded, ungrounded, or of a compensated neutral point structure. The device is suited for networks that are radial, and for lines with single-terminal feed. The 7SJ61 is equipped with motor protection applicable for asynchronous machines of all sizes.

The 7SJ61 includes the functions that are necessary for protection, monitoring of circuit breaker positions, and control of the circuit breakers in straight bus applications or breaker-and-a-half configurations; therefore, the device can be universally employed. The 7SJ61 provides excellent backup facilities of differential protective schemes of lines, transformers, generators, motors, and busbars of all voltage levels.

Protective Functions

Non-directional overcurrent protection (50, 50N, 51, 51N) is the basis of the 7SJ61. Four definite-time overcurrent protective elements exist, two for the phase and two for the ground (50 and 50N) currents. The elements can be set with no time delay, where instantaneous tripping is desired. Inverse-time overcurrent protective elements are also available for both the phase and the ground (51 and 51N) currents. The common U.S. ANSI time-characteristics are also available. Alternatively, user-defined characteristics can be programmed or IEC characteristics can be selected.

Depending on the version of the device that is ordered, the non-directional overcurrent protection can be supplemented with breaker failure protection (50BF), and sensitive ground fault detection for high-resistance ground faults or systems that are resistively grounded (50 Ns).

Other protective functions are available, some of which depend on the version of the device that is ordered. These additional functions include negative sequence (phase balance) current protection (46), automatic reclosing (79), thermal overload protection (49). For motor protection, starting time supervision (48), start inhibit (66/68), and undercurrent monitoring (37) are optionally available.

Control Functions

The 7SJ61 supports all control and monitoring functions that are required for operating medium to high-voltage substations. A major application is the reliable control of switchgear or circuit breakers. Such control can be accomplished via the integrated operator panel, the system interface, the binary inputs, and the serial port using a personal computer with DIGSI® 4.

The status of the primary equipment or auxiliary devices can be transmitted to the 7SJ61 via auxiliary contacts connected to binary inputs. The present status (or position) of the primary equipment can be displayed on the 7SJ61, and used for interlocking or, if applicable, plausibility monitoring. Only the quantity of binary inputs and outputs available in the 7SJ61 limits the number of primary devices that can be operated. Depending on the primary equipment being controlled, one binary input (single indication) or two binary inputs (double indication) can be used in the position monitoring process.

The capability of switching primary equipment can be restricted by a setting associated with switching authority – Local, DIGSI® 4 PC, or Remote, and by the operating mode – Interlocked or Non-Interlocked, with password request. Processing of interlocking conditions for switching (e.g. switching error protection) can be established with the aid of integrated, user-configurable logic functions.

Messages and Measured Values; Recording of Event and Fault Data

A series of operating messages provide information about conditions in the power system and the 7SJ61. Measurement quantities and values that are calculated can be displayed locally and communicated via the serial interfaces.

Messages of the 7SJ61 can be indicated by a number of programmable LEDs on the front panel, externally processed through programmable output contacts, and communicated via the serial interfaces (see Communication below).

Important events and changes in conditions are saved under Annunciation in the Event Log or the Trip Log, the latter being used for faults. Waveform capture is available, as an option.

Communication

Serial interfaces are available for communications with PC's, RTU's, and SCADA systems.

A 9-pin D-subminiature female connector on the front panel is used for local communications with a personal computer. DIGSI® 4 software is required to communicate via this port. Using the DIGSI® 4 software, settings and configuration can be made to the relay, Realtime operating quantities can be viewed, Waveform capture and Event Log records can be displayed, and controls can be issued.

A DIGSI® 4 service interface port, a system (SCADA) port and a time-sync port (IRIG-B or DCF77) are optionally available on the rear of the device.

A rear **service** interface can be supplied as RS-232, RS-485, or multimode fiber optics type ST. DIGSI® 4 software is required to communicate via this port.

A rear **system** interface can be supplied as RS-232, RS-485, or multimode fiber optics type ST for communications between the 7SJ61 and a PC's, RTU's, or SCADA systems Standard Protocols, IEC 60870–5–103 are available via the system port. Integration of the devices into the automation systems SINAUT® LSA and SICAM® also take place with this profile.

Alternatively, a field bus coupling with PROFIBUS FMS is available for the 7SJ61. The PROFIBUS FMS is performed in accordance with IEC 61850, is an open communications standard that particularly has wide acceptance in process control and automation engineering, with especially high performance. A profile has been defined for the PROFIBUS communication that covers all of the information types required for protective and process control engineering. The integration of the devices into the energy automation system SICAM® can also take place with this profile.

1.3 Characteristics

- Powerful 32-bit microprocessor system.

- Complete digital processing and control of measured values, from the sampling of the analog input quantities to the initiation of outputs for, as an example, tripping or closing circuit breakers or other switchgear devices.

- Total electrical separation between the processing stages of the 7SJ61 and the external transformer circuits, control circuits, and DC supply circuit because of the design of the binary inputs, outputs, and the DC converters.

- Complete set of functions necessary for the proper protection of lines, feeders, motors, and busbars.

- Additional protection and control functions available, some as options.

- Continuous calculation and display of measured quantities on the front of the device.

- Easy device operation through an integrated operator panel or by means of a connected personal computer running DIGSI® 4.

- Recording of event data, fault data, and waveform captures with SER information to be used for analysis and troubleshooting.

- Communication with SCADA or substation controller equipment via serial interfaces through the choice of data cable, modem, or optical fibers.

- Constant monitoring of the measurement quantities, as well as continuous self-diagnostics covering the hardware and software.

1.4   Scope of Functions

The protection features of a SIPROTEC® 4 7SJ61 equipped with all options are listed below pointing out highlights of each feature. The actual features of a 7SJ61 depend on the order number.

Time-Overcurrent Protection

- Two instantaneous (Definite-Time) overcurrent elements and an inverse-time overcurrent element, for both phase protection and ground protection (50-1, 50-2, 51, 50N-1, 50N-2, and 51N);

- The 50 and 50N elements can be set with definite-time delay;

- Common ANSI and IEC time overcurrent curves are available for 51 and 51N, or user defined characteristics can be employed.

- Blocking capability for reverse-interlocking busbar protection, or directional comparison line protection;

- Second harmonic inrush restraint of 50, 50N, 51, and 51N for transformer energizing;

- Instantaneous tripping by any overcurrent element upon manual closure of a circuit breaker, if selected (Switch-Onto-Fault-Protection).

Dynamic Cold Load Setting Adjustment

- Dynamic adjustments of the pickup values and the tripping times of the time-overcurrent function when cold load conditions are anticipated;

- Cold load conditions are anticipated when the circuit breaker has been in the open position for an extended period of time. Circuit breaker position is determined by auxiliary contacts or the state of a sensitive overcurrent element.

Sensitive Ground Fault Detection

- Two sensitive ground fault instantaneous overcurrent elements 50Ns-1 and 50Ns-2 that can have definite time delay;

- Pickup currents of 50Ns-1 and 50Ns-2 are adjustable and can be set very sensitive (as low as 3mA);

- Sensitive ground fault time-overcurrent element 51Ns is available instead of 50Ns-1, if selected;

- Time-current characteristic curve for 51Ns is defined by the user;

- Phase current stabilization is included to accommodate current transformers saturation.

Negative Sequence Current Protection

- Two definite-time elements 46-1 and 46-2 and one inverse-time element 46-TOC;

- Common U.S. ANSI time-characteristics or IEC characteristics are available for 46-TOC.

Starting Time Monitoring for Motors

- Current dependent tripping based on an evaluation of the motor starting current.

- Blocked rotor protection.

Thermal Overload Protection

- Temperature rise of the protected equipment is calculated using a thermal homogeneous-body model that takes into account energy entering the equipment and energy losses. Thermal overload protection has full memory capability;

- Adjustable warning levels based on temperature rise and current magnitude;

- Additional time constant setting for motors to accommodate both the motor rotating and the motor at standstill.

Start Inhibit for Motors

- Rotor temperature is calculated based on the stator currents;

- Start-up is permitted only if the rotor has sufficient thermal reserves for a complete start-up;

- Disabling of the start inhibit is possible if an emergency start-up is required.

Breaker Failure Protection

- Breaker failure condition determined by current flow after a trip signal has been issued. As an option, the breaker position indication (binary input) can be evaluated;

- Breaker failure protection initiated by the tripping of any integrated protective element that trips the circuit breaker (internal start);

- Initiation possible through a binary input from an external protective device (external start);

- Initiation possible through the integrated control function (control start).

Automatic Reclosing

- Single-shot or multi-shot;

- Dead times associated with the first, second, third, and fourth shots are programmable and can be different from one another. Dead times for the remaining shots are identical to the dead time for the fourth shot;

- Protective elements that initiate automatic reclosing are selectable. The choices can be different for phase faults and ground faults;

- Monitoring of the circuit breaker response during reclosing sequence is possible.

Phase Rotation

- Selectable ABC or ACB with a setting (static) or binary input (dynamic).

User-defined Functions

- Internal and external signals can be logically combined to establish user-defined logic functions;

- All common logic functions are available for programming (AND, OR, NOT, Exclusive OR, etc.);

- Time delays and limit value inquiries are available;

- Processing of measured values, including zero suppression.

Monitoring Functions

- Availability of the 7SJ61 is greatly increased because of self-monitoring of the internal measurement circuits, power supply, hardware, and software;

- Current transformer secondary circuits are monitored using summation and symmetry check techniques;

- Trip circuit monitoring;

- Phase rotation.

Breaker Control
- Circuit breakers can be opened and closed via the process control keys (7SJ63 only) or the programmable function keys on the front panel, through the SCADA, or through the front PC interface using a personal computer with DIGSI® 4;
- Circuit breakers are monitored via the breaker auxiliary contacts;
- Plausibility monitoring of the circuit breaker position and check of interlocking conditions.

Other Functions
- Battery-buffered clock that can be synchronized with an IRIG-B (or DCF77) signal, binary input signal, or system interface command;
- Recording and saving of fault data in chronological order for the last eight faults;
- Recording, saving and transfer of waveform capture;
- Recording of circuit breaker statistics including the number of trip signals sent and the accumulated, interrupted currents of each pole of the circuit breaker;
- Tracking of operating hours (time when load is supplied) of the equipment being protected;
- Commissioning aids such as connection check, and the display of test recordings.

■

Hardware and Connections

2

An overview of the hardware of the 7SJ61 and detailed information regarding connections to the device are provided in this section.

The options for panel mounting and cubicle mounting are described. Device construction is presented. The options for terminal connections and communication interfaces are covered.

Data are given for wire connections and communication connections. Information on accessories and tools is given.

2.1 Version of 7SJ61 for Panel Flush-Mounting / Cubicle Mounting

The numerical, multi-functional SIPROTEC® 4 7SJ61 for panel flush-mounting or cubicle mounting is a sealed device in a 7XP20 $^1/_3$ size case (based on 19 inches). Two different general types of terminals are available, threaded terminals and plug-in terminals. The terminals provided depend on the order number of the device.

2.1.1 Construction

The major components of a 7SJ61 are the front panel, the case, and the rear panel. The terminals for connections to external equipment are located on the rear panel, which is bolted to the case. Inside the device are two printed circuit boards that have the rear serial interface modules attached. The boards are connected together via a ribbon-cable that has plug connectors. The boards are connected to the terminals and supported in guide rails.

The front panel is removable. The screws for removing the component are located behind the four covers at the corners. The front panel has a covered keypad with operating and display elements necessary for equipment operation. All connections for these elements are combined into an adapter module on the front panel that is linked via a ribbon-cable with plug connectors to the internal processor board (CPU).

The nameplate sticker, showing important information such as power supply rating, nominal current rating, and ordering number, is located on the top of the case and the interior of the front panel.

View of Front Panel
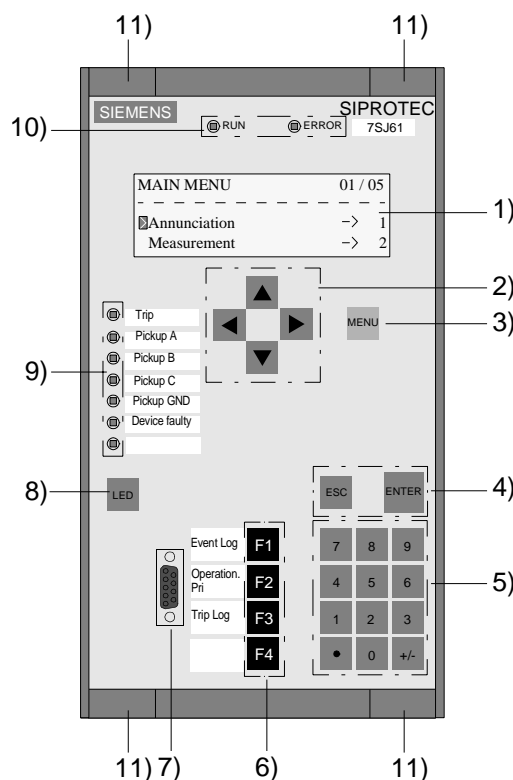
Figure 2-1   Front View of a 7SJ61 for Panel Flush-mounting / Cubicle Mounting

Referring to the operating and display elements in Figure 2-1:

1. Display (LCD)
   The LCD shows processing and device information as text in various lists. Commonly displayed information includes measured values (metering), counter values, binary information regarding the condition of circuit breakers, status of the device, protection information, general reports, and alarms.

2. Navigation Keys
   These keys serve for navigation through operating menus.

3. MENU Key
   This key activates the main menu.

4. ESC and ENTER Keys
   These keys serve to escape from specific menues or execute changes (such as setting changes).

5. Numerical Keys
   These keys serve for entry of numerical values, such as protective settings.

6. Function Keys
   Four function keys allow the quick and simple execution of frequently used actions. Typical applications include, for example, jumping to a particular position in the menu tree such as the fault data in the Trip Log (F1) or the metering values (F2). The function keys are programmable, and may be used to execute control functions such as closing (F3) or tripping (F4) circuit breakers. Next to the keypad, a labeling strip is provided on which the user-specified key functions may be written.

7. Serial Communication Interface, 9-pin Female D-subminiature connector
   This serial interface is for the connection of a local PC running DIGSI® 4.

8. LED Key
   This key has the dual purpose of resetting latched LEDs and the latched contacts of binary outputs, as well as testing all of the LEDs.

9. LEDs
   The function of these indicators can be programmed. There is a vast selection of signals from which to choose. Some examples are protective element status, related to specific protective elements, processing or control information, and binary input or output status. Next to the LEDs on the front panel, a labeling strip is provided on which the user-specified LED functions may be written.

10. Operating Condition Indicators
    The two LEDs "RUN" (green) and "ERROR" (red) indicate the operating condition of the device.

11. Coverings for the screws that secure the front panel.

View of Rear Panel Figure 2-2 is a simplified view of the rear panel of the version of the device with threaded (screw-type) terminals and optical fiber ports for the service interface at location B.
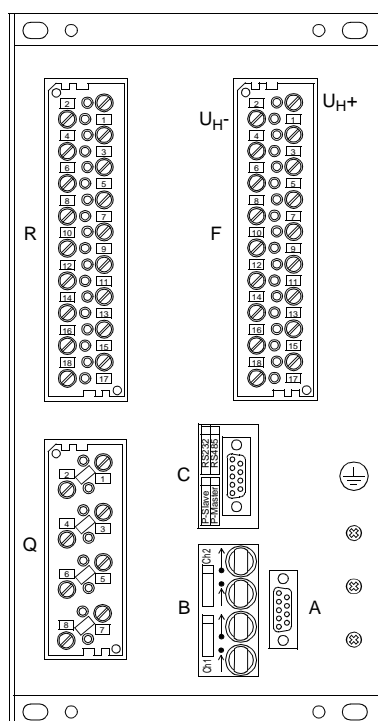
Figure 2-2   Rear View of a 7SJ61 with Screw-type Terminals (example only)

2.1.2 Connections to Threaded Terminals

Terminal blocks for the threaded connections are designated as:

Terminal blocks for voltage connections, and
Terminal blocks for current connections.

A simple flat-blade 6x1-mm screwdriver can be used to turn the slotted screws in either terminal block type.

Terminal Blocks for Voltage Connections

The two available versions of terminal blocks for voltage connections are shown in Figure 2-3.

| 18 Terminal | 12 Terminal |
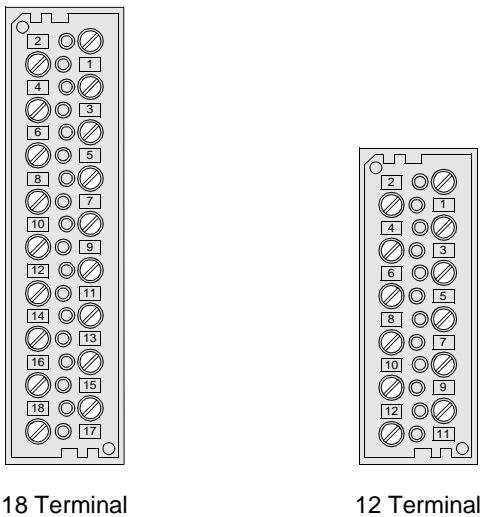
Figure 2-3   Terminal Blocks of Threaded Terminals for Voltage Connections — Rear View

The numbering system for the threaded terminals is illustrated in Figure 2-4.
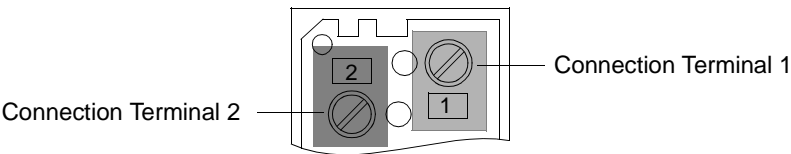
Figure 2-4   Correlation between Threaded Terminals and Connection Numbers (example)

Terminal Block for Current Connections

There is one version of a terminal block for current connections to a 7SJ61. The terminal block is illustrated in Figure 2-5.
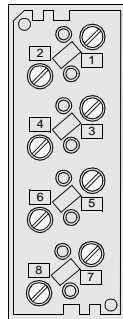
8 Terminal

Figure 2-5   Terminal Block of Threaded Terminals for Current Connections - Rear View

The correlation between threaded terminals and connection numbers is the same for both the current connections and the voltage connections. Compare Figures 2-4 and 2-5.

In the terminal block for current connections, the terminals are grouped in pairs. Two neighboring terminals such as terminals 5 and 6 form one pair. The terminal block contains four pairs, one for each of the input currents.

The current transformers present low burden to the main current transformers.

When the I/O board is extracted, the current circuits are automatically short-circuited prior to the separation of the current transformers from the current circuits. This prevents hazards to service personnel due to the high voltages that can occur if the secondary circuits of the current transformers are open.

When the I/O board is properly inserted into the case of the 7SJ61, the short-circuits of the current paths are removed after the transformers of the device are connected to the terminal-pairs.

The short-circuit feature of the 7SJ61 is an important and reliable safety feature; however, the feature does not relieve the user from exercising proper care when working with current transformer secondary circuits.

Connections to Voltage Terminals

Ring or spade lugs may be used. To maintain proper isolation of the circuits, the lugs must be insulated or insulating sleeves must be fitted to cover the exposed crimp zones.

The following must be observed:

Connections with Cable lugs: inner diameter of lugs, 4 mm;
maximum outer width of lugs, 10 mm;
conductor with cross-section of 1 mm^2 to 2.6 mm^2 or AWG 17 to 13.
Use copper wires only!

Cable lugs of series PIDG from AMP Co. are recommended, e.g.
Ring cable lug: PIDG PN 320 565–0
Spade lug: PIDG PN 321 233–0.

Direct Cable Connections: solid or stranded conductor with connector sleeve; conductor with cross-section of 0.5 mm^2 to 3.3 mm^2 or AWG 20 to 12. Use copper wires only!

Maximum Tightening Torque: 1.3 ft-lb or 16 in-lb (1.8 Nm).

Connections to Current Terminals

Ring or spade lugs may be used. To maintain proper isolation of the circuits, the lugs must be insulated or insulating sleeves must be fitted to cover the exposed crimp zones.

The following must be observed:

Connections with Cable lugs: inner diameter of lugs, 5 mm; maximum outer width of lugs, 12 mm; conductor with cross-section of 2.7 mm^2 to 6.6 mm^2 or AWG 13 to 9. Use copper wires only!

Cable lugs of series PIDG from AMP Co. are recommended, e.g., Ring cable lug: PIDG PN 130 171–0 Spade lug: PIDG PN 326 865–0

Direct Cable Connections: solid or stranded conductor with connector sleeve; copper conductor with cross-section of 2.0 mm^2 to 5.0 mm^2 or AWG 14 to 10. Use copper wires only!

Maximum Tightening Torque: 2.0 ft-lb or 24 in-lb (2.7 Nm).

Short-Circuit Links

Short-circuit links are available for convenience in making terminal connections.

The links can be used to connect two terminals located on the same side of the terminal block. Thus, if the 7SJ61 is the last device in the current transformer circuits, the links provide a convenient way to terminate the circuits. The links can be useful for other connections as well.

Each terminal can receive two links, one link and one cable lug, or one single wire.

The links meet the safety requirements for protection against electric shock.

There are two types of links, one for voltage connections and one for current connections. The links are illustrated in Figure 2-6.

Ordering information for the links is provided in Section A.1 in the Appendix.

Short-Circuit Links for   Short-Circuit Links for
Voltage Connections   Current Connections
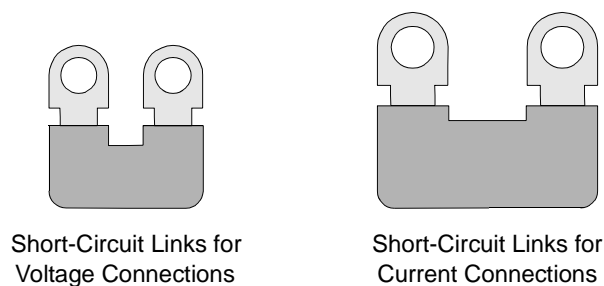
Figure 2-6   Short-circuit Links for Voltage Connections and Current Connections

Covering Caps   Covering caps are available for terminal blocks with threaded terminals. The caps enhance the safety of personnel by covering the terminal screws; thereby, decreasing the likelihood of inadvertent contact with the live terminals.

The caps snap on to the terminal blocks, and can easily be removed with a 6x1-mm screwdriver. All of the terminal block screws must be tightened to apply a cap.

There are two types of covering caps, as shown in Figure 2-7. Ordering information is provided in Section A.1 in the Appendix.
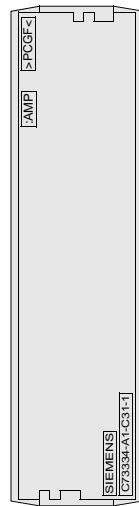
Covering Cap for
18 Terminal Voltage
Connection Terminal Block
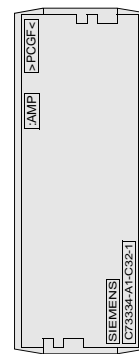
Covering Cap for
12 Terminal Voltage
or 8 Terminal Current
Connection Terminal Block

Figure 2-7   Covering Caps for Terminal Blocks with Threaded Terminals

2.1.3 Connections to Plug-In Terminals

Plug-in terminals are only available for voltage connections. Current connections are made with threaded terminals on all 7SJ61.

Terminal Blocks for Voltage Connections

There are two versions of plug-in terminal blocks. They are shown in Figure 2-8.

18 Terminal   12 Terminal
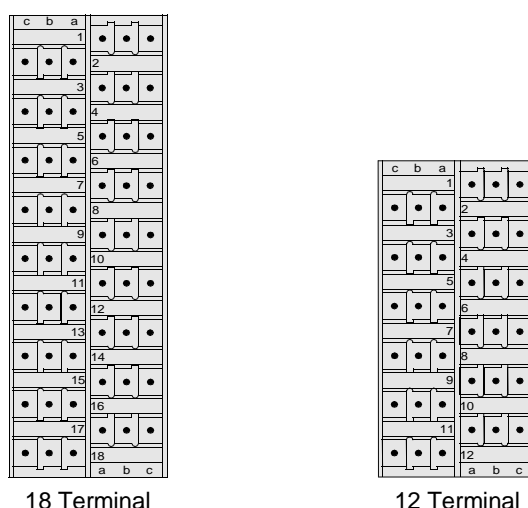
Figure 2-8   Terminal Blocks of Plug-in Terminals for Voltage Connections — Rear View

The system of numbers and letters used to designate the plug-in terminals is illustrated in Figure 2-9.
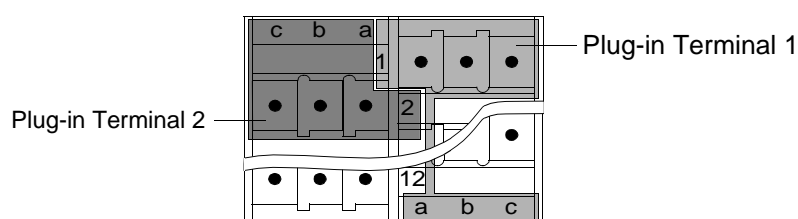
Figure 2-9   Correlation between Plug-in Terminals and Connection Numbers / Letters

Each plug-in terminal forms a complete set of connections that consists of three pins arranged as follows:

Pin a: Signal Connection
Pin b: Common Connection
Pin c: Shielding Connection

The signal pins are the only terminal pins that are directly connected to the internal printed circuit boards of the 7SJ61. Depending on the version of the terminal block, 18 or 12 signal connections are provided. Refer to Figure 2-10.

There are two isolated groups of common pins. Within a group the pins are inter-connected as shown in Figure 2-10. The common pins "b" are not connected to the boards

inside the 7SJ61. Each common group can, for example, be used for signal replication or as a common point for a signal (independent of the signals on the pin "a" terminals). Depending on the version of the terminal block, 18 or 12 common connections are available.

Grouping of common connections within a terminal block is as follows:

12 Terminal Block:	Group 1	Terminals 1 through 6
	Group 2	Terminals 7 through 12
18 Terminal Block:	Group 1	Terminals 1 through 9
	Group 2	Terminals 10 through 18

All shielding pins are connected together as shown in Figure 2-10. The shielding pins are also connected to the rear panel of the 7SJ61. Depending on the version of the terminal block, 18 or 12 shielding connections are provided.
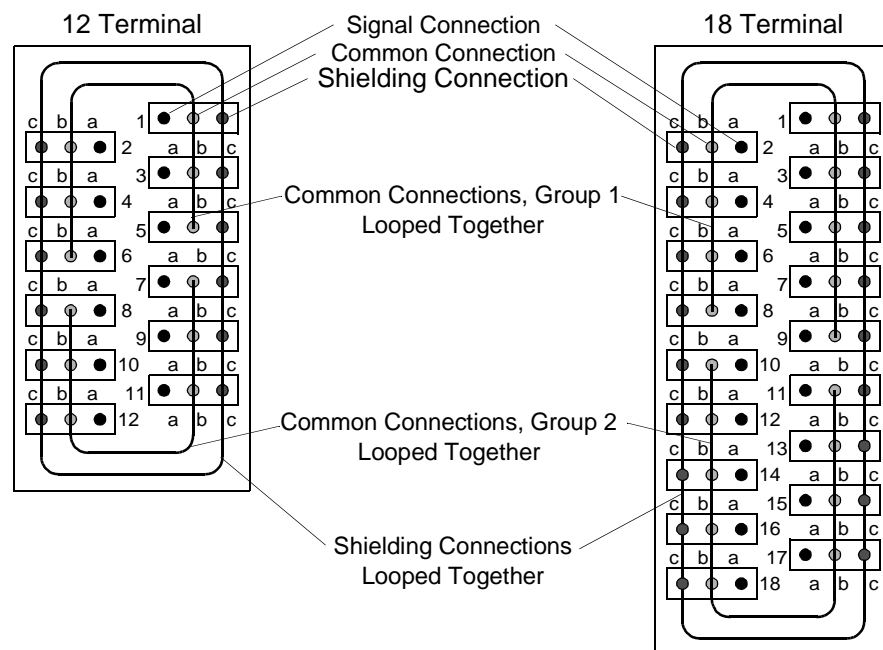
Figure 2-10   Schematic Diagram of the Plug-in Terminal Blocks

Connections to Plug-In Terminals

Connections to plug-in terminals are made with pin connectors.

There are two versions of pin connectors:

Version 1: 2-pin connector
Version 2: 3-pin connector
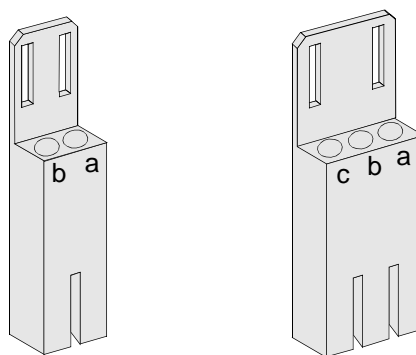
Figure 2-11   2-Pin Connector and 3-Pin Connector

Ordering information for the pin connectors is provided in Section A.1 of the Appendix.

The design of the pin connectors is such that only correct connections can be made. For example, the design of the 2-pin connector allows connection only to pins "a" and "b". An erroneous connection to pins "b" and "c" is not possible.

The pin connectors snap-in to the plug-in terminals. The connectors can be removed without tools.

Control wires are connected to contacts of the pin connectors. AWG 20 to 13 wire (0.5 mm^2 to 2.5 mm^2 diameter) can be accommodated.

Use only flexible copper control wire!

The crimp connector required depends on the diameter of the conductor being used. Section 0.5 mm^2 to 1.0 mm^2:

e.g.   Bandware 4000 Pieces   Type: 827039–1 from AMP Corp.
          Individual Piece   Type: 827396–1 from AMP Corp.

Section 1.0 mm^2 to 2.5 mm^2:

e.g.   Bandware 4000 Pieces   Type: 827040–1 from AMP Corp.
          Individual Piece   Type: 827397–1 from AMP Corp.

Connection of a conductor to a contact is performed using a hand crimping tool, e.g., type 0–825582 from AMP Co.

After the wires are crimped, the contacts are pressed into the terminals of the connector until they snap into place.

Note:

Stress relief for individual pin connector must be provided with cable ties. Stress relief should also be provided for the entire set of cables, e.g., cable ties.

The following separation tool must be used to remove the contacts from the pin connectors:
Type: 725840–1 from AMP Co.

The separation tool contains a small tube that is subject to wear. The tube can be ordered separately:
Type: 725841–1 from AMP Co.

2.1.4   Connections to Optical Communication Interfaces

Optical Communication Interfaces

The two available versions of optical communication interfaces are shown in Figure 2-12. The ports are supplied with caps to protect the optical components against dust or other contaminants. The caps can be removed by turning them 90° to the left.
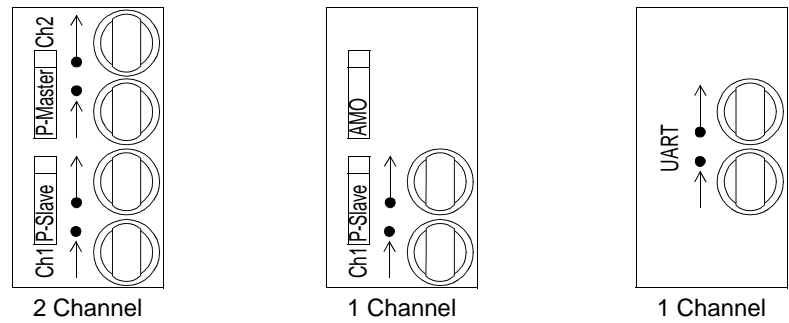
Figure 2-12   Optical Communication Interfaces with Protective Caps

Connections to Optical Communication Interfaces

Optical Connector Type: ST–Connector

Fiber Type: Multimode graded-index ("G") optical fiber
                                          G50/125 µm,
                                          G62.5/125 µm,
                                          G100/140 µm
Wavelength: λ = 820 nm (approximately)

<u>Allowable Bending Radius:</u>   For indoor cable r_{min} = 2 in (5 cm)
                                          For outdoor cable r_{min} = 8 in (20 cm)

Laser class 1 (acc. EN 60825–1) is achieved with fiber type G50/125 µm and G62.5/125 µm.

2.1.5 Connections to Electrical Communication Interfaces

Electrical Communication Interfaces

9 pin D-subminiature female socket connectors are provided for all electrical communication interfaces of the 7SJ61. The connector is illustrated in Figure 2-13. The pin assignments are described in Sub-section 8.2.1.
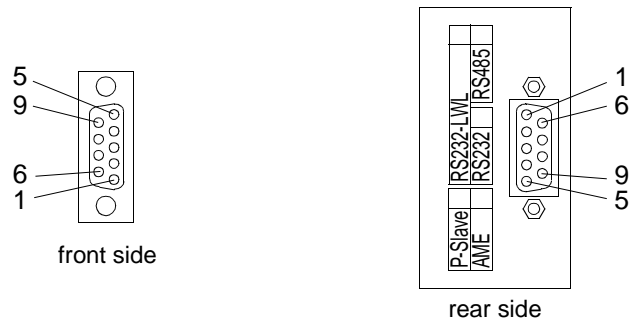
Figure 2-13   9 pin D-subminiature Connector

Connections to Serial Communication Interfaces

Standard 9-pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

The necessary communication cables are dependent on the interface:

- EIA 232: Five-wire, twisted and shielded, e.g. interface cable 7XV5100–4.

- EIA 485: Three-wire, twisted and shielded.

- Profibus: Two-wire or four-wire, twisted and shielded:
  Wire Type A, DIN 19245, Part 2 and EN 50170 vol. 2, twisted and shielded,
  Wire Resistance: 135 Ω to 165 Ω (f > 100 kHz)
  Capacitance: < 30 nF/km or < 48 nF/mile
  Circuit Resistance: < 110 Ω/km or 177 Ω/mile
  Conductor Diameter: > 0.64 mm
  Conductor Cross-sectional Area: > 0.34 mm^2
  e.g., SINEC L2 Industrial twisted pair installation wire (see catalog 1K 10 "SIMATIC NET, Industrial Communications Networks").

- Time synchronization: at least two-wire, shielded.

2.2   Version of 7SJ61 for Panel Surface-Mounting

The numerical, multi-functional SIPROTEC® 4 7SJ61 for panel surface-mounting is a sealed device in a 7XP20 $^1/_3$ size case (based on 19 inches) which again is installed in a housing.

2.2.1   Construction

The case is inserted in a housing and secured with four screws that are located at the corners of the front panel behind the covers. The front panel is attached to the case. The terminals for connections to external equipment are grouped into two blocks that are fastened to the top and the bottom of the housing. Inside the device are two printed circuit boards that are connected together with a ribbon-cable with plug connectors. The boards are supported with guide rails inside the case.

The front panel is removable. The screws for removing the component are located behind the four covers at the corners. The front panel has a covered keypad with operating and display elements necessary for equipment operation. All connections for these elements are combined into an adapter module on the front panel that is linked via a ribbon-cable with plug connectors to the internal processor board (CPU).

The nameplate sticker, showing important information such as power supply rating, nominal current rating, and ordering number, is located on the top of the housing and the interior of the front panel.

View of Front Panel   Referring to the operating and display elements in Diagram 2-14:

1. Display (LCD)
   The LCD shows processing and device information as text in various lists. Commonly displayed information includes measured values (metering), counter values, binary information regarding the condition of circuit breakers, status of the device, protective information, general reports, and alarms.

2. Navigation Keys
   These keys serve for navigation through operating menus.

3. MENU Key
   This key activates the main menu.

4. ESC and ENTER Keys
   These keys serve to escape from specific menues or execute changes (such as setting changes).

5. Numerical Keys
   These buttons serve for the entry of numerical values, such as protective settings.
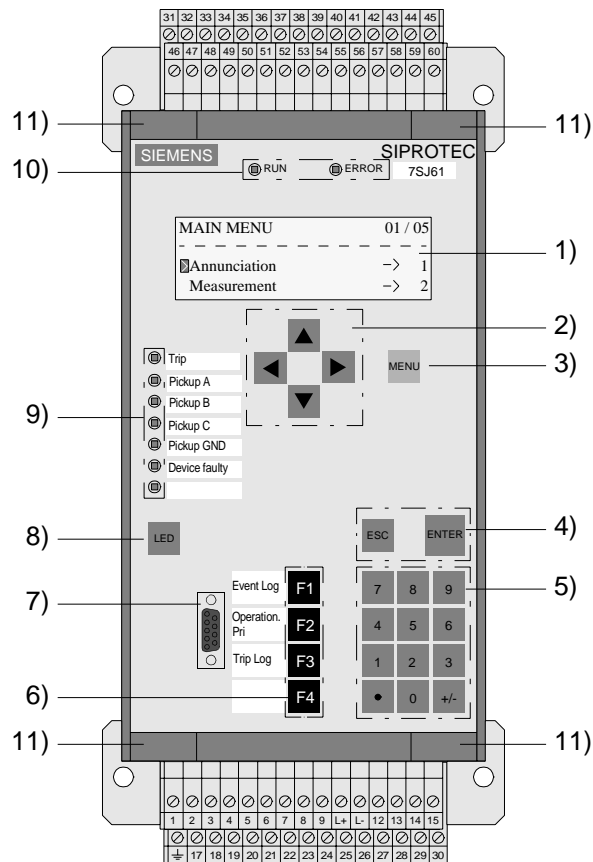
Figure 2-14   Front View, 7SJ61 for Panel Surface-mounting, Without Optical Connections

6. Function Keys
   Four function keys are typically used for quick and simple execution of frequently performed actions. The function of the keys can be defined (programmed) by the user. For example, the F1 key could be set to activate the display of operational reports, and the F2 key could be set to cause the display of operating values. The keys can also be programmed for control purposes. For example, the F3 key could be programmed to initiate a close command for a circuit breaker, while the F4 key could be programmed to initiate a trip command. Next to the keypad, a labeling strip is provided on which the user-specified key functions can be written.

7. Serial Communication Interface, 9-pin D-subminiature Connector
   This serial interface is for the connection of a local PC running DIGSI® 4.

8. LED Key
   This key is used to reset latched LEDs and the latched contacts of binary outputs, and provide a test of all LEDs in the group.

9. LEDs
   The function of these indicators can be programmed. There is a vast selection of signals to choose from. Next to the LEDs on the front panel, a labeling strip is provided on which the user-specified LED functions can be written.

10. Operating Condition Indicators
    The two LEDs "RUN" (green) and "ERROR" (red) indicate the operating condition of the device.

11. Coverings for the screws that secure the front panel.

2.2.2   Connections to Threaded Terminals

Terminal Blocks   All connections including the electrical communication interfaces and the ground are made to threaded terminals on the two, double-row terminal blocks mounted on the top and bottom of the 7SJ61. The terminal blocks are shown in Figure 2-14. The terminals are consecutively numbered from left to right on each block. There are a total of 60 terminals.

The 7SJ61 is equipped with a short-circuit safety feature for the current circuits. If the internal board that is connected to the current circuits is extracted, the current circuits are short-circuited before the board breaks from the current circuits. When the board is replaced, connections are first made to the current circuits, and then the short-circuit connection is removed. This safety feature does not relieve the user from exercising proper care when working with current transformer secondary circuits.

Connections to Terminals   Solid conductor or stranded wire with lugs can be used.
The following specifications must be observed:

Direct Cable Connections: solid or stranded conductor with connector sleeve conductor with cross-section of 0.5 mm^2 to 7 mm^2 or AWG 20 to 9.
Use copper wires only!

Maximum Tightening Torque: 0.9 ft-lb (1.2 Nm).

2.2.3   Connections to Optical Communication Interfaces

Optical Communication Interfaces   There are two versions of optical communication interfaces – 1 channel and 2 channels.

The optical interface is mounted in a housing that is located on the bottom of the 7SJ61. See Figure 2-15.

A front view of the optical interface housing is shown in Figure 2-16. The optical ports are located at the bottom of the housing panel. The transmitters and receivers are marked. A table is provided to indicate the channels that are configured. For example, Figure 2-16 illustrates a case in which channels B and C are configured. For the 7SJ61 the channels D and E are not available.

All configured optical ports are covered with caps to protect the optical components against dust and other contaminants. These caps should remain in-place until the ports are used. The caps can be removed by turning them 90° to the left. Non-configured optical interfaces are replaced with plastic plugs.

Connections to Optical Communication Interfaces   Optical Connector Type: ST–Connector

Fiber Type:	Multimode graded-index ("G") optical fiber G50/125 µm, G62.5/125 µm, G100/140 µm
Wavelength:	λ = 820 nm (approximately)

Allowable Bending Radius: For indoor cable r_{min} = 2 in (5 cm)
For outdoor cable r_{min} = 8 in (20 cm)

Laser class 1 (acc. EN 60825–1) is achieved with fiber type G50/125 μm and G62.5/125 μm.

Housing for optical communication interfaces
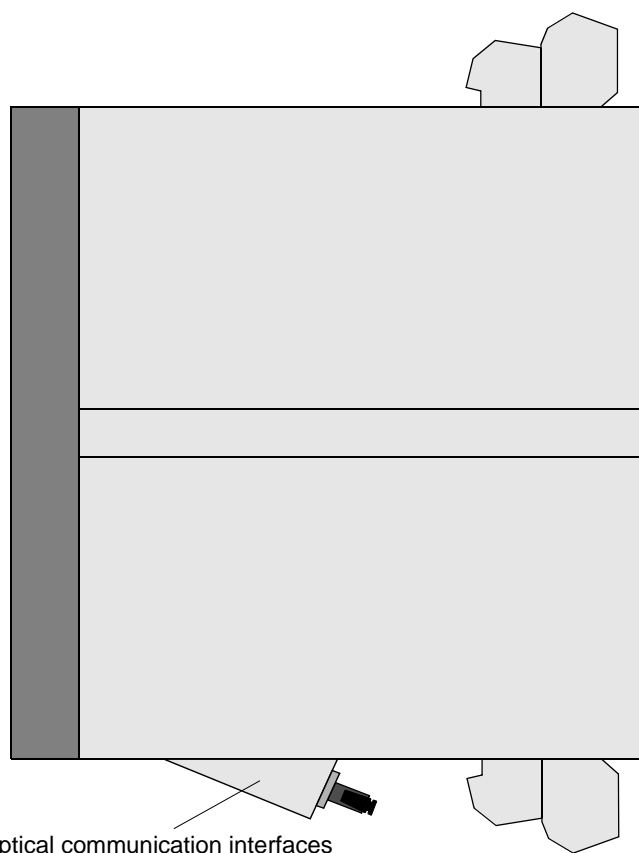
Figure 2-15   Side View of 7SJ61, Panel Surface-mounting, Optical Communication Interface

For a version of the device with Profibus, the optical ports for Channel B are replaced with a D-subminiature port containing the Profibus interface. See Figure 2-16.

Optical communication interfaces

Optical communication interfaces and D-subminiature connector
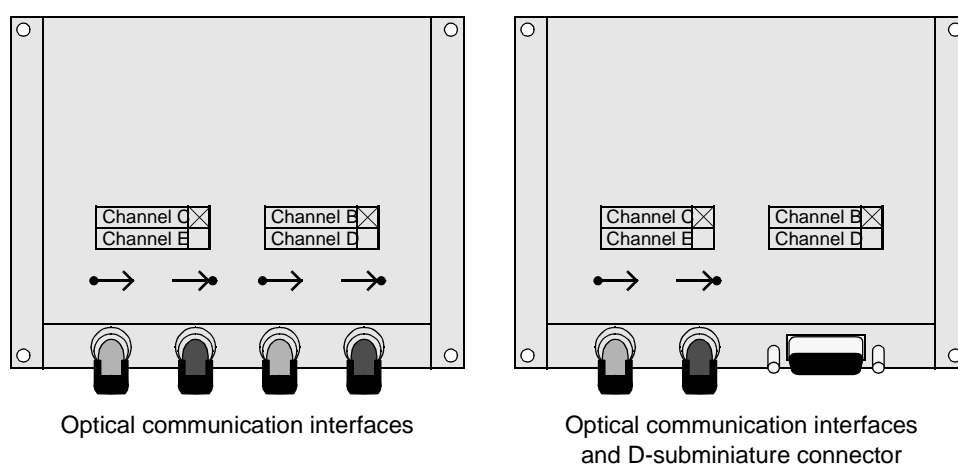
Figure 2-16   Housing Panel with Optical Communication Interfaces

■

Initial Inspections

<div style="text-align: right;">**3**</div>

This section describes the first steps that should be taken upon receiving the SIPROTEC® 4 7SJ61.

Unpacking and packing is explained.

Visual and electrical checks that are appropriate for initial inspection are discussed. The electrical tests include navigating through the operating menus of the device using the operator control panel on the front of the device, and the operator control windows in DIGSI® 4. For personnel inexperienced with the 7SJ61, these checks also provide a quick and simple method for understanding the operation of the control panel and DIGSI® 4. The electrical tests can be done without measuring quantities being applied.

Observations relevant to long-term storage of the device are noted.

3.1 Unpacking and Packing

The 7SJ61 is packaged at the factory to meet the requirements of IEC 60255–21.

Unpacking and packing must be done with normal care, without using force, and with appropriate tools. Visually check the device immediately upon arrival for correct mechanical condition.

Please observe also the brief reference booklet and all notes and hints that are enclosed in the packaging.

The shipping packaging can be reused in the same manner for further shipment. Storage packaging alone, for individual devices, is not sufficient for shipping. If other packaging is used, shock requirements under IEC 60255–21–1 Class 2 and IEC 60255–21–2 Class 1 must be met.

The device should be in the final operating area for a minimum of two hours before the power source is first applied. This time allows the device to attain temperature equilibrium, and dampness and condensation to be avoided.

3.2 Inspections Upon Receipt

3.2.1 Inspection of Features and Ratings

Ordering Number   Verify that the 7SJ61 has the expected features by checking the complete ordering number with the ordering number codes given in Sub-section A.1 of the Appendix. Also check that the required and expected accessories are included with the device. The ordering number of the device is on the nameplate sticker attached to the top of the case or housing. The nameplate also indicates the current, voltage, and power supply ratings of the device. A verification that these ratings are the expected values is especially important. The jumpers for the control voltage of the binary inputs are set at the factory for a DC control voltage equal to the DC voltage rating of the power supply. The jumpers can be changed if a different control voltage is to be used.

3.2.2 Electrical Check

Operating conditions that meet VDE 0100/5.73 and VDE 0105 Part 1/7.83, or national and international standards, are to be observed.

Before applying power supply voltage or measuring quantities for the first time, be sure the device has been in the operating area for at least two hours. This time period allows the device to attain temperature equilibrium, and prevents dampness and condensation from occurring.

⚠️ **Warning!**

The following inspection steps are done in the presence of dangerous voltages. Only appropriately qualified personnel familiar with and adhering to safety requirements and precautionary measures shall perform these steps.

Power-Up   Ensuring safe grounding and applying power supply voltage are sufficient for a first electrical inspection of the device.

☐ Connect the ground of the device to the ground of the location. The ground of a 7SJ61 designed for flush-mounting is on the back panel. The ground of a device designed for surface-mounting is on the terminal with the grounding symbol.

☐ With the protective switches (e.g. test switches, fuses, or miniature circuit breakers) for the power supply open, prepare the connections to the power supply. Verify that the power supply voltage has the correct magnitude. Check polarity connections to the device inputs. Follow the appropriate connection diagram in the Appendix, Section A.2.

☐ Close the protective switches to apply the power supply.

☐ The green "RUN" LED on the front panel must light after no more than 0.5 second, and the red "ERROR" LED must go out after no more than 10 seconds.

☐ After no more than 15 seconds, the start-up messages must vanish from the display (in which the complete ordering number, the version of firmware implemented, and the factory number are shown), and the default display must appear. Depending on the masking of the LEDs, some indicators may light up during and after power-up.

3.3 User Interface

3.3.1 Navigating through the Operating Menus Using the Operator Control Panel

Operator Control Panel
The device has a hierarchically structured operating tree, within which movements and actions are made using the ▲, ▼, ◀, ▶ keys and the MENU, ENTER, and ESC keys on the front panel.

The brief discussions below illustrate the navigation techniques using the integrated operations in the operator control panel. Some typical operations are covered. For easier understanding, the accompanying figures show the entire contents of the menus, while only a limited number of lines can be seen in the display at any time.

Ordering Number / Version Reading
To view the complete ordering number of the device, the version of firmware implemented, and the serial number:

❑ When the device is ready for operation, first press the MENU key. The **MAIN MENU** appears.

❑ Using the ▼ key, select the menu item **Settings**, and move to the device settings using the ▶ key. The **SETTINGS** menu appears, as shown in Figure 3-1.

❑ Using the ▼ key, select the menu item **Setup/Extras** and switch to the selection **SETUP/EXTRAS** using the ▶ key. See Figure 3-2.

```
              MAIN MENU      04/05
   ▼          --------------------
               Annunciation  —>   1
               Measurement   —>   2
               Control       —>   3
              ≥Settings      —>   4      ▶
               Test/Diagnose —>   5
```

```
                                         SETTINGS       10/11
                                  ▼      --------------------
                                          Device Config. —> 01
                                          Masking (I/O)  —> 02
                                          P.System Data1 —> 03
                                          Group A        —> 04
                                          Group B        —> 05
                                          Group C        —> 06
                                          Group D        —> 07
                                          Change Group   —> 08
                                          Osc.Fault Rec. —> 09
                                         ≥Setup/Extras   —> 10    ▶
                                          Device         —> 11
```
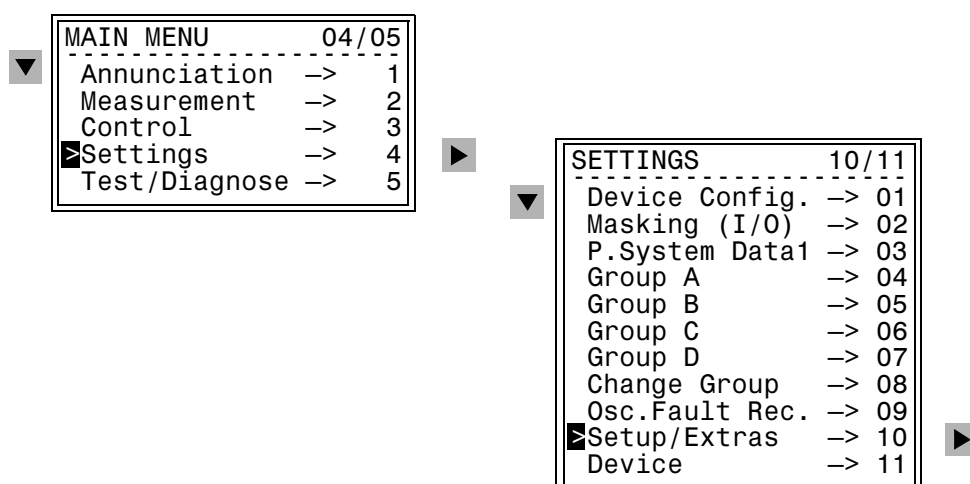
Figure 3-1   Sub-menu **SETTINGS**

❑ Using the ▼ key, select the menu **MLFB/Version** and view the selection **MLFB/ VERSION** using the ▶ key.

The device-specific data appear in two or three locations. Press the ▼ key as necessary to view all of the data:

```
┌─────────────────────────────┐
│ SETUP/EXTRAS      05/06     │
│ ------------------------    │
│▼  Date/Time      ─>   1     │
│   Clock Setup    ─>   2     │
│   Serial Ports   ─>   3     │
│   Device-ID      ─>   4     │
│▶▶MLFB/Version    ─>   5     │
│   Contrast       ─>   6     │
└─────────────────────────────┘
```

```
┌─────────────────────────────┐
│ MLFB/VERSION      01/03     │
│ MLFB: 7SJ6125─5EP00         │
│ 3HA1                        │
│ BF─Nr.: 9811049704          │
└─────────────────────────────┘
```

```
┌─────────────────────────────┐
│ MLFB/VERSION      02/03     │
│ Firmware:        4.00.18    │
│ Bootsystem:      1.00.04    │
└─────────────────────────────┘
```
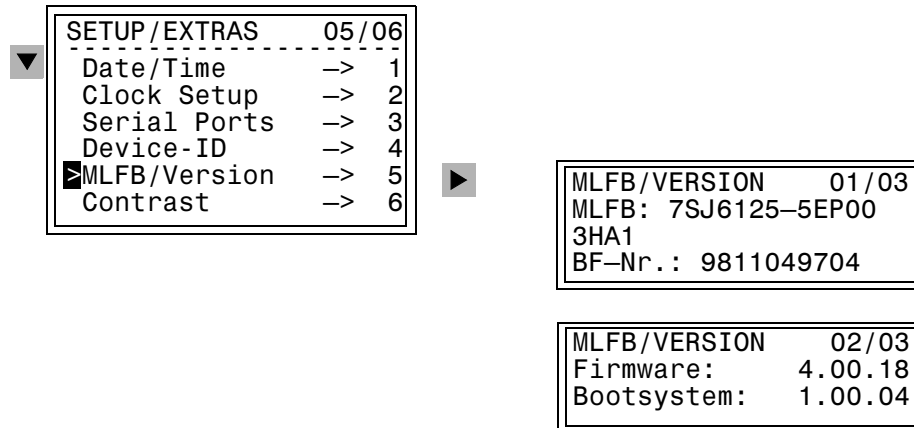
Figure 3-2   Display of Device-specific Data (Example)

Measurement Viewing

To view the measured values:

□ If the main menu is not shown, press the `MENU` key. The **MAIN MENU** appears.

□ Using the ▼ key, select the menu item ***Measurement***, and move to the measurement values using the ▶ key. The **MEASUREMENT** menu appears.

□ Using the ▼ key, select the menu item ***Operation. sec*** (operating measured values, secondary), and switch to the **OPERATION. SEC** menu using the ▶ key.

□ Using the ▲ and ▼ keys, all operating measured values can be viewed.

Since no AC voltages or currents are present at this time, all operating measured values show near zero. Deviations of the last digit are insignificant.

Event Messages Reading

Reading the event messages is described to serve as an additional example.

□ If the main menu is not shown, press the `MENU` key. The **MAIN MENU** appears.

□ Using the ▼ key, select the menu item ***Annunciation***, and switch to the annunciation using the ▶ key. The **ANNUNCIATION** menu appears.

□ Using the ▼ key, select the menu item ***Event Log***, and move to the **EVENT LOG** menu using the ▶ key.

The last quantity in the upper right corner of the display indicates the number of event messages stored in memory. The number before the slash indicates the message presently being displayed. Upon entering the menu, the latest (newest) message is shown. The date and time of the event are shown in the display line above the message.

□ Use the ▲ key to read other event messages.

□ Press the `LED` key; all LEDs should illuminate. Press the ▼ key. The newest message in the event log should be "Reset LED", and the number of messages in memory should increase by one (maximum of 200).

To return to the main menu, press the `MENU` key once, or repeatedly press the `ESC` key or the ◀ key.

Display Contrast Setting

If the image in the integrated LCD does not have satisfactory contrast, adjustments can be made. A stronger contrast serves, among other purposes, to improve the readability of the image from an angle. With increasing numbers, the contrast is increased and the picture gets darker. If the contrast is too weak or too strong, there is a risk that

the display will be unreadable and that no operation will be possible using the integrated operator control panel. Therefore, the preset contrast value should only be changed in small steps (1 or 2 levels).

❑ When the device is ready for operation, first press the MENU key. The **MAIN MENU** appears.

❑ Using the ▼ key, select the menu item *Settings*, and switch to the settings using the ▶ key. The **SETTINGS** menu appears.

❑ Using the ▼ key, select the menu item *Setup/Extras* and switch to the selection **SETUP/EXTRAS** using the ▶ key. See Figure 3-3.

❑ Using the ▼ key, select the menu item *Contrast*.

❑ If a change of the contrast of the integrated LCD is desired, press the ENTER key. The existing setting appears in a frame with a blinking cursor.

❑ Overwrite the present setting with the desired setting using the numerical keys. The setting range is [11 to 22].

❑ Confirm the change with the ENTER key, or cancel the change with the ESC key.

Exit the menu using the ESC key, or return to the main menu using the MENU key.

```
  ┌─────────────────────┐                    ┌─────────────────────┐
  │ SETUP/EXTRAS  6/06   │                    │ SETUP/EX┌──┐  06/06  │
  │ -------------------- │           ENTER    │ --------│18│-------- │
▼ │  Date/Time     ─>  1 │          ───────   │         └──┘         │
  │  Clock Setup   ─>  2 │                    │ MLFB/Ve└─ ┘n  ─>   5 │
  │  Serial Ports  ─>  3 │                    │ Contrast      ─>   6 │
  │  Device-ID     ─>  4 │                    └─────────────────────┘
  │  MLFB/Version  ─>  5 │
  │ ▶Contrast      ─>  6 │
  └─────────────────────┘
```
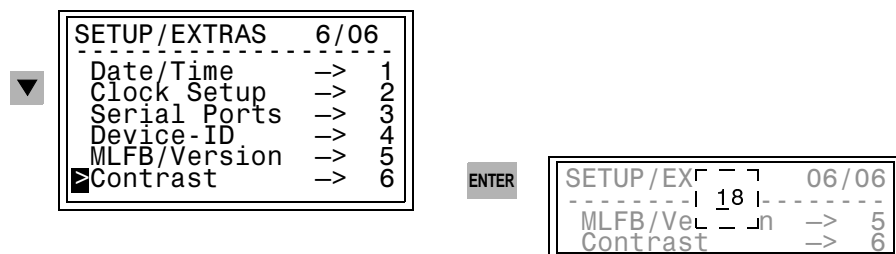
Figure 3-3   Operating Sub-menu for Adjusting the Display Contrast

3.3.2   Operation Using DIGSI® 4

DIGSI® 4 Operator Control Panel

DIGSI® 4 has the typical PC application Windows operating environment to guide the user. The software has a modern, intuitive, user-interface. Further details are found in Section 4, as well as in the DIGSI® 4 handbook "Device Operation".

Some applications of DIGSI® 4 are described below. They include viewing the measurement values, reading messages in the Event Log, and setting the clock. The handling of the operator control windows of DIGSI® 4 can be learned quickly by following the simple examples as descibed below. To perform the steps in the examples, first connect the SIPROTEC® 4 device to the PC and match the DIGSI® 4 interface data with the equipment. To accomplish this task:

❑ Establish a physical connection between a serial interface of the PC and the operating serial interface of the device on the front panel.

❑ Open the DIGSI® 4 application in the PC.

❑ Generate a new project by clicking on **File** → **New** in the DIGSI® 4–Manager menu bar.
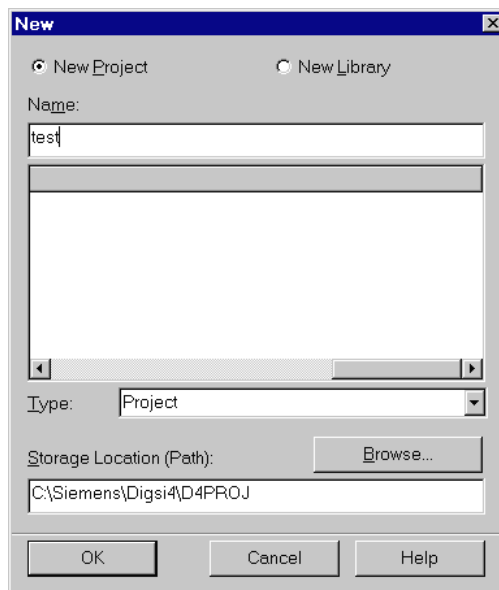
Figure 3-4   Dialog box to Open a New Project

❑ Enter a name for the new project in the **Name** entry field (e.g. test 1) and close the box with **OK**.

❑ Select **Folder** by clicking on the item in the newly opened dialog field. Then click on **DIGSI > Device** (**Plug & Play)**. The **Plug & Play** dialog box opens, as shown in Figure 3-6.
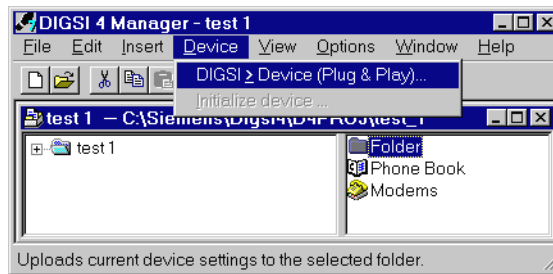
Figure 3-5   Dialog Field for Data Transfer

❑ Enter the designation of the PC serial interface (COM 1,2, 3, or 4) and select in the popup list under **Frame** the transfer format, to be used in making the connection.

❑ Click on **OK**. DIGSI® 4 automatically determines the type of device present and reads the settings needed for communication (transfer format, transfer speed) through the interface.
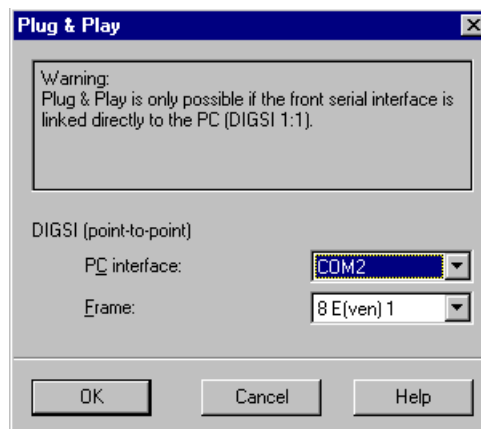
Figure 3-6   Plug & Play Dialog Box for Communication between Device and PC

A direct connection is then established (on-line), the data are exchanged between the PC and the device, and the initial window for DIGSI® 4 opens, as shown on Figure 3-7.

❑ By double clicking **Online** in the navigation window (left window), the structure opens (directory tree).

❑ By clicking on one of the menu items offered there, the associated contents become visible in the right window.
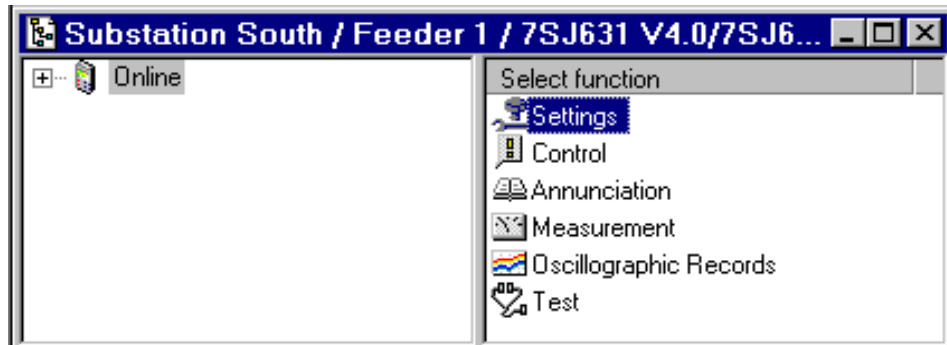
Figure 3-7   DIGSI® 4 — Online Initial Window (Example)

Measurement Viewing

As an example the procedure for viewing the measured values is described.

❑ Double click on **Measurement** in the navigation window (left).

❑ Double click on the subdirectory **Secondary Values** in the navigation window.

❑ Click on **Operational values, secondary**.

❑ The present date and time are shown in the data window (right), as illustrated in Figure 3-8.

❑ Double click on this entry in the data window.
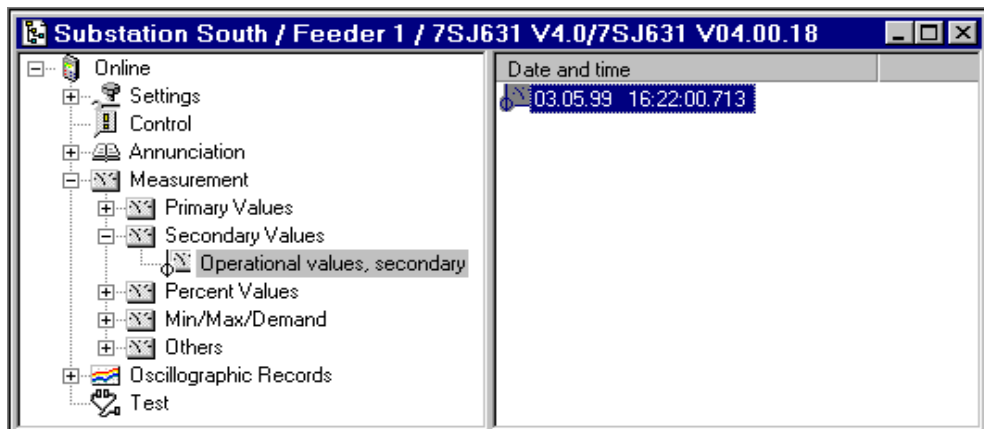
Figure 3-8   DIGSI® 4 — Viewing the Secondary Operating Measured Values

A table of the secondary operating measured values appears, as shown in Figure 3-9.

Since no AC currents or voltages are present, all measured values are close to zero. Deviations of the last digit are insignificant. The measured values are automatically updated.

In the same manner, other measured and counter values can be viewed.

Figure 3-9   DIGSI® 4 — Table of Secondary Operating Measured Values – Example

Event Messages Reading

The readout of operating messages is described and serves as an additional example.

❑ Double click on **Annunciation** in the navigation window.

❑ Click on **Event Log** in the function selection.

The present date and time are shown in the data window.

❑ Double click on this entry in the data window.

A table of the accumulated event messages is displayed. See Figure 3-10. The number designation for an event is provided with a description of the event. The corresponding cause, value (ON or OFF), and date and time of the event are given. The events are listed chronologically; the newest message is shown first.

Figure 3-10   DIGSI® 4 — Event Log Messages Window – Example

❑ Press the LED key on the device; all LEDs should light while the key is pressed.

❑ The message "Reset LED" appears as the newest message as soon as the window is updated. The window is updated by clicking on **View** in the menu bar, and then on **Refresh**. Pressing the **F5** function key on the keyboard also updates the window.

The operating messages can be saved in DIGSI® 4, and also deleted from the device's memory.

Date and Time Setting	To enter the date and time:
	☐ Click on **Device** in the menu bar. See Figure 3-11.
	☐ Select **Set Clock**.
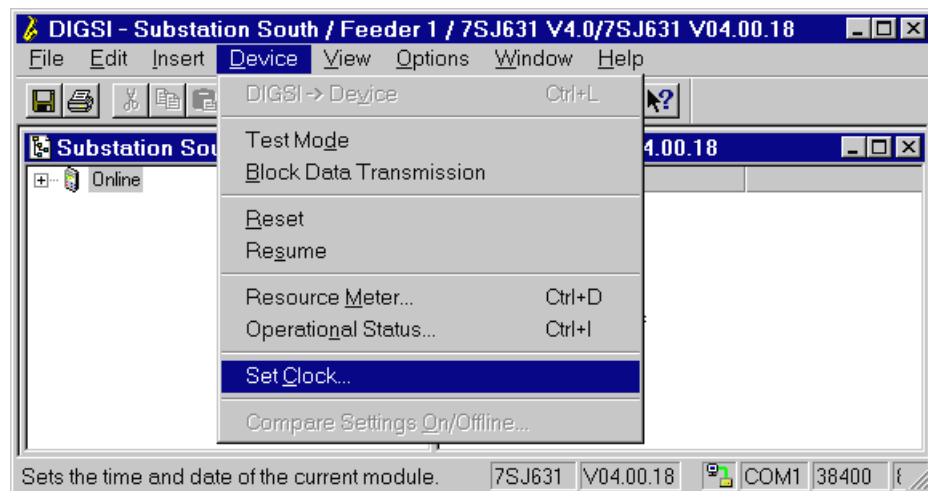
Figure 3-11   DIGSI® 4 — Selection of the Option **Set Clock**

The dialog field **Set clock & date in device** opens. The field shows the present date and the approximate present time according to the device. The day of the week is automatically derived from the date and cannot be edited.

- Edit the input fields **Date** and **Time**. The format depends on your regional settings of the PC. See Figure 3-12.

      Date: mm/dd/yyyy or dd.mm.yyyyy
      Time: hh.mm.ss

  Click **OK** to download the entered values to the device. The former values are changed and the dialog field is closed.
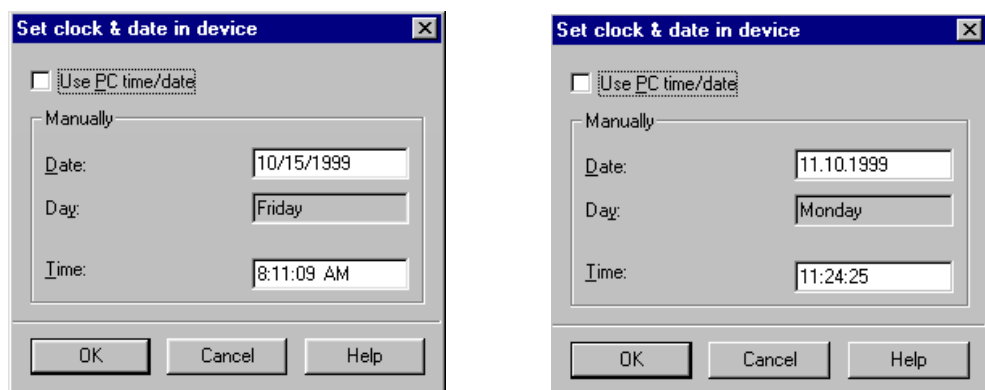
Figure 3-12   DIGSI® 4 — Dialog Field: **Set clock & date in device**

3.4   Storage

If the device is to be stored, note:

SIPROTEC® 4 devices and associated assemblies should be stored in a dry and clean place, with a maximum temperature range of [−12 °F to 131 °F], or [−25 °C to +55 °C]. See Sub-section 10.1.7 under Technical Data. To avoid premature aging of the electrolyte capacitors in the power supply, a temperature range of [50 °F to 95 °F], or [+10 °C to +35 °C], is recommended for storage.

The relative humidity must not lead to condensation or ice buildup.

After extended storage, the power supply of the device should be energized, approximately every two years, for one or two days to regenerate the electrolytic capacitors in the power supply. This procedure should also be done prior to the device being put in-service. Under extreme climatic conditions (tropics), preheating is achieved at the same time, and condensation is prevented.

After long storage, power should not be applied until the device has been in the operating area for a minimum of two hours. This time period allows the device to attain temperature equilibrium, and prevents dampness and condensation from occurring.

■

SIPROTEC 4 Devices

<div style="text-align: right">**4**</div>

This section provides an overview of the family of SIPROTEC® 4 devices and the integration of the devices into process control systems. Principle procedures are provided for setting the devices, controlling primary equipment with the devices, and performing general operations with the devices.

Please note the SIPROTEC® 4 family of devices is described in general in this section, and the examples shown may differ in detail from a specific device. Also, depending on the version of the specific device, some of the functions discussed may not be available.

Details about the extent of the functions of the devices, the individual settings, and the representation structure of the system data are found in the following sections and the DIGSI® 4 instruction book.

4.1 General

The SIPROTEC® 4 family is an innovative product series of numerical protective and control devices with open communication interfaces for remote control and remote setting, ergonomically designed control panels, and highly flexible functionality.

4.1.1 Protection and Control

The devices utilize numerical measuring techniques. Complete numerical signal processing offers high measurement accuracy and long-term consistency, as well as reliable handling of harmonics and transients. Digital filtering techniques and dynamic stabilization of measured values ensure the highest security in establishing the devices' correct responses. Device errors are recognized and quickly annunciated by integrated self-monitoring routines. Failure of protection during a fault is therefore almost entirely prevented.

The user can choose devices with separate protective and process control functions, or select a solution that implements both requirements.

The following solutions are available:

❑ Protection and control in separate devices,

❑ Protective devices that provide the capability of control of a circuit breaker or primary switching equipment through a communication interface,

❑ Devices with combined features that, in addition to protective functions, offer on-site operation for several circuit breakers and primary switching equipment and extensive process control functions.

4.1.2   Communication

SIPROTEC® 4 devices are completely suited for the requirements of modern communication technology. They have interfaces that allow for integration into higher-level control centres, and user friendly operation through an on-site PC or via a modem connection. Simple, comfortable device setup and operation are provided.

SIPROTEC® 4 devices support the widespread, internationally accepted communication standards

❑ PROFIBUS FMS and

❑ IEC 60870-5-103

Prepared for

❑ DNP3.0 (available 12/99)

❑ Modbus (available 04/00)

❑ Profibus DP (available 12/99)

❑ UCA II / Ethernet (future)
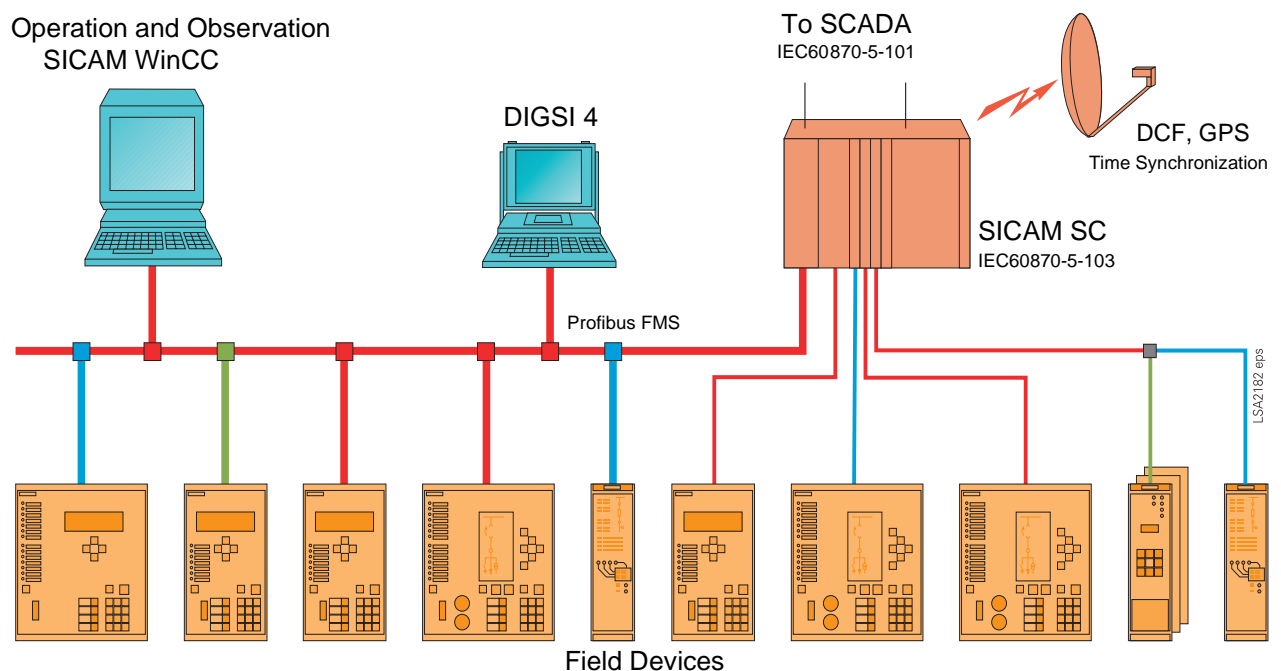
Figure 4-1   Integration of Field Devices in the SICAM Station Control System, example

Refer to the sample configuration in Figure 4-1. In the case when data is transmitted from the field devices it can be processed in the sub-station control device SICAM SC, displayed at the operating and observation station SICAM WinCC, and transferred by the remote terminal unit interfaces (via the network channels) to SCADA.

In the case when commands are sent to the devices, equally flexible processing is possible; that is, substation control operations can be initiated from the network control centres (SCADA), as well as from the operation and observation unit of the substation control system.

> *Note:*
>
> All SIPROTEC® 4 devices also operate with the proven star coupler (e.g. 7XV5). Thus, for simple applications, the user can retrieve all information from the office or while on the road.

4.1.3 Settings

The devices in the SIPROTEC® 4 family are delivered with factory default settings. After settings are made for specific applications, the devices are suitable for direct use in power systems.

The windows-based DIGSI® 4 software program offers an application-oriented interface with thorough guidance for quick and simple setting of the devices.

DIGSI® 4 is installed on a normal PC. For local use, the PC is connected to the operating serial interface on the front panel of the device.

4.1.4 Operations

All on-site operations of a SIPROTEC® 4 device can be done with DIGSI® 4. Examples of operations are breaker control, retrieval of information, or changing of setting groups. All of the operations can also be performed using the HMI on the front of the SIPROTEC® 4 device.

4.1.5 Waveform Capture

DIGSI® 4 can also be used to retrieve waveform data and SER information captured by the SIPROTEC® 4 device. The **DIGRA® 4** software program can then be used to provide several different graphical representations of the captured signals. DIGRA® 4 also calculates additional values on the basis of the captured signals. The program presents the data in analogue curves with time base, vector diagrams, circle diagrams, and harmonic charts.

4.2 Operator Control Facilities

4.2.1 Operating Panel On Device

The operating panels of SIPROTEC® 4 devices are ergonomically designed and easy to read. The operating panels allow on-site control operations to be done, individual settings to be entered, and all information required for operations to be displayed.

The operating panel contains either a full graphical display or a four-line display, depending on the specific device of the SIPROTEC® 4 family.

HMI with Four-Line Display
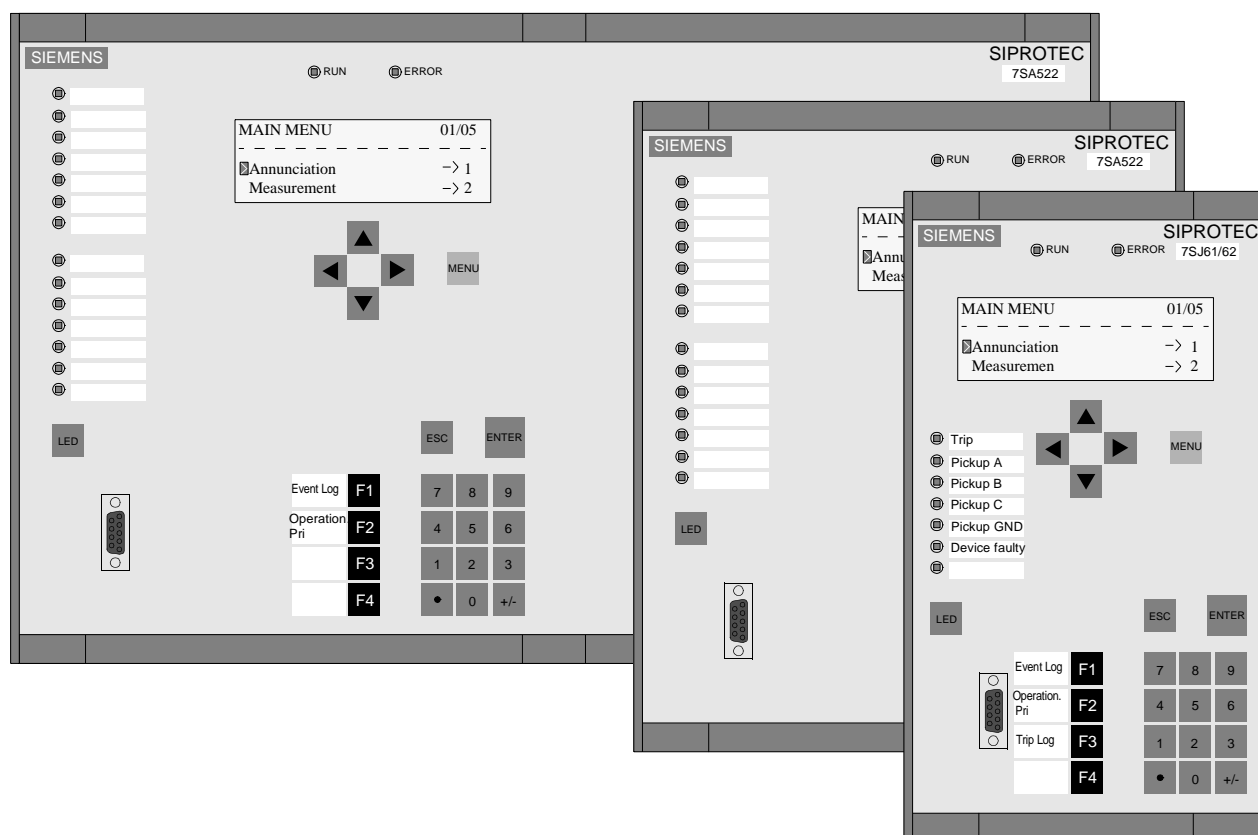
Figure 4-2   SIPROTEC® 4 Device, HMI with Four-line Display, example

Note:

Refer to Section 2 to determine the type of HMI for the specific SIPROTEC®4 device.

The functions of the operating and display elements on the control panel are described below.

Display

Process and device information are displayed in the LCD. Commonly displayed information includes measured values, counter values, binary information regarding the condition of the device, protection information, general messages, and alarms.

The light for the display is normally off. The light automatically turns on whenever a key is pressed on the HMI. If no input from the HMI occurs for ten minutes, then the light turns off again. The light can be controlled via a binary input that is configured (programmed) for this purpose.

Keys

The keys have various functions.

- Navigation through the operating menus of the device are accomplished with the ◀, ▶, ▲, ▼ keys.

- The main menu is opened with the MENU key.

- Changes are cancelled or confirmed with the ESC and ENTER keys, respectively.

- Numerical values are entered with the 0 to 9 keys, the . key for a decimal point, and the +/– key for a negative sign. If a value of infinity (∞) is desired, press the decimal point key twice; ∞ appears in the display.

- The F1 to F4 keys are programmable. The keys are typically used to execute commonly performed actions. Labeling strips are provided.

- Latched LEDs and binary outputs are reset and the group of LEDs are tested with the LED key (dual purpose).

LEDs

- "**RUN**" and "**ERROR**" LEDs indicate the condition of the device.

- All other **LEDs** are freely configured to indicate process information, status, etc. Labeling strips are provided.

Operating Serial Interface

Local communication with the device is established through the front operating serial interface with a PC running DIGSI® 4. The interface on the device is a 9-pin, female, D-subminiature port.

4.2.2 DIGSI® 4 Tool

DIGSI® 4 uses the familiar Windows operating environment.

User Guide

In DIGSI® 4 only the settings that are available within a specific device are shown in the specific windows. If a protective feature is changed from disabled to enabled in the Device Configuration, then the settings relevant to that feature become available.

Entering settings for SIPROTEC® 4 devices is simplified due to many types of assistance offered, such as context menus, pop-up lists for the selection of available options, and specific limits for the entry of numerical values.

Masking Inputs and Outputs (Configuration Matrix)

A configuration matrix is used to mask the binary inputs, binary outputs, and LEDs. Information to be saved in the various buffers and transmitted via the system interface is also selected in this matrix. The setting options are presented in an easy-to-read tabular format. Parts of the matrix can be minimized or expanded as desired to simplify the displayed sections, and therefore the setting process. Filter functions can reduce the size of the matrix to display only relevant information.

Passwords

Password entry is required for tasks such as changing settings, executing control commands, or exercising the test and diagnostics features. The passwords protect against unauthorized access to these critical tasks.

Commissioning Aids

DIGSI® 4 simplifies commissioning with test functions for the binary inputs, outputs and LEDs. Control of primary equipment can be done. The measured values of the device can be viewed with the program. Waveform capture can be triggered with DIGSI® 4.

Help System

The help system clarifies the individual functions and settings, and provides additional support.

Note:

Detailed information about DIGSI® 4 can be found in the DIGSI® 4 instruction book, order number E50417-H1176-C097.

4.3 Information Retrieval

A SIPROTEC® 4 device has an abundance of information that can be used to obtain an overview of the present and past operating conditions of the device and the portion of the power system being protected or controlled by the device. The information is represented in separate groups:

❑ Annunciation,

❑ Measurements,

❑ Waveform capture.

Remote If the device is integrated into a process control system, then information transfer can take place, via a connection to the system interface of the SIPROTEC® 4 device, to:

❑ SCADA, or

❑ substation controller device, e.g. SICAM SC

Local On site, the HMI of the SIPROTEC® 4 device can be used to retrieve information.

DIGSI® 4 Information retrieval is simple and fast when DIGSI® 4 is used. For local use, connect a PC to the operating serial interface at the front of the SIPROTEC® 4 device. For re- mote retrieval of information, communication occurs via a modem connected to the service serial interface. DIGSI® 4 must operate in the **Online** mode to obtain informa- tion from the device.

4.3.1   Annunciations

The scope of the indication (messages) that are given under Annunciation is automatically determined when settings for the basis configuration of functions are applied to the SIPROTEC® 4 device.

The messages are divided into the following categories, and displayed using DIGSI® 4 or the HMI of the device:

❏ Event Log: Operational messages independent of network faults, e.g. messages about control operations or monitoring functions;

❏ Trip Log: Fault messages;

❏ Sensitive Ground Fault Log: Ground fault messages for devices with sensitive ground fault detection;

❏ General Interrogation: Display of present condition messages;

❏ Spontaneous Annunciation: Continuous display of important messages from the device; e.g., after faults, control operations, etc. This feature is very helpful during commissioning.
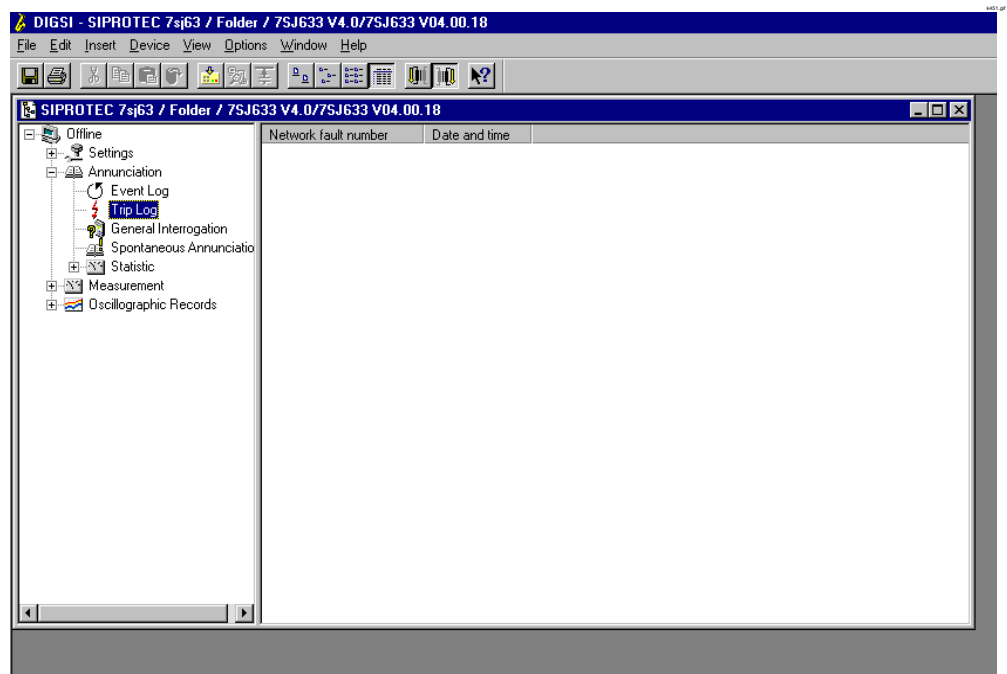
Figure 4-3   DIGSI® 4, Annunciation

Display in DIGSI® 4

To view the indications in the DIGSI® 4 Tool **Online**:

• Select **Annunciation** in the navigation window.

All annunciation groups are shown in the data window.

• Double click on an annunciation group in the data window, such as **Event Log**.

The data and time appear. Double click on the entry. The list of indications appears.

Display on the Device

To display messages in the HMI of the SIPROTEC® 4 device:

• Select **Main Menu** → **Annunciation** → e.g. **Event Log** or **Trip Log**.

```
┌─────────────────────┐
│MAIN MENU     01/05  │
│-------------------- │
│▶Annunciation  –>  1 │
│ Measurement   –>  2 │
└─────────────────────┘
```
▶
```
┌─────────────────────┐
│ANNUNCIATION    01/05│
│---------------------│
│▶Event Log      –> 01│
│ Trip Log       –> 02│
└─────────────────────┘
```

```
┌─────────────────────┐
│EVENT LOG      19/19 │
│-------------------- │
│06.19.98 11:52:05,461│
│Reset LED         ON │
└─────────────────────┘
```
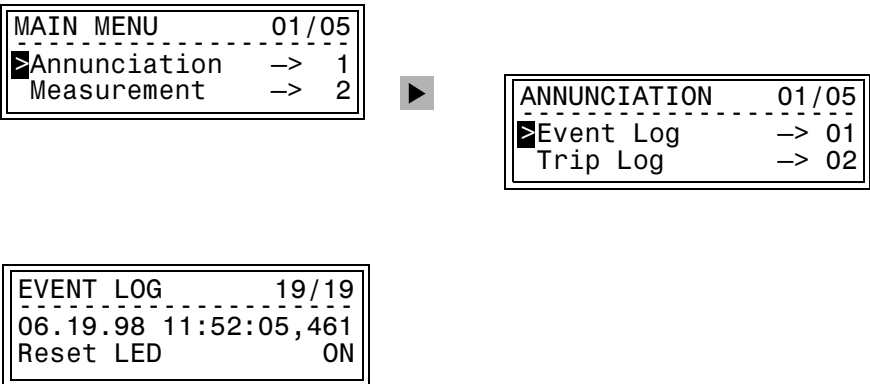
Figure 4-4   SIPROTEC® 4, Device Display of Operating Messages in the Event Log, Example

```
┌─────────────────────┐
│TRIP LOG      01/08  │
│-------------------- │
│▶Last Fault    –>  1 │
│ 2nd Last Fault –>  2│
└─────────────────────┘
```
▶
```
┌─────────────────────┐
│LAST FAULT      01/10│
│---------------------│
│06.22.98 23:49:34.845│
│Network Fault    6 ON│
└─────────────────────┘
```

```
┌─────────────────────┐
│GROUND FAULT   01/03 │
│-------------------- │
│▶Last Fault     –>  1│
│ 2nd Last Fault –>  2│
└─────────────────────┘
```
▶
```
┌─────────────────────┐
│LAST FAULT      01/04│
│---------------------│
│06.11 98 09:37:23.203│
│Ground Fault    1  ON│
└─────────────────────┘
```
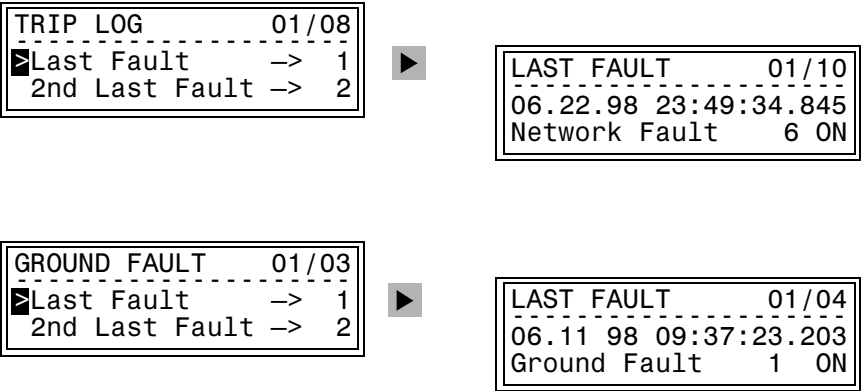
Figure 4-5   SIPROTEC® 4, Device Display, Trip Log and Ground Fault Messages, Example

4.3.2   Measurements

The measured values that are registered are divided into the following categories for display in DIGSI® 4 or on the HMI of the device:

❑ Primary values, based on the measured secondary values and the settings entered for the current transformers and voltage transformers.

❑ Secondary values, which are the measured values or are derived from the measured values.

❑ Percentage values, relative to nominal ratings.

❑ Other values including thermal values and user-defined values.

❑ Statistics values.
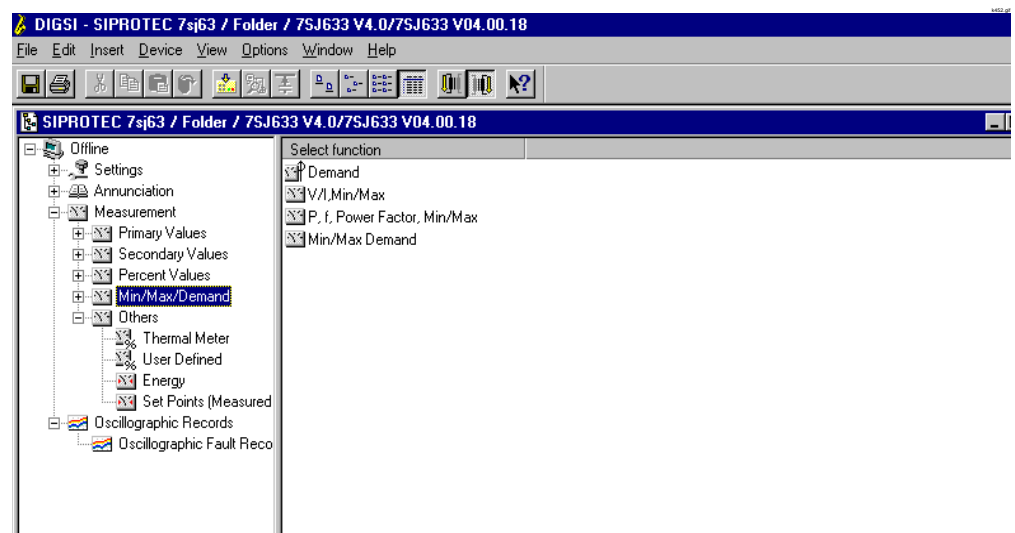
Figure 4-6   DIGSI® 4 Measured value display, Example

Display in DIGSI® 4   To display the measured values using the DIGSI® 4 **Online** control panel:

• Select **Measurement** in the navigation window. The measured value groups appear in the data window.

• Double click on a group, for example **Primary Values**.

• Double click on the next item in the data window, **Operational values, primary** in the example. The date and time appear.

• Double click on the date and time, and the measured values appear.

**Display on
the Device**

To display the measured values in the HMI of the SIPROTEC® 4 device:

- Select **Main Menu** → **Measurement** →
  e.g. **Operation. pri** − or **Operation. sec** −.

```
┌─────────────────────┐
│MAIN MENU      02/05 │
│- - - - - - - - - - -│
│ Annunciation   ─>  1│
│>Measurement    ─>  2│
└─────────────────────┘
```
▶
```
┌─────────────────────┐
│MEASUREMENT    01/12 │
│- - - - - - - - - - -│
│>Operation. pri ─> 01│
│ Operation. sec ─> 02│
└─────────────────────┘
```


```
┌─────────────────────┐
│MEASUREMENT    01/12 │
│- - - - - - - - - - -│
│>Operation. pri ─> 01│
│ Operation. sec ─> 02│
└─────────────────────┘
```
▶
```
┌─────────────────────┐
│OPERATION. PRI 02/24 │
│- - - - - - - - - - -│
│ Ia =     1062.8A    │
│>Ib =     1081.5A    │
└─────────────────────┘
```
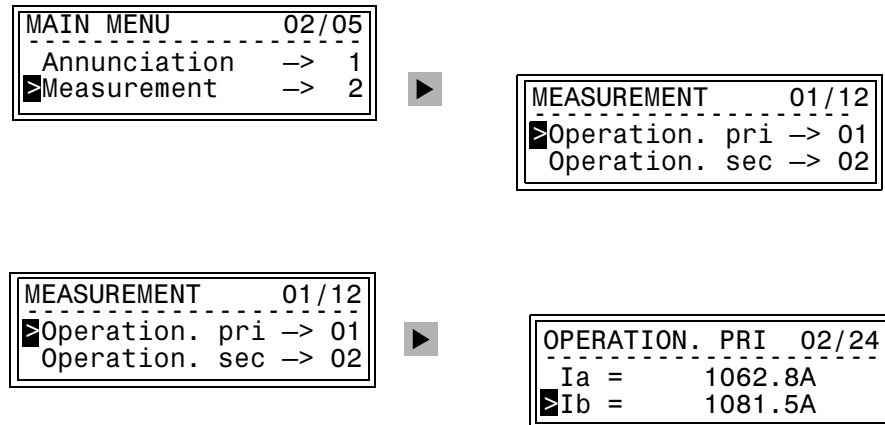
Figure 4-7   SIPROTEC® 4, Device Display of Measured Values, Example

4.3.3 Waveform Capture

As an option, SIPROTEC® 4 devices can have waveform capturing that includes Sequence of Event Report (SER) for the elements in the device. Furthermore, the elements that are shown in the SER can be selected by the user.

The waveform and SER data are retrieved from the device memory by DIGSI® 4 and are saved as waveform capture in standard COMTRADE format.

The DIGRA® 4 program is used to convert the oscillographic data into graphical representations that can be used to analyze the fault or the event captured by the device.

DIGRA® 4 calculates additional values from the waveform data, e.g. impedances and rms values, and displays the captured and calculated values in:

❑ Analogue Curves with timebase (Time Signals),

❑ Vector Diagrams,

❑ Circle Diagrams, and

❑ Harmonic graphs.

Figure 4-8   DIGRA® 4 Graphical Representations of the Waveform Data, View Examples

Details can be found in the DIGSI® 4 instruction book, order number E50417-H1176-C097, and the DIGRA® 4 instruction book, order number E50417-H1176-C070.

4.4 Control

The multiple application possibilities for SIPROTEC® 4 devices require an equally flexible concept for command editing and control.

Remote

If the device is integrated into a control system, then command outputs can be remotely controlled via the system interface using telegrams from

❑ SCADA or

❑ substation controller devices such as SICAM SC.

Local

On-site, the SIPROTEC® 4 device offers the possibility to control a circuit breaker or primary switching equipment using the HMI.

For devices with a four-line display, control operations are carried out using:

- **Main menu** → **Control** → **Breaker/Switch** → **Control** → Equipment and intended direction **ON** or **OFF** (Figure 4-9), or

- The Function Keys F1 to F4.

The functionality of these keys is programmable using CFC. Their factory default function does not do any breaker control.

```
┌────────────────────┐
│MAIN MENU     03/05 │
│--------------------│              ┌────────────────────┐
│ Measurement   ─>  2│              │CONTROL       01/03 │
│▶Control       ─>  3│       ▶      │--------------------│
└────────────────────┘              │▶Breaker/Switch─>  1│
                                    │ Tagging       ─>  2│
                                    └────────────────────┘

┌────────────────────┐
│CONTROL       01/03 │              ┌────────────────────┐
│--------------------│              │BREAKER/SWITCH 02/04│
│▶Breaker/Switch─>  1│       ▶      │--------------------│
│ Tagging       ─>  2│              │◼Display       ─>  1│
└────────────────────┘              │▶Control       ─>  2│
                                    └────────────────────┘
```
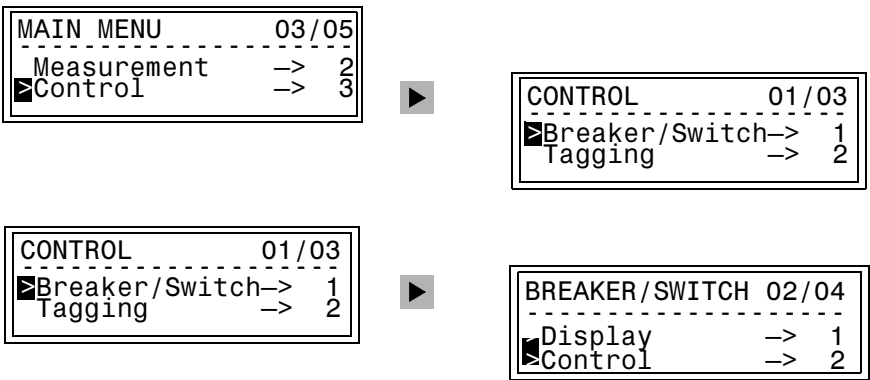
Figure 4-9   On-site Control Using the HMI

The status of a primary switch can be read out on the display using **BREAKER/SWITCH** → **Display** (Figure 4-10).

```
┌───────────────────────┐              ┌───────────────────────┐
│ BREAKER/SWITCH  01/04 │              │ DISPLAY         01/03 │
│ - - - - - - - - - - - │              │ - - - - - - - - - - - │
│▶Display        ─>  1  │      ▶       │▶52Breaker       OPEN  │
│  Control       ─>  2  │              │   Disc.Swit.    CLOS  │
└───────────────────────┘              └───────────────────────┘
```
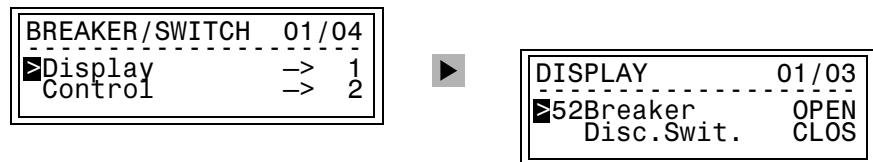
Figure 4-10   Determining Primary Switch Status using the HMI

DIGSI® 4
Control operations can be carried out using the DIGSI® 4 Tool. Connect a PC to the PC-interface at front of the device on site, or communicate with the SIPROTEC® device using a modem and the service interface.

DIGSI® 4 must operate in the On-line mode for this function.

- Select **Control** in the Navigation window and double click on **Breaker / Switches** in the data window.

In the dialog window that follows, all relevant primary control equipment is displayed in a table with the present status.

- Enter the intended device position in the **Scheduled** column. Answer the question with **Yes**.

The password is requested, the interlocking conditions are checked, and the command is issued.

Note:

The control option of DIGSI® 4 is typically used during commissioning, and for test and diagnostic purposes.

CFC
Using the graphically supported design tool CFC for logic functions in DIGSI® 4, information can be logically combined. Command outputs can be derived from the output of logic functions. The link of the output of the CFC functions to the respective device outputs is determined in the configuration matrix.

Password
Only authorized personnel shall perform control operations. ***Control operations are protected by passwords.***

Interlocking
Command outputs are subject to interlocking checks, which can be configured individually and graphically using the CFC logic too. Standard interlockings, such as ground switch closed status indication are already contained in the basic settings of the device when delivered from the factory.

Command Processing Times
Details about the command output time, checkback indication monitoring time, etc., are entered within the framework of the settings.

Event Recording
All control operations are recorded in the message list with date and time.

4.5   Manual Overwrite / Tagging

Manual Overwrite   If the breaker/switch position is not available, the status of the switchgear can be manually set to the actual present position using the HMI: **Main Menu** → **Control** → **Breaker/Switch** → **Man. Overwrite**. The simulated breaker/switch position is used for interlocking checks, and for automatically initiated control operations.

Set Status   For convenience during commissioning or at other times, decoupling of the switchgear and the protective device may be desired for a short period, without disconnecting the wires. This function is activated using the HMI: **Main Menu** → **Control** → **Breaker/Switch** → **Set Status**.

Tagging   To identify unusual operating conditions in the power system, tagging can be done. The tagging can, for example, be entered as additional operating conditions in interlocking checks, which are set up with CFC. Tagging is configured in the same way as for operating devices.

- The status of the tagging is displayed on the HMI, **Main Menu** → **Control** → **Tagging** → **Display** (Figure 4-11),

or changed using

- **Main Menu** → **Control** → **Tagging** → **Set**.

```
MAIN MENU      03/05          CONTROL        02/03          TAGGING        01/02
-----------------             -----------------             -----------------
Annunciation  ->  1           Breaker/Switch ->  1          Display        ->  1
Measurement   ->  2     ▶     Tagging        ->  2    ▶     Set            ->  2
Control       ->  3           Interlock      ->  3
```
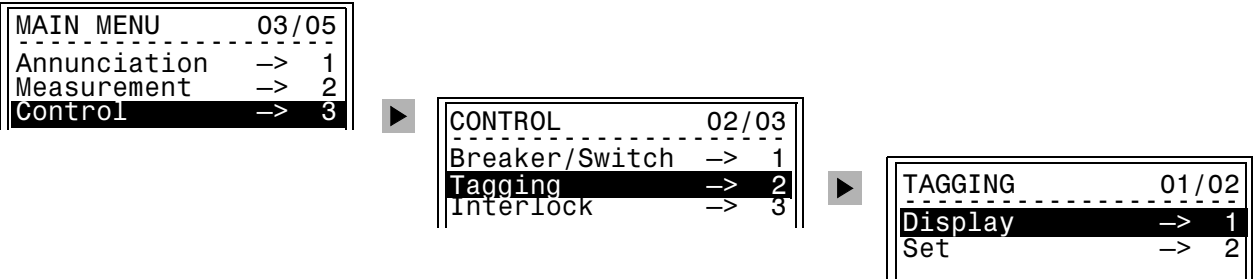
Figure 4-11   Tagging Equipment from the HMI

> *Note:*
>
> The Manual Overwrite function is always done using the HMI on the SIPROTEC® 4 devices.

4.6   General Setting Procedure

The SIPROTEC® 4 devices are delivered with standard default settings. Changes to the settings are done with DIGSI® 4.

The setting procedure for a SIPROTEC® 4 device consists of:

❑ Overall Protection and Control Design:

   ❑ Determining the functions that are to be used (device configuration),

   ❑ Masking the binary inputs, outputs, LEDs, buffers, system port, etc.

   ❑ Defining special logic functions (CFC).

❑ Specific Settings:

   ❑ Settings for all elements to be used,

   ❑ Settings of the protective functions,

   ❑ Settings of the process control functions.

Settings are first done **Off-line**. The settings are then loaded into the SIPROTEC® 4 device on-site using the operating serial interface, or remotely by modem and the service interface.
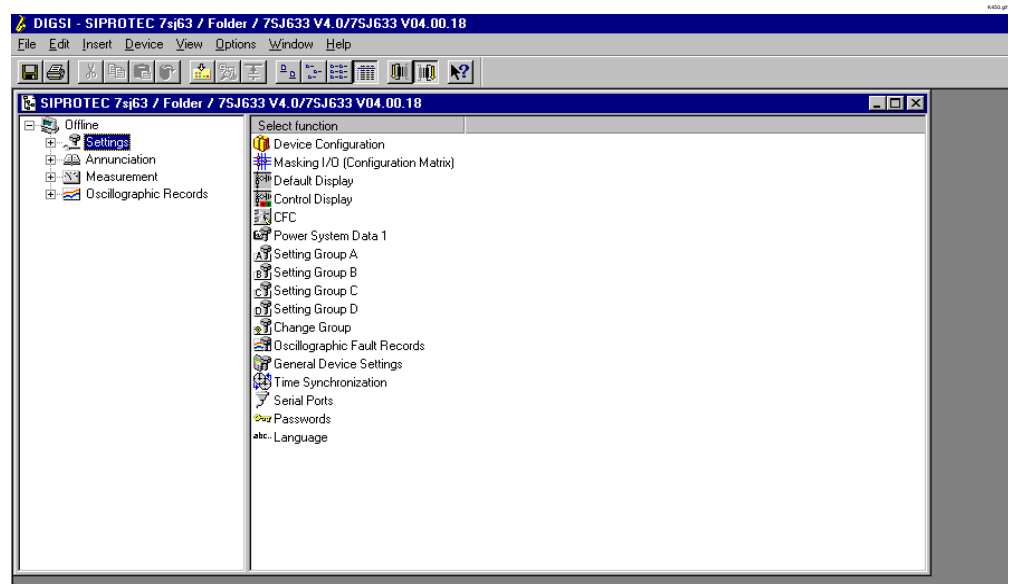
Figure 4-12   Setting a SIPROTEC® 4 device using DIGSI® 4

The transfer of data from DIGSI® 4 to the SIPROTEC® 4 device is indicated in the display. The progress of the transfer is displayed. See Figure 4-13.

```
┌─────────────────────────┐
││LOAD PARAMETER         ││
││--------------------   ││
││.....................  ││
││.....................  ││
││....                   ││
││                       ││
││                       ││
││                       ││
││                       ││
││--------------------   ││
││Download active        ││
└─────────────────────────┘
```
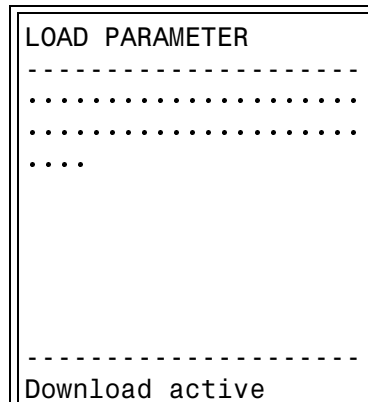
Figure 4-13   Display of Device during Settings Transfer

Setting Sequence   When setting a SIPROTEC® 4 device, adhere to the following sequence:

❑ Specify the interfaces, the device data, and the time synchronization,

❑ Determine the device configuration to be used,

❑ Design the masking of the inputs and outputs using the configuration matrix,

❑ Set the default display,

❑ Design all of the special logic that is to be employed using CFC,

❑ Enter the power system data,

❑ Apply the settings to groups A to D (groups B to D optional),

❑ Set the passwords.

Setting steps partially build on the decisions from the previous steps. By following the sequence listed, unnecessary changes and rework are avoided. The sequence ensures that information required for an individual step will be available.

Note:

Online changes to the configuration matrix and the control display are protected by Password No. 7 (Password for parameter set).

Settings for Protective Elements

Setting changes to individual protective elements can be done using the local HMI on the SIPROTEC® 4 device.

Other settings such as input/output masking and device configuration can be viewed from the front panel, but not changed.

- Display the settings on the LCD using **Main Menu** → **Settings** → e.g. **Masking (I/O)**.

- Change settings such as date and time using **Main Menu** → **Settings** → **Setup**/**Extras**.

```
 ▼ ┌─────────────────────┐
   │MAIN MENU      04/05 │
   │---------------------│
   │Annunciation   ─>  1 │
   │Measurement    ─>  2 │
   │Control        ─>  3 │       ▶
   │Settings       ─>  4 │
   │Test/Diagnose  ─>  5 │
   └─────────────────────┘
```

```
 ▼ ┌─────────────────────┐
   │SETTINGS      10/11  │
   │---------------------│
   │Device Config. ─>  01│
   │Masking (I/O)  ─>  02│
   │P.System Data1 ─>  03│
   │Group A        ─>  04│
   │Group B        ─>  05│
   │Group C        ─>  06│
   │Group D        ─>  07│
   │Change Group   ─>  08│
   │Osc.Fault Rec. ─>  09│
   │Setup/Extras   ─>  10│    ▶
   │Device         ─>  11│
   │                     │
   │---------------------│
   │Active Group is:    A│
   └─────────────────────┘
```
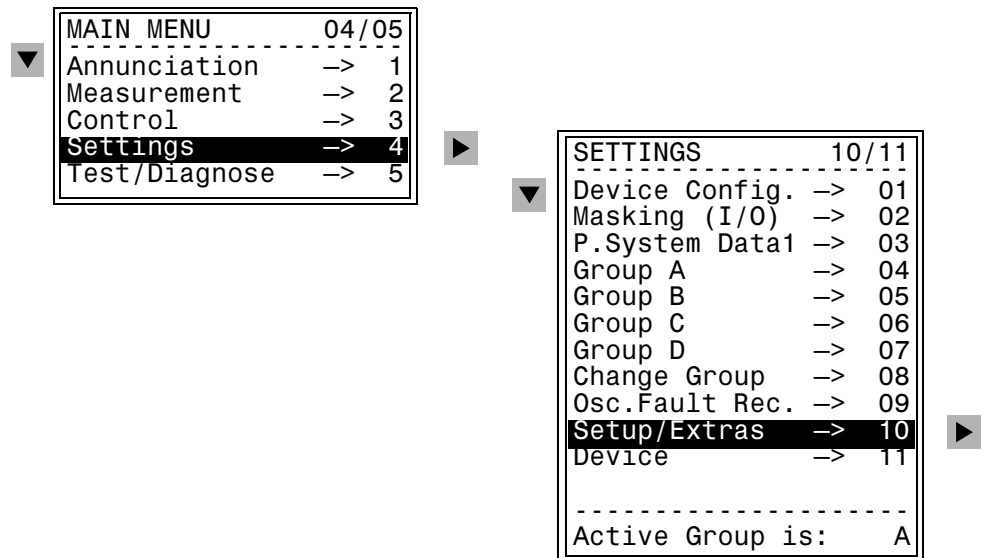
Figure 4-14   Changing Settings using the HMI, Example

Note:

Online changes to the individual settings are protected by Password No. 5 (Password for single settings).

4.7   Device Configuration

The individual devices within the SIPROTEC® 4 family can be supplied with various protective functions. The ordering number of the device determines the available functions. The functions are specified more precisely through the process of enabling and disabling in the Device Configuration area of the settings.

To specify the active functions using DIGSI® 4:

- Double click on **Device Configuration** in the data window.

- Click on the individual fields and select the functions to be enabled., e.g. 66 Startup Counter for Motors.
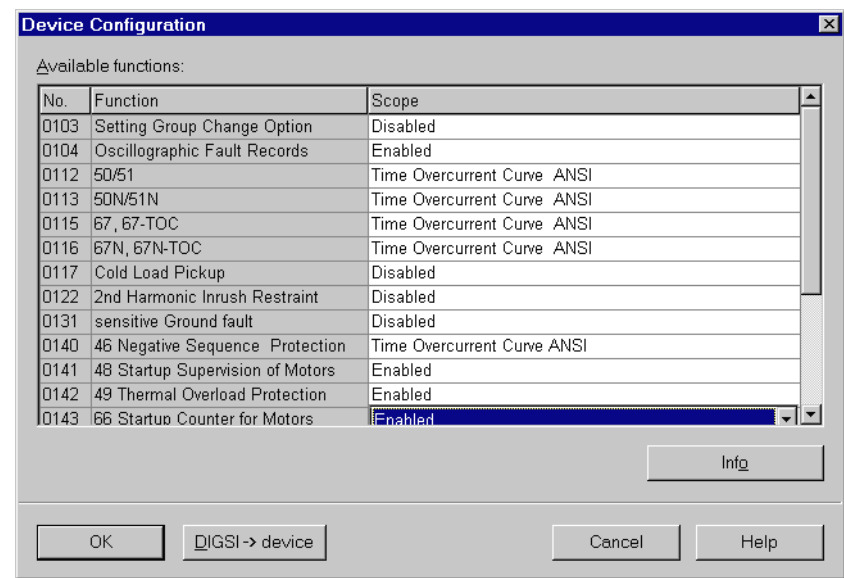
Figure 4-15   DIGSI® 4, Setting the Device Configuration, Example

The Device Configuration can be viewed from the HMI on the SIPROTEC® 4 device.

- In the main menu, select **Settings → Device Config**.

```
DEVICE CONFIG.    07/16
--------------------
0117 Coldload Pickup
     Enabled
```

Figure 4-16   Viewing Device Configuration from the HMI, Example

4.8   Configuration of Inputs and Outputs (Configuration Matrix)

A configuration matrix is used to determine processing of the binary inputs, outputs, LEDs, and indication buffers.

Configuration is performed with DIGSI® 4.

The configuration matrix is primarily divided into the following columns:

❑   Device functions with a selection field for the function settings;

❑   messages, e.g. indications or command with

   ❑ Information number, identification of the information, and a description in the appropriate device documentation,

   ❑ Display text, representative of the information on the device display,

   ❑ Long text, extensive description of the information,

   ❑ Type, identification of the information, e.g. BR_D2   Double command with check-back indication;

❑   Source, that is, origin of the information with

   ❑ Binary inputs for initiating indications,

   ❑ Function key F, freely programmable key on the HMI, e.g. assigned to trigger events,

   ❑ CFC (Programmable logic), user-specific logic outputs as the origin of the information;

❑   Destination of the information, with

   ❑ Binary outputs for the output of signals,

   ❑ LED, display of information, e.g. messages,

   ❑ System interface, transmission of information, e.g. to SCADA or substation controller,

   ❑ CFC (Programmable logic), information as an input to a user-specified logic,

   ❑ Buffer, in which the information should be entered,
      – Operation buffer or
      – Sensitive Ground Fault buffer or
      – Trip Log,

   ❑ Display within
      Default Display,

   ❑ Control Menu, primary device can be controlled or tagging can be set.

The user determines the configurations by

   ❑ Clicking on the appropriate column, or by

   ❑ Using the context menu: L (latched), U (Unlatched), H (activate high), L (activate low), _ (not configured), etc.

DIGSI® 4 checks the entry for plausibility and locks the input field if necessary. A locked input field is shown in gray.

Figure 4-17   DIGSI® 4, Input/Output Masking with the Configuration Matrix, Example

Filter Function

With the use of filters, either all information can be displayed or a selection can be done according to indications, commands, or measured values.

Additionally, there is a filter setting that differentiates between information configured and not configured.

The filters allows for a quick overview and simple checking of the configuration settings.

Also, columns and rows can be temporarily hidden from view, so that the user can combine only the sections of the total matrix that are relevant.

New Information

A further function of the configuration matrix is the capability to define new information. This is accomplished by inserting a new line, assigning the appropriate information type, and configuring the source with an output (binary outputs, LED, etc.). The new information can also be displayed in the LCD of the SIPROTEC® 4 device.

Function Keys

The function keys on the HMI of the SIPROTEC® 4 device can be assigned to commonly performed operating functions, e.g. initiation of a control operation. Select the appropriate function key **F1** to **F4** in the Source F column for the related information (e.g. control command).

CFC

SIPROTEC® 4 device information can be connected in a user-specified manner using the programmable logic components of the DIGSI® 4 CFC. For example, the user can implement interlocking checks, create grouped messages, or derive limit value violation messages.

Information can be both a source and a destination in combined CFC editing. The specific logic's inputs, e.g. the individual messages that are to be combined to form a grouped message, must be marked in the **Destination C** column. The logic's output, the grouped message in this example, is derived from the **Source C** column.

Displaying Masking in the HMI

The masking can be seen in the HMI of the SIPROTEC® 4 device.

- In the main menu, select **Settings** → **Masking (I/O)**.

```
┌─────────────────────┐
│MASKING (I/O)   01/03│
│---------------------│
│>Binary Inputs  —>  1│
│ LED            —>  2│
└─────────────────────┘
```

- In the next menu, select **Masking (I/O)** → e.g. **Binary Inputs**.

```
┌─────────────────────┐
│BINARY INPUTS   02/20│
│---------------------│
│ Binary Input 1 —>  —│
│>Binary Input 2 —>  —│
└─────────────────────┘
```

Figure 4-18   Reading the Masking using the HMI, example Binary Input 2

4.9   Programmable Logic CFC

The CFC program in DIGSI® 4 can be used to create additional logic in SIPROTEC® 4 devices. For example, special interlocking conditions for controlled equipment can be designed. Limit checks for measured values can be created, and corresponding control can be designed.

SIPROTEC® 4 devices have some CFC functions set at the factory, according to the version of the device.

User-defined CFC functions are done in graphical form. Generic logic modules (AND, OR, NAND, etc.) and analog modules that are specially created for the requirements of process control engineering (e.g., MAX, MIN, etc.) are available.

The CFC-modules are combined to form complete CFC-Logic Functions in order to

❑ perform system-specific checks (interlocking),

❑ generate messages if measured values approach a critical value, or

❑ build group messages for transfer to higher-level control systems.

k4122.gif

Figure 4-19   DIGSI® 4, CFC Basic Options, Example

CFC Designing   Figure 4-20 shows the graphical nature of the CFC logic tool, and some of the components that can be used to build the logic.

Note:

Online changes are protected in DIGSI® 4 by Password No. 7 (Password for parameter set).

Details about designing with the CFC program can be found in the instruction book, order number E50417-H1176-C098.
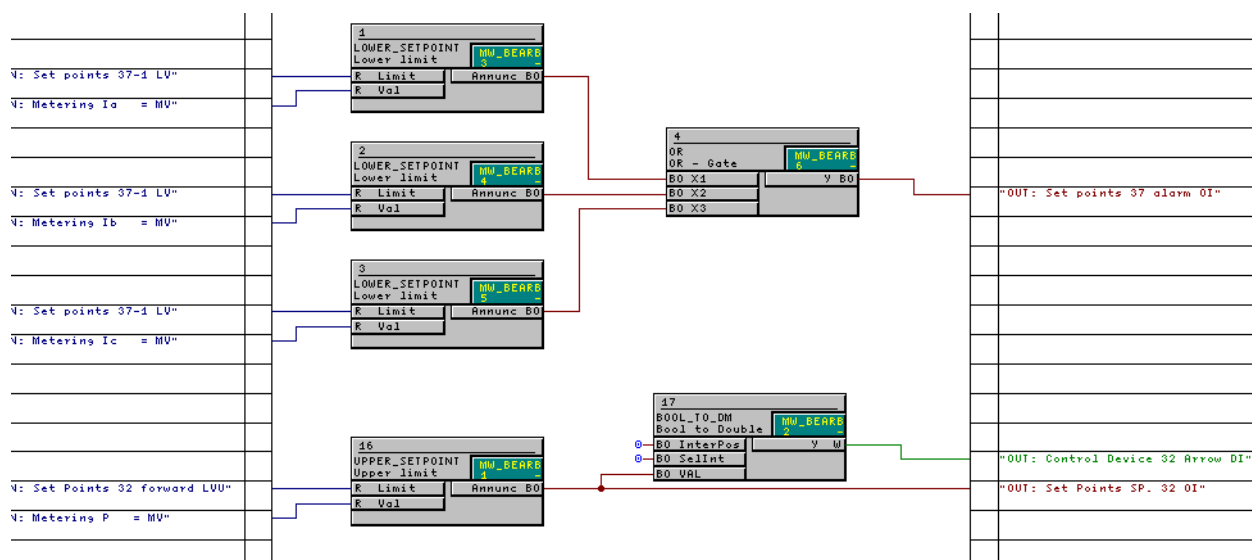
Figure 4-20   CFC Logic, example

4.10   Power System Data

Power System Data 1

In the window for Power System Data 1, important settings are entered that relate to the power system and primary equipment connected to the device. The settings include:

❏ Power system data such as frequency, voltage, etc.

❏ Data for the main current transformers and voltage transformers,

❏ Circuit breaker or primary switchgear information, including a current threshold setting that is used to indicate the open/close position of the primary equipment in several protection functions.
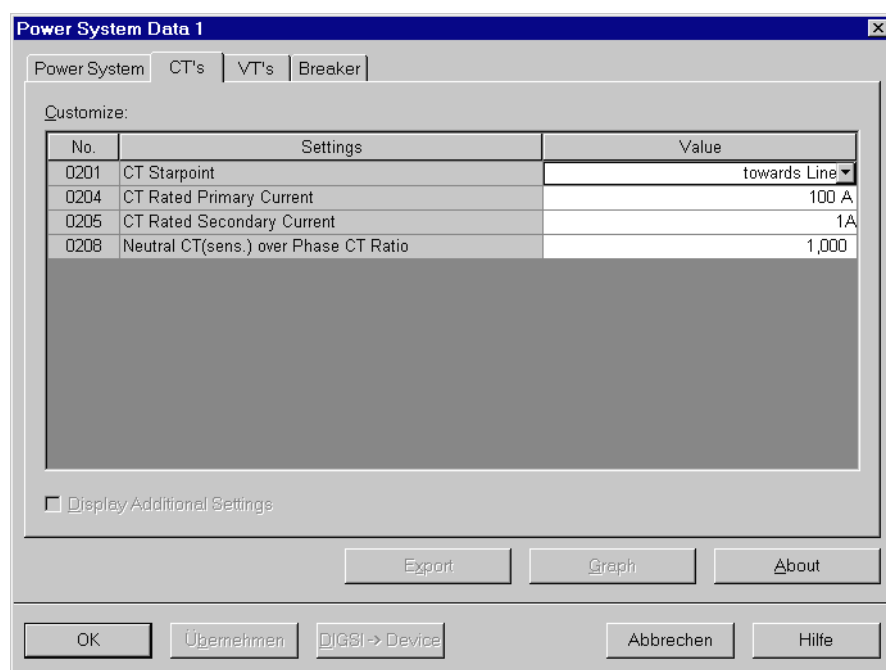
Figure 4-21   DIGSI® 4 Window for Setting the Power System Data 1, example

Power System Data 2

Power System Data 2 are part of the setting groups, which can be switched over during operation (see chapter 4.11). These include for example:

❏ Primary Operating Voltage

❏ Primary Operating Current

❏ Characteristic Data of the protected object etc.

4.11   Setting Groups

A SIPROTEC® 4 device has four setting groups A through D. The setting options for each group are the same; however, the applied settings can be, and are typically intended to be, different in each group. The active setting group can easily be changed while the device is in-service. A major advantage of multiple setting groups is the capability of optimizing the protection and control for the existing configuration of the network being protected. In other words, the protection and control can be changed as the network changes.

The setting groups are saved in the device. The setting groups can be changed during operation using DIGSI® 4, from the HMI on the device, by triggering binary inputs, or via the system interface.

k4114.gif
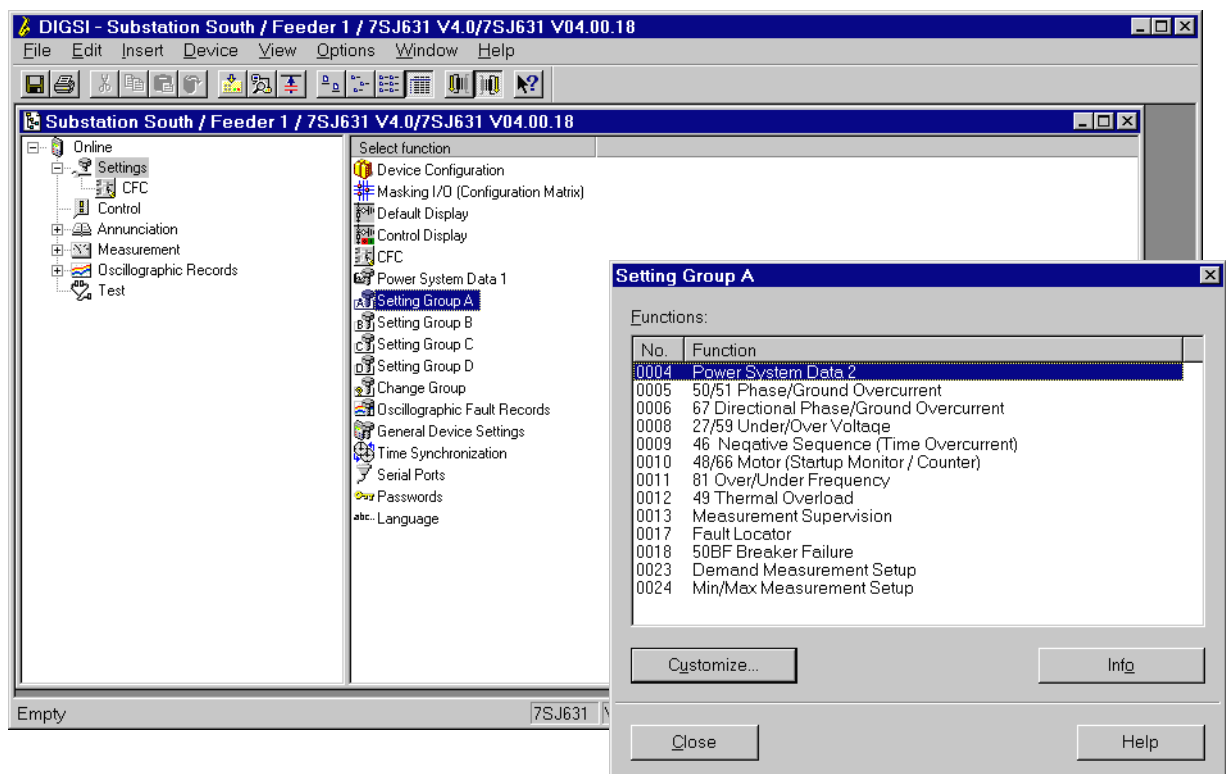
Figure 4-22   DIGSI® 4, Entering Settings in Setting Group A; Other Groups are Similar

Note:

Settings that are common to all protective functions, such as Device Configuration and Power System Data 1, cannot be dynamically activated like the settings in Groups A through D.

Settings   Double click on a protective function shown in the smaller window of Figure 4-22 to obtain a window for entering the general settings associated with the function and the settings of the protective elements belonging to the function.
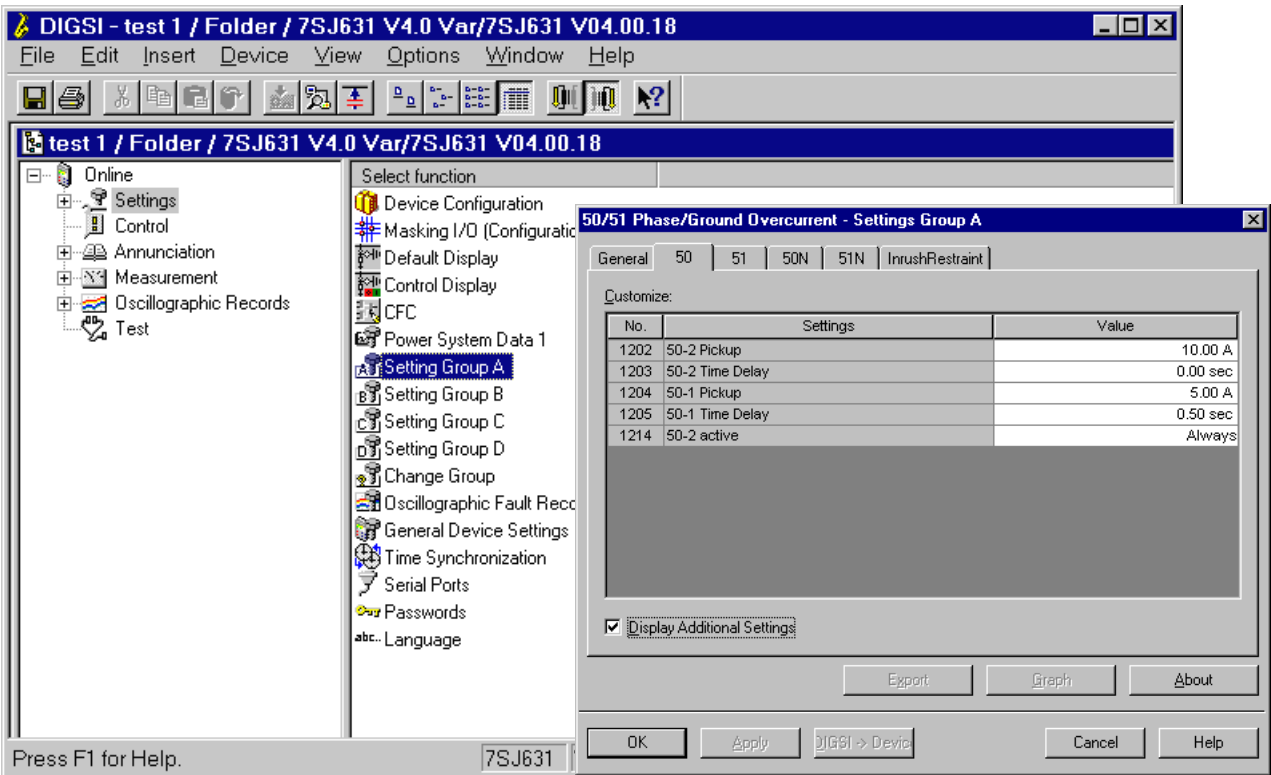
Figure 4-23   DIGSI® 4, Entering Settings for a Protective Function, example

Changing Setting Groups   The setting groups can be changed during operation using DIGSI® 4, from the HMI on the device, by triggering binary inputs, or via the system interface. The active setting group is indicated.
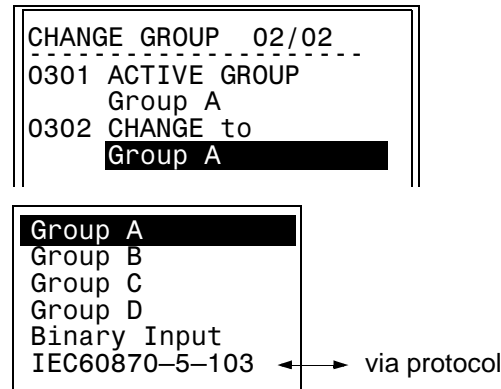
Figure 4-24   SIPROTEC® 4 Device, Changing Setting Groups on the HMI

4.12   General Device Settings

The settings of the display to show information of network faults on the LEDs and the LCD on the front of the SIPROTEC® 4 device are defined in the DIGSI® 4 window shown below.

k4123.gif
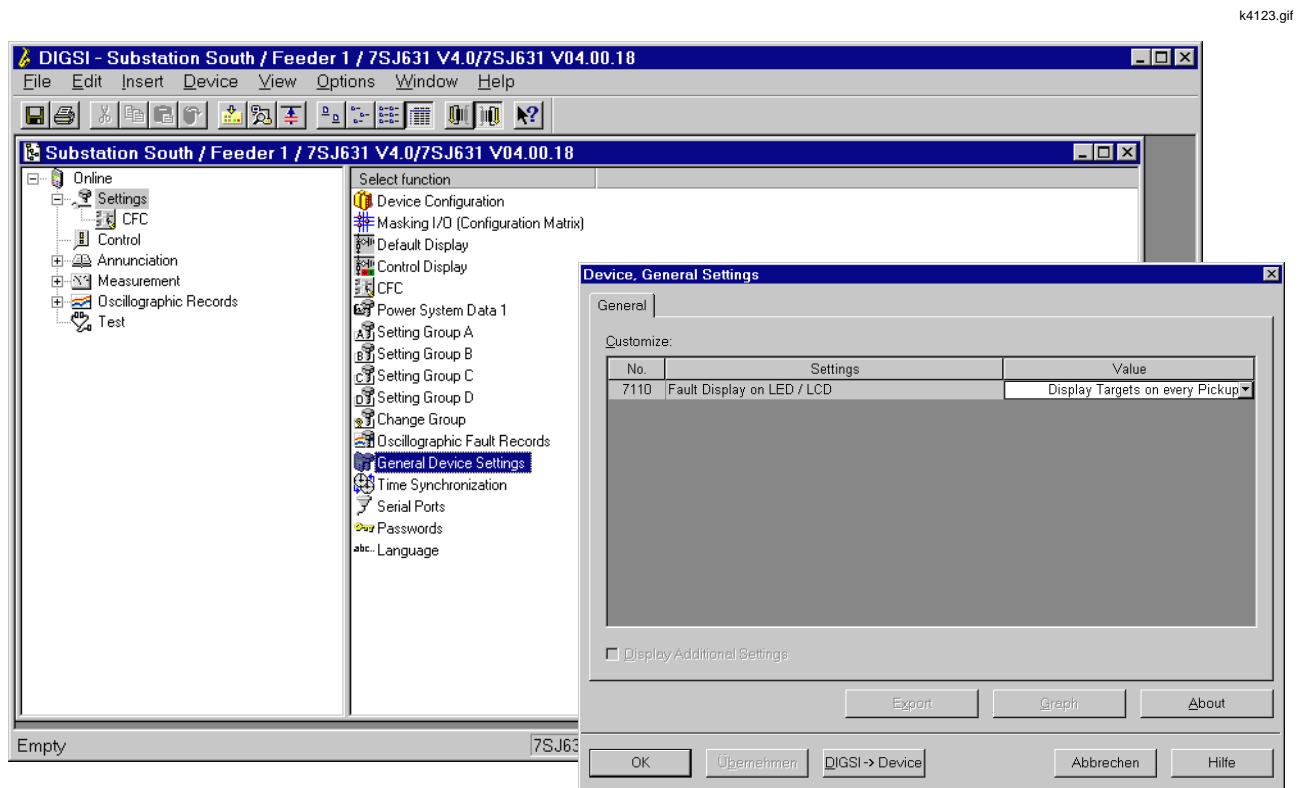
Figure 4-25   DIGSI® 4, General Device Settings (Targets), example

The setting can also be changed at any time using the HMI on the SIPROTEC® 4 device: `Main Menu` → `Settings` → `Device`.

4.13   Time Synchronization

Time tracking in a SIPROTEC® 4 device can be implemented using:

❑ DCF77 Radio Receiver (Time Signal from PTB Braunschweig),

❑ IRIG-B Radio Receiver (Time Signal from the global positioning satellite (GPS) system),

❑ Signals via the system interface from SCADA, for example,

❑ Radio clock using a system-specific synchronizer box,

❑ Minute impulses on a binary input.

Time signal generators are connected via a 9-pin D-subminiature port on the back panel of the device.

Setting of the time synchronization is done exclusively with DIGSI® 4:

• Double click on **Time Synchronization** in the data window and enter the settings.
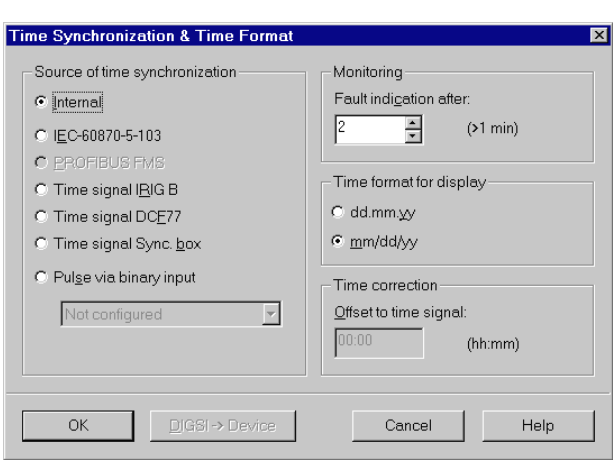
ka455.gif

Figure 4-26   DIGSI® 4 Setting of the Time Synchronization, example

Readout in the HMI

Using the SIPROTEC® 4 device HMI, the time synchronization settings can be checked: **Main Menu → Settings → Setup/Extras → Clock Setup**.
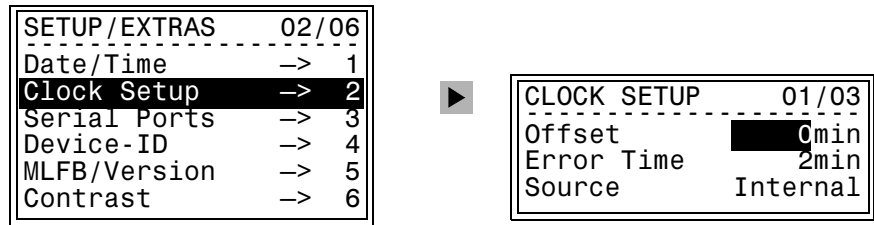
Figure 4-27   Readout of Time Synchronization Settings from the HMI

4.14   Serial Interfaces

Devices in the SIPROTEC® 4 family can be equipped with up to three serial interfaces and a time.

❑ The system interface on the back panel of the device is used for connection to a SCADA, such as SICAM SC,

❑ The time control interface on the back panel of the device is used for time synchronization (e.g. IRIG B),

❑ The service interface (DIGSI® 4, Modem) on the back panel is for connection to remote diagnostic facilities, e.g. DIGSI® 4 via modem and/or a star connection. All DIGSI® 4 operations are possible via this interface,

❑ The PC-interface at front is used for on-site connection of a PC, on which DIGSI® 4 is installed. All operations that are possible using DIGSI® 4 can be done at this interface.

In the DIGSI® 4 Interface Settings window (under Serial Ports) there are, among other items, settings for:

❑ Transmission protocols and

❑ Transmission speeds.

Note:

The service (DIGSI® 4, Modem) and system interface (SCADA) can be equipped with different modules for connection to other devices via optical fibers or an RS 232/485 bus.

To set the framing and baud rate:

- Double click on **Serial Ports** in the data window and enter the specific settings in the window that follows.
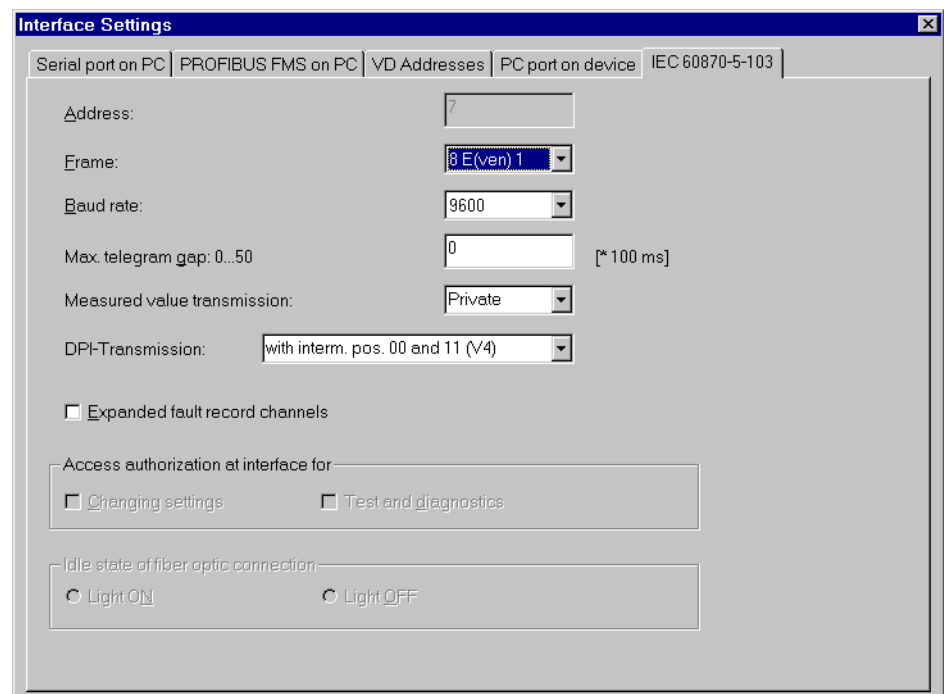
Figure 4-28   DIGSI® 4, Interface Settings Window

Readout in the HMI

The interface settings can be checked using the SIPROTEC® 4 device HMI.

In the main menu, select **Settings** → **Setup/Extras** → **Serial Ports** → following menus.
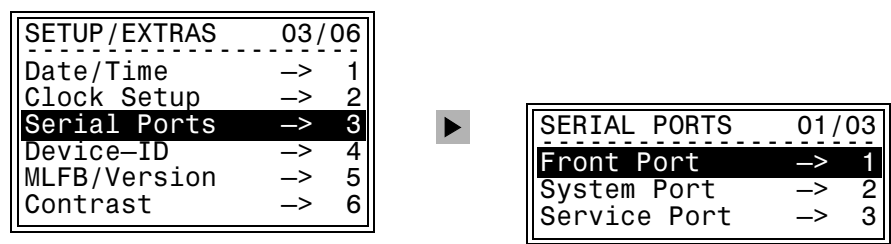
Figure 4-29   Readout of Serial Interface Settings from the HMI, example

Note:

The interface for connecting a time control device is described in the Sub-section 4.14, Time Synchronization.

4.15 Passwords

Passwords are assigned to a SIPROTEC® 4 device to protect against unintended changes to the device or unauthorized operations from the device, such as control.

The following access levels are defined at the factory:

❑ Switching/tagging/manual overwrite,

❑ Non-interlocked switching,

❑ Test and diagnostics,

❑ Hardware test menus,

❑ Individual settings,

❑ Setting Groups.
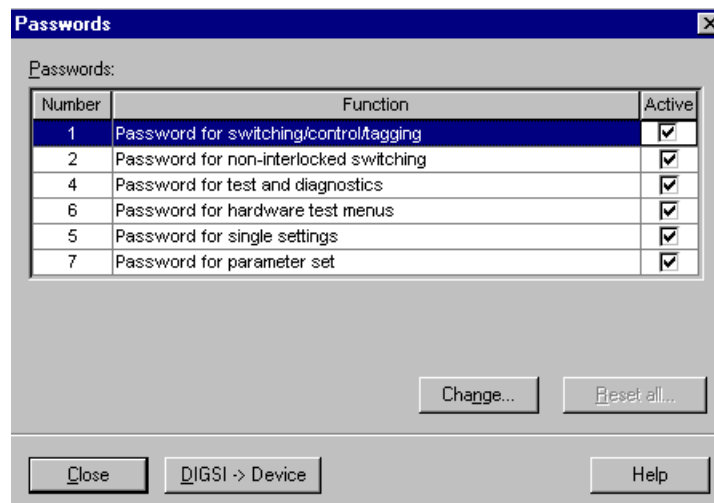
ka458.gif

Figure 4-30 DIGSI® 4, Window Indicating the Active Passwords, example

When using DIGSI® 4 or the HMI on the SIPROTEC® 4 device, a password is requested for the specific function.

Note:

Password protection against unauthorized access is only in place during on-line operation. The passwords for setting changes are first activated when the settings are loaded into the device. The passwords are irrelevant in the DIGSI® 4 off-line mode.

To deactivate a password, the password must be known.

Passwords can only be changed using DIGSI® 4.

To change an existing password:

- In the Passwords window shown in Figure 4-30, double click on the password to be changed. In the next window (Figure 4-31), enter the present password, the new password, and confirm with the new password again and **OK**.

k4119.gif

Figure 4-31   DIGSI® 4, Changing Passwords

Passwords are numbers up to 8 digits.

At delivery all passwords are set to 000000.

Note:

If the password for setting group switching has been forgotten, a temporary password can be received from Siemens. The temporary password can be used to define a new password for this function.

The registration number of the DIGSI® 4 software package will be required to receive the temporary password.

■

Configuration

5

Configuration is the process of customizing the relay for the intended application.

To accomplish this, the following questions must be answered:

- Which functions are needed?
- Which data and measured quantities need to be retrieved via which inputs?
- Which control actions need to be issued via which outputs?
- Which user-definable functions need to be performed in CFC (Continuous Function Chart)?
- What should the displays look like?
- Which interfaces are to be used?
- Which time source is to be used to synchronize the internal clock?

This chapter describes in details how to configure the 7SJ61.

5.1 Configuration of Functions

General

The 7SJ61 relay contains a series of selectable protection functions as well as many other functions, based on the options purchased. The first step in configuring the relay is to determine which functions are required.

Example for the configuration of functional scope:

A protected system consists of overhead and underground feeders. Since automatic reclosing is only needed for the overhead feeders, the automatic reclosing function is not configured or "Disabled" for the relays protecting the underground feeders.

The available functions must be configured as ***enabled*** or ***disabled***. For individual functions, the choice between several alternatives may be presented, as described below.

Functions configured as ***disabled*** are not processed by the 7SJ61. There are no messages, and corresponding settings (functions, limit values) are not displayed during detailed settings.

Note:

Available functions and default settings are depending on the ordering code of the relay (see table 6-1 and ordering code in the appendix for details).

Determination of Functional Scope

Configuration settings must be entered using a PC and the software program DIGSI® 4 and tranferred via the front serial port, or via the rear DIGSI® 4 serial port interface. Operation via DIGSI® 4 is described in Chapter 4 as well as in the DIGSI® 4 manual, order number E50417-H1176-C097.

Entry of password No. 7 (for setting modification) is required to modify configuration settings (see Section 4). Without the password, the settings may be read, but may not be modified and transmitted to the device.

The functional scope with the available alternatives is set in the **Device Configuration** dialog box (see Figure 5-1) to match equipment requirements. To change a function, click on the corresponding line under **Scope**, and select the desired option in the list which appears. The drop-down menu closes automatically upon selection of an item.
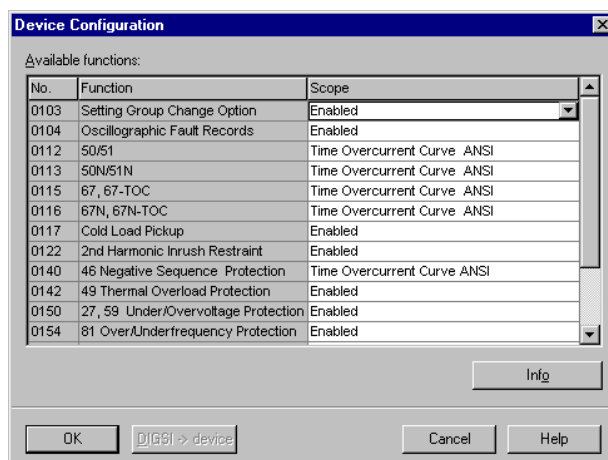
Figure 5-1   **Device Configuration** Dialog Box in (example) DIGSI® 4

Before closing the dialog box, transfer the modified functional setting to the relay by clicking on the item **DIGSI → Device**. The data is stored in the relay in a Non-Volatile Memory Buffer.

The configured functional scope can be *viewed* from the front display of the relay itself, but cannot be modified. The settings associated with the functional scope can be found in the **MAIN MENU** under → **Settings** → **Device Config**.

Special Character-istics

If use of the setting group change function is desired, address 0103 should be set to *Enabled*. In this case, up to four different groups of settings (see Chapter 6) may be entered quickly and easily during device operation. Only one setting group may be selected and used if the setting is *Disabled*.

For the relay elements associated with non-directional overcurrent protection (both phase and ground), various tripping characteristics may be selected at the addresses 0112 (phase) and 0113 (ground). If only the definite time characteristic is desired, then *Definite Time only* should be selected. Additionally, depending on the relay model ordered, various inverse time characteristics are available (based on either IEC standards or ANSI standards), or user defined characteristics may be specified. A user defined characteristic can include both a tripping and a reset characteristic. Non-directional overcurrent protection may be defeated during configuration by selecting *Disabled*.

For sensitive ground fault protection, address 0131 is used to specify whether the function should be disabled, enabled with definite time tripping characteristics only, or enabled with a user defined inverse time characteristic.

For negative sequence protection, address 0140 is used to specify whether the function should be disabled, enabled with definite time tripping characteristics only, or enabled with an ANSI inverse time characteristic.

For trip circuit monitoring, address 0182 **74 Trip Ct Supv** is used to specify whether two binary inputs should be utilized, one binary input should be utilized, or the function should be disabled.

Adr.	Setting	Setting Options	Default Setting	Explanation
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting group switching (A, B, C, D)
104	OSC. FAULT REC.	Disabled Enabled	Disabled	Waveform capture
112	Charac. Phase	Disabled Definite Time only Time Overcurrent Curve IEC Time Overcurrent Curve ANSI User Defined Pickup Curve User def. Reset	Definite Time only	Determines if definite-time (50) and inverse-time (51) elements are enabled, and the general characteristics available for 51. Selection of 51 automatically enables 50.
113	Charac. Ground	Disabled Definite Time only Time Overcurrent Curve IEC Time Overcurrent Curve ANSI User Defined Pickup Curve User def. Reset	Definite Time only	Determines if definite-time (50N) and inverse-time (51N) elements are enabled, and the general characteristics available for 51N. Selection of 51N automatically enables 50N.
117	Coldload Pickup	Disabled Enabled	Disabled	Dynamic cold load setting adjustments
122	InrushRestraint	Disabled Enabled	Disabled	Inrush restraint (stabilization) of phase and ground 50/51/67
131	Sens. Gnd Fault	Disabled Definite Time only User Defined Pickup Curve	Disabled	Sensitive ground fault detection. Similar to Addresses 112 through 116.
140	46	Disabled Definite Time only Time Overcurrent Curve ANSI Time Overcurrent Curve IEC	Disabled	Negative-sequence current protection. Similar to Addresses 112 through 116.
141	48	Disabled Enabled	Disabled	Starting time monitoring for motors
142	49	Disabled Enabled	Disabled	Thermal overload protection
143	66 #of Starts	Disabled Enabled	Disabled	Start inhibit for motors
170	50BF	Disabled Enabled	Disabled	Breaker failure protection
171	79 Auto Recl.	Disabled Enabled	Disabled	Automatic reclosing
182	74 Trip Ct Supv	Disabled with 2 Binary Inputs with 1 Binary Input	Disabled	Trip circuit (e.g. breaker) monitoring and method - using one binary input or two.

5.2   Configuration of Information, Meaured Values, and Commands

General   Upon delivery, the displays on the front panel of the relay, some of the function keys, the binary inputs, and the output contacts are configured to receive information. These configurations may be modified to meet your specific requirements.

During configuration, certain information within the relay is automatically configured to certain physical interfaces (e.g., binary inputs and output contacts) or logical interfaces (e.g., user-defined logic, CFC).

It must be determined *which information* should be linked *with which* device *interface*. It must also be determined which characteristics the information and the interfaces should have .

Messages and statistical values from earlier events can be lost during configuration; therefore, data from the trip log, event log, and statistic counters should be read and saved if desired, prior to changing the configuration.

5.2.1   Preparation

Before configuration is started, the overall interfacing requirements must be assessed. The required inputs and outputs must be compared with the number of physical inputs and outputs present on the relay. The types of indications and commands, and their requirements, should be taken into account.

Indications   Some indications may be device information regarding events and conditions, which can be transmitted via output contacts (e.g. startup of the processor system). These are known as **output indications**. Indications also include information from the protected equipment to the relay regarding equipment status and conditions (e.g. position or condition of a circuit breaker). These are known as **input indications.**

Depending on the type, indications may be further classified. Figures 5-2 and 5-3 show typical indication types schematically. Two binary inputs whose normal conditions are opposite, and which are monitored by the relay, are required for a double point indication.
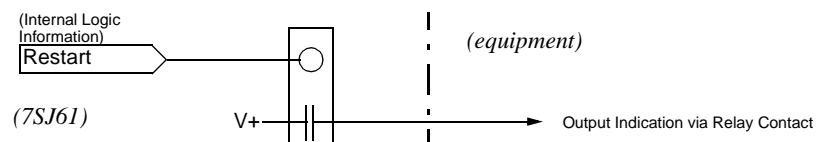
Figure 5-2   Output Indication (OUT)
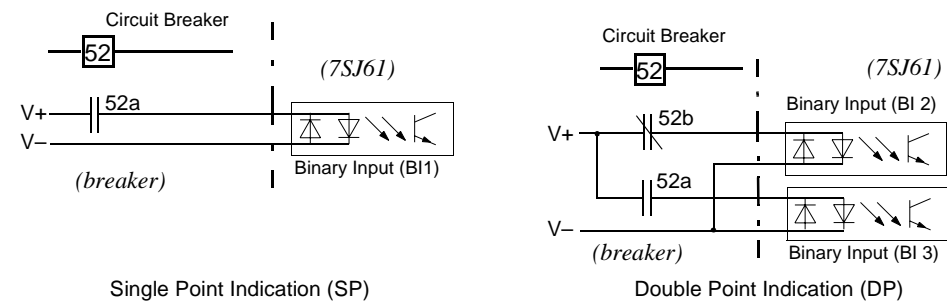
Figure 5-3   Input Indications (SP & DP)

Commands

Commands (control actions) are output indications which are specially configured for the transmission of control signals to switching devices (circuit breakers, etc.).

❑ For each device to be controlled, determine if switching is to be done with 1 contact, $1^1/_2$ contacts (single contact and common), or 2 contacts; with a single or double command; and with or without feedback signals. See Table 5-1 and Figures 5-4 to 5-9. The information to be processed and the command type are determined with these decisions.

❑ Assign the necessary binary inputs and outputs in the SIPROTEC® device to the specific function. Important to note are:

– Messages and commands associated with a switching device must always occupy sequential binary inputs and outputs in the SIPROTEC® device;

– The TRIP (OFF)–command is always configured prior to the associated CLOSE (ON)–command;

– Limitations may arise because of the commoning of some binary inputs and outputs in the SIPROTEC® device.

When the types of commands have been established, DIGSI® 4 reserves a corresponding number of relay outputs contacts. For this, the corresponding output contacts are numbered consecutively. This must be observed when wiring the relays to the corresponding equipment to be controlled.

Table 5-1 shows the most important command types. They are made available as options in the Configuration Matrix for the SIPROTEC® device (see also "Binary Outputs for Switching Devices" in Sub-section 5.2.4). All double commands, with and without feedback indications, are also available as transformer step commands. The following Figures 5-4 through 5-9 show time diagrams, control settings, and the sequence of relay positioning in the configuration matrix for frequently used command types.

Table 5-1   Most Important Command Types

Single **C**ommand with Single Output	With 1 contact	without feedback with **f**eedback	**C_S** **CF_S**
Double **C**ommand with Single Outputs	With **2** contacts	without feedback with **f**eedback	**C_D2** **CF_D2**
Double **C**ommand with Single Outputs plus Common Output	With **3** contacts	without feedback with **f**eedback	**C_D3** **CF_D3**

Table 5-1   Most Important Command Types

Double **C**ommand with Single Outputs and Common Bus Output	Minimum 3 contacts	without feedback with **f**eedback	**C_D2** **CF_D2**
Double **C**ommand with Double Outputs	With **4** contacts	without feedback with **f**eedback	**C_D4** **CF_D4**
Double **C**ommand with Double (Close) and Single (Trip) Outputs	With 3 contacts	without feedback with **f**eedback	**C_D12** **CF_D12**

For double commands, the first output relay is selected using DIGSI® 4. The other output relays will automatically be selected by DIGSI® 4. In the sequence of output relays, **each TRIP command is placed before the associated CLOSE command**. For commands with processing of feedback indications, DIGSI® 4 reserves a line in the configuration matrix for the switching device feedback indications. **The 52b contact must be placed before the 52a contact**.

For Figures 5-4 through 5-9, the following abbreviations apply:

− C+   Relay Contact for Closing
− C−   Relay Contact Tripping
− CC   Relay Contact is Common
− CCC   Relay Contact is Common to a Bus
− V+, V−   Control Voltage
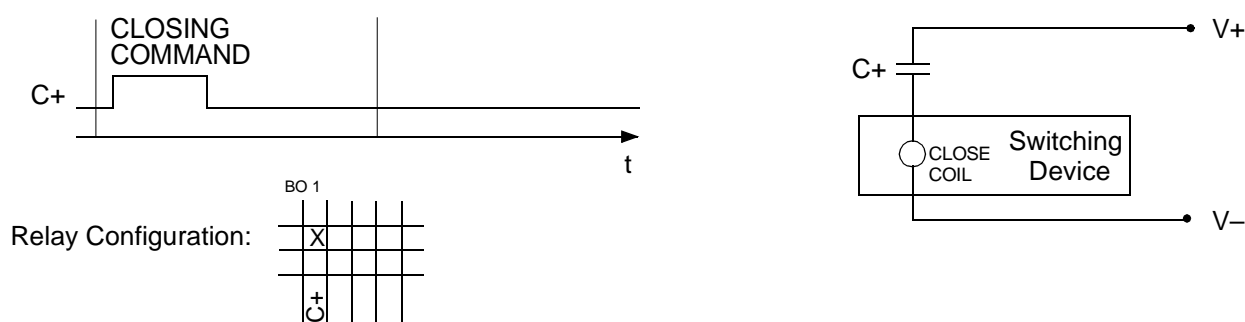
Figure 5-4   Single Command with Single Output
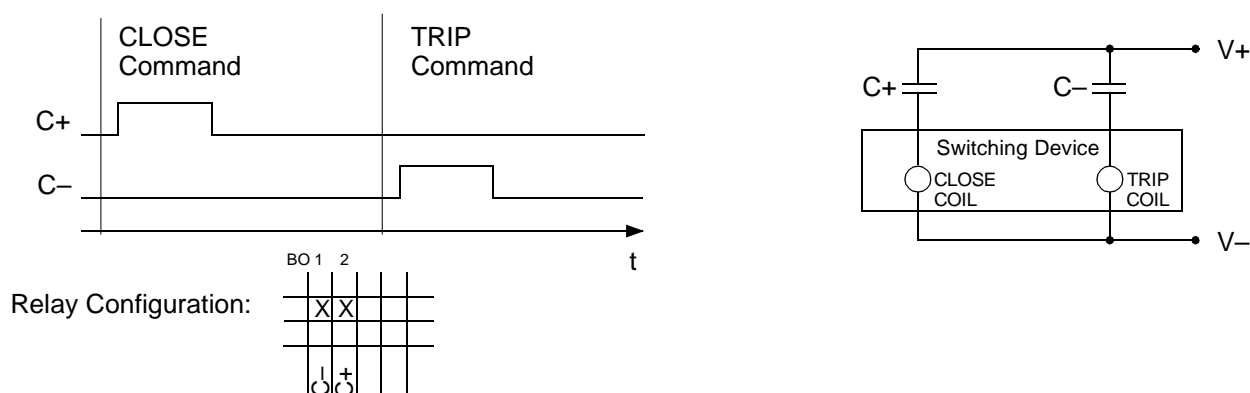
Figure 5-5   Double Command with Single Contacts
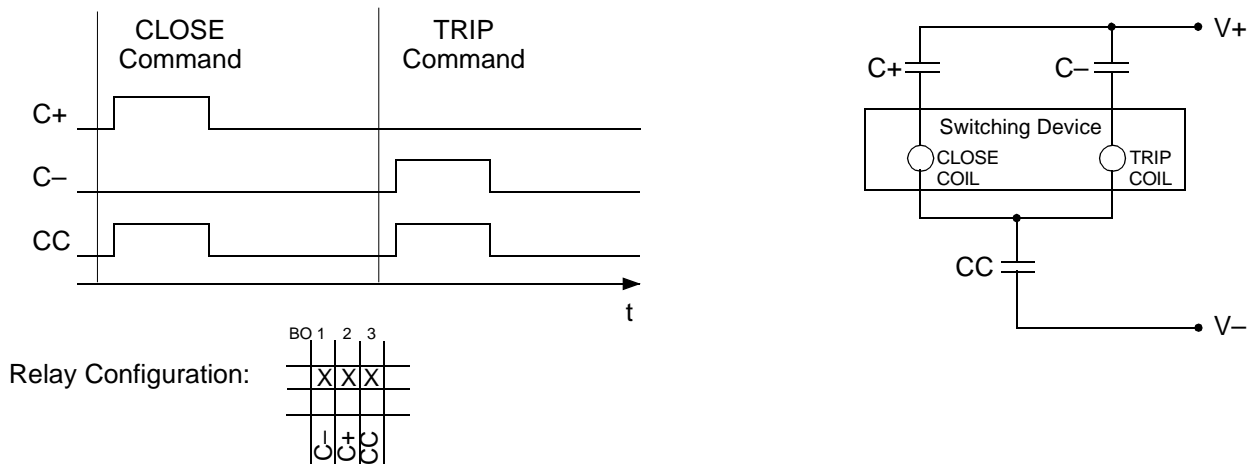
Figure 5-6   Double Command with Single Contacts plus Common Contact
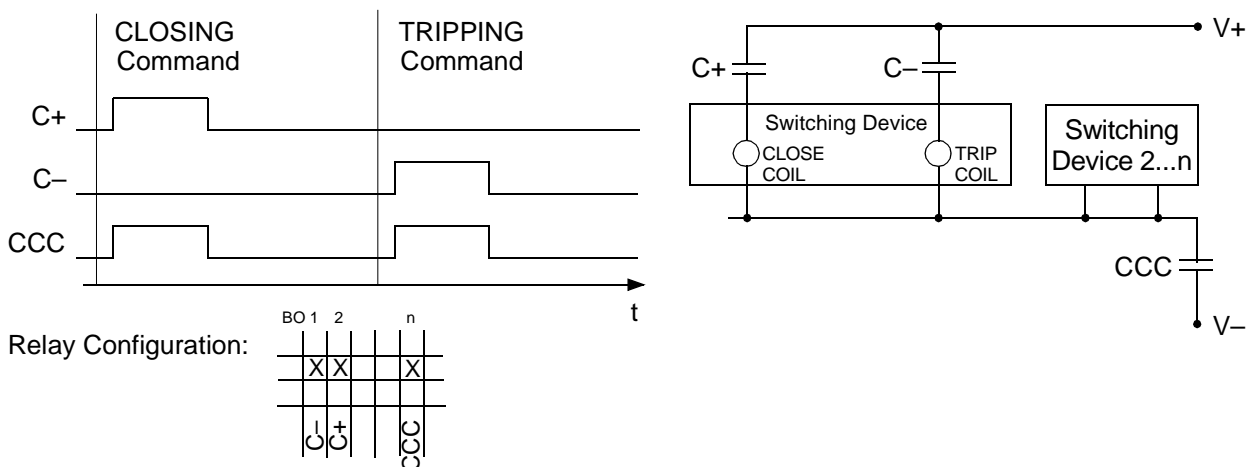
Figure 5-7   Double Command on Common Bus with Single Contacts and Common Contact

Figure 5-7 shows the common output relay with several switching devices, in contrast to all other output relays. Simultaneous control of multiple switching devices is blocked, for safety reasons.

The common output relay automatically acquires the characteristics of the controlling relay upon issuing of a command to a switching device and, therefore, is not individually configured. The final command output is via a single contact.
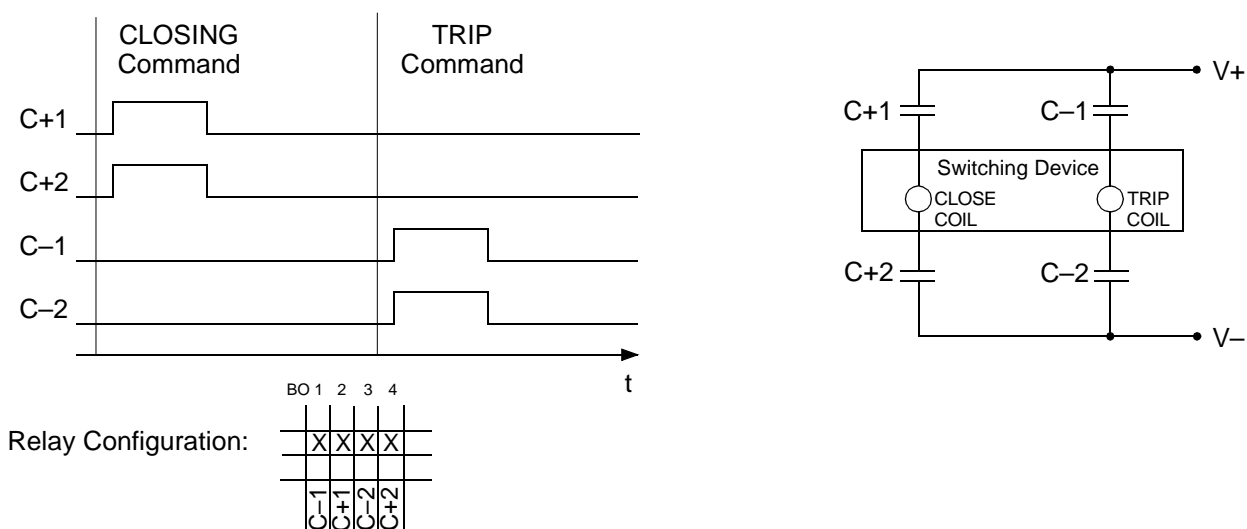
Figure 5-8   Double Command with Double Contacts (with 4 Relays)
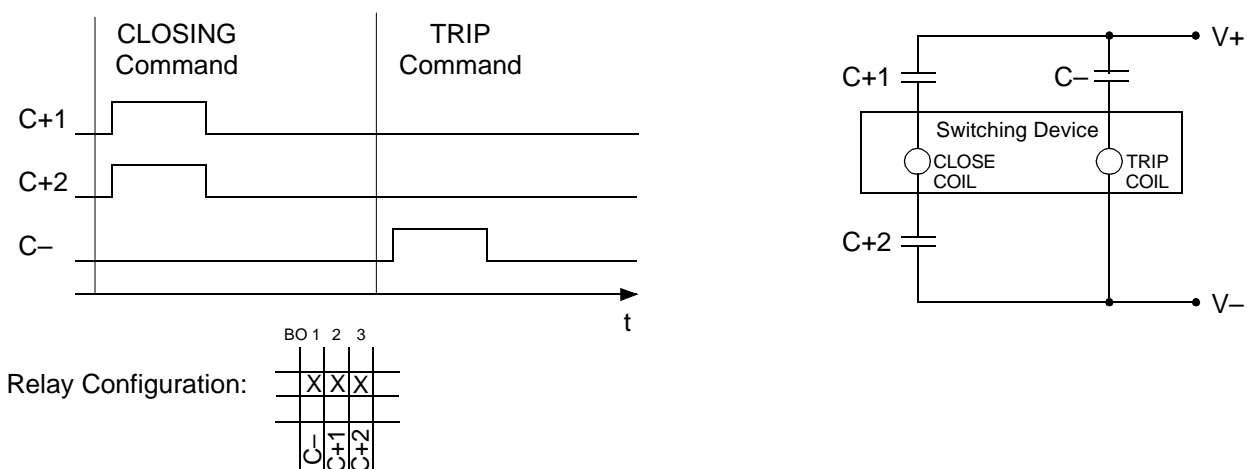
Figure 5-9   Double Command with Double and Single Contacts (with 3 Ralays)

Note:

It is recommended to mask Trip and Close commands from a protection function the same binary I/O's, if they operate the same breaker. If for instance, the Close command of the Control function uses two contacts the auto reclose function should be masked also to both contacts. See elementary diagrams in the appendix A.

5.2.2   Structure and Operation of the Configuration Matrix

General

This section deals with the structure and operation of the configuration matrix. The configuration matrix can be viewed without making any configuration changes. Information characteristics and configuration steps are described in Section 5.2.3, and configuration is demonstrated in Section 5.2.4.

Configuration of information is performed, using a PC and the DIGSI® 4 software program, via the operator or service interface. The configuration is represented in DIGSI® 4 as a matrix (Figure 5-10). Each row is assigned to relay information. It is identified by a function number, brief text (display text), an explanation (long text, minimized in Figure 5-10), and an information type. The columns give the interfaces which are the sources and/or destinations of the information. In addition to physical device inputs and outputs, there may be internal interfaces for user definable logic (CFC), message buffers, or the device display.

Figure 5-10   Extract from the Configuration Matrix in the DIGSI® 4 Software — Example

Information in the rows is assigned to appropriate interfaces in the columns via an entry in the intersecting cell. This establishes which information controls which destination, or from which source information is received.

In the configuration matrix, not only the configuration is shown, but also the type of configuration. For example, information regarding an event which is configured for display on a LED may be latched or unlatched.

The possible combinations of information and interfaces is dependent on the information type. Impossible combinations are mostly filtered out by DIGSI® 4 plausibility checks.

The matrix columns are divided into three types: Information, Source, and Destination. To the left of the matrix, information is divided into information groups.

Reducing the Matrix

The matrix may become very extensive because of the amount of information contained within. Therefore, it is useful to limit the display (via filtering) to certain information, thus reducing the number of rows.

The toolbar below the menu line contains two pull-down menus by which information may be filtered. Using the first menu, the rows can be limited to indications, commands, indications and commands, or measured and metered values. The second menu allows display of configured information, information configured to physical inputs and outputs, or non-configured information.

A further reduction in the number of rows is possible, by compressing an information group to one row. This is done by double-clicking on the group label area (located to the far left). If this is done, the number of rows is reduced, allowing the user to focus on the information group of interest. A second double-click restores all rows in the information group.

To limit the width of the matrix, the tool bar may be used to switch between standard view and short view, thus modifying the display under the **Source** and **Destination** title blocks. The columns associated with the **Information** block remain unchanged.

In standard view, *all* binary inputs, binary outputs, and LEDs are accessible, as shown in Figure 5-10 for the binary outputs and LEDs.

In short view, three common columns are displayed: one for binary inputs, one for binary outputs, and one for LEDs. Within the individual cells of a common column, information regarding the configuration type is available in the form of abbreviations. For example, the abbreviation H1 in a cell of the common binary input (BI) column shows the corresponding information is configured with active voltage (High) to binary input 1. If one information unit (indication, etc.) is configured to several destinations (binary outputs, etc.), the abbreviations of all destinations are shown, separated by commas. If there is not enough room in the cell for the simultaneous display of all abbreviations, a double-click on the cell and movement of the text cursor within the cell will show the entire contents of the cell.

To switch between standard view and short view, the menu item **View** can also be used.

The width of the matrix can also be reduced by hiding the contents of a row or column. For example, In Figure 5-10, long text (**L**) under **Information**, and the binary inputs (**BI**) under **Source**, are not shown. By double-clicking on long text field (**L**), the long text becomes visible; by double-clicking on binary input field (**BI**), the binary inputs become visible, and vice versa.

Information Groups

All information is organized into information groups. In addition to general relay information, information regarding individual relay functions is also included.

By clicking on an information group title area with the *right* mouse button, a context menu can be viewed, which contains information regarding the properties of that infor-

mation group. This is particularly useful if the information group is associated with a function that contains settings.

If the information group belongs to a protective function for the relay, a dialog window can be accessed in which the settings of the protective function may be modified. The procedure for entering settings of a protective function is described in general in Chapter 4. Details regarding the settings for various functions are found in Chapter 6.

The settings group to be processed may be selected via the menu item **View** → **Setting Group**.

Information
The column header **Information** comprises the function number, the brief text (display text), an explanation (long text), and the information type. The following abbreviations are used for the information types:

- Messages:
  - **SP**   **S**ingle **P**oint Indication
  - **DP**   **D**ouble **P**oint Indication
  - **OUT**   **Out**put Indication
  - **IntSP**   **Int**ernal **S**ingle **P**oint Indication
  - **IntDP**   **Int**ernal **D**ouble **P**oint Indication
  - **TxTap**   **T**ransformer **Tap** Changer
  - **Ev**   **Ev**ent

- Commands:
  - **C_S**   **S**ingle **C**ommand with Single Output without feedback
  - **CF_S**   **S**ingle **C**ommand with Single Output with **f**eedback
  - **C_SN**   **S**ingle **C**ommand with Single Output **N**egated without feedback
  - **CF_SN**   **S**ingle **C**ommand with Single Output **N**egated with **f**eedback
  - **C_D2**   **D**ouble **C**ommand (**2** relays) with Single Outputs without feedback
  - **CF_D2**   **D**ouble **C**ommand (**2** relays) with Single Outputs with **f**eedback
  - **C_D12**   **D**ouble **C**ommand with Single Trip Outputs and Double Close Outputs without feedback
  - **CF_D12**   **D**ouble **C**ommand with Single Trip Outputs and Double Close Outputs with **f**eedback
  - **C_D3**   **D**ouble **C**ommand (**3** relays) with Single Outputs and Common Output without feedback
  - **CF_D3**   **D**ouble **C**ommand (**3** relays) with Single Outputs and Common Output with **f**eedback
  - **C_D4**   **D**ouble **C**ommand (**4** relays) with Double Outputs without feedback
  - **CF_D4**   **D**ouble **C**ommand (**4** relays) with Double Outputs with **f**eedback
  - **C_D2N**   **D**ouble **C**ommand (**2** relays) with Single Outputs **N**egated without feedback
  - **CF_D2N**   **D**ouble **C**ommand (**2** relays) with Single Outputs **N**egated with **f**eedback

- Measured Values:
  - **MV**   **M**easured **V**alue
  - **MVU**   **M**easured **V**alue, **U**ser Defined
  - **MVT**   **M**easured **V**alue with **t**ime
  - **LV**   **L**imit **V**alue
  - **LVU**   **L**imit **V**alue, **U**ser Defined

- Metered Values:
  - **PMV**   **P**ulse **M**etered **V**alue

The information contains various properties depending on the information type, which are partially fixed and may be partially influenced.

Source

The source indicates the origin of the information which the device receives for further processing. Possible sources are:
- **BI**   **B**inary **i**nput
- **F**   **F**unction key, which may serve to introduce a control action
- **CFC**   **CFC**, i.e., message comes from user-definable logic

Destination

The destination indicates to which interface the information is forwarded. Possible destinations are:
- **BO**   **B**inary **o**utput
- **LED**   **LED** display on the device front panel
- **Buffer E**   **E**vent buffer in the device
- **Buffer S**   **S**ensitive Ground fault buffer in the device (if present)
- **Buffer T**   **T**rip Log buffer in the device
- **S**   **S**CADA interface
- **C**   **CFC**, information is processed by CFC program of the user-definable logic
- **Di C**   Control display, if information is to be displayed in the **c**ontrol **dis**play of the **d**evice
- **Di D**   Default display, if information is to be displayed in the **d**efault **dis**play of the device
- **CM**   **C**ontrol of switching devices, if a switching object should be controlled from **c**ontrol **display/menue** of the device

For additional information please refer to appendix A.7.

5.2.3   Establishing Information Properties

General

Different types of information contain different types of properties. To view the properties associated with a specific information unit (indication, command, etc.), the user should position the mouse on the specific row associated with that **Information** unit, and then use the *right* mouse button to access a menu where **Properties** can be selected.

For example, if the cursor is positioned on a specific output indication, the *right* mouse button is pressed, and the menu item **Properties** is selected, then a choice of whether the indication should appear in the oscillographic fault record (Figures 5-11,

5-12, and 5-13) is presented. For internal single point indications, the default status of the indication (on, off, or undefined) after device reset can be selected as well (Figure 5-12).

Output Indication (OUT)

Figure 5-11   Information Properties Example for the Information Type "Output Indication" (OUT)

Internal Single Point Indication (IntSP)

Figure 5-12   Information Properties Example for the Information Type "Internal Single Point Indication" (IntSP)

Singe Point Indication (SP)

Figure 5-13   Information Properties Example for Information Type "Single Point Indication" (SP)

Double Point Indication (DP)

In addition to the properties entered for single point indications, a "Suppress intermediate position" check box is available, which may be checked to suppress the intermediate indication during operations. If this field is marked, then the filter time, which can also be set (see "Filtering/Contact Chatter Suppression" below), is only effective for the intermediate (= undefined position) indication. Hence, briefly undefined conditions during contact chattering will not lead to a fault message; however, defined changes in the condition (final positions) are immediately reported.
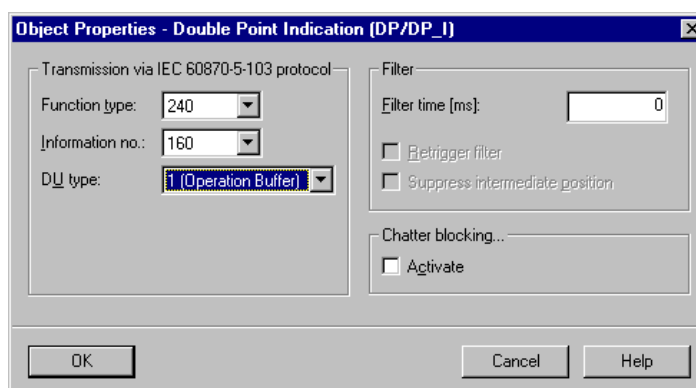
Figure 5-14   Information Properties Example for Information Type "Double Point Indication" (DP)

Filtering / Contact Chatter Suppression

For input indications (single point indications **SP**, double point indications **DP**, or Transformer stage messages **TM**, if present), filter times may be entered (pickup and drop-out delays) to suppress momentary changes in potential at the binary input (e.g. contact chatter). Filtering occurs during an input change of state, with the same setting values whether coming or going. Information is only distributed when the new state continues to exist after a preset time interval (in milliseconds). The setting range is from 0 to 86,400,000 ms, or 24 hours. Whether or not the filter interval is restarted for each change of state during the filtering (filter re-triggering) is selectable.

It is also possible to set chatter suppression for each indication (Figure 5-13). The contact chatter settings, themselves, are set the same for all input indications (see Section 5.2.6).

Transformer Tap Changer (TxTap)

The transformer tap changer position is communicated, via binary inputs, in a specified encoding format (maximum of 62 positions). Only binary inputs that are in direct order with regard to numbering can be used.

For the encoding formats available (binary code, BCD code, "1 of n" code), four settings (number of positions, number of bits, display offset, and position change) may be programmed. Their bit pattern corresponds to an individual transformer tap changer position which is represented in the device display and in the indication buffers (Figure 5-15).
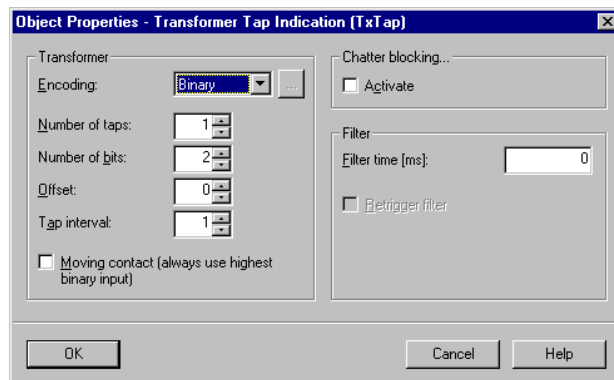
Figure 5-15   Information Properties Example for Information Type "Transformer Tap Changer" (TxTap)

If none of the available encoding formats are selected, each individual tap changer position may be set in a table. The table is accessed after the pull-down menu **Table** for encoding is opened, by selecting the button to the side.

The encoded transformer tap changer position bit pattern is transformed into digital values between 1 and 62. An unrecognized pattern is interpreted as position 63.

The number of bits coincides with the number of the binary inputs to be configured, and limits the number of positions to be represented.

Using the display offset, the beginning of the evaluated bits may have an offset of a programmed number. The stepping of the transfomer taps may be modified, using the tap interval feature (see example).

Example:Four transformer position settings are to be represented by three binary inputs, using the designators 3 through 6. The encoding is binary.

Orientation			Desired representation
BI1	**BI2**	**BI3**	
-	-	-	63.00
X	-	-	3.00
-	X	-	4.00
X	X	-	5.00
-	-	X	6.00
X	-	X	63.00

Using three binary inputs (= 3 bits), a maximum of 2^3 = 8 position settings may be represented in binary code. In order to begin the representation of transformer tap changer positions with the value 3, the display offset is chosen accordingly. The following must be set on the information property window:

Encoding	`Binary`
Number of positions	4
Number of bits	3
Display offset	2
Position change	1

The three binary inputs used for this must have sequential numbers, such as BI 1, BI 2, and BI 3.

Measured Values User Defined (MVU) and Limit Values User Defined (LVU)

For the information type "Measured Values User Defined" (**MVU**), the units, the conversion factor, and the number of significant digits following the decimal point may be specified. For the information type "Limit Values User Defined" (**LVU**), a limit value may be programmed (Figure 5-16).

Figure 5-16   Information Properties Example for Information Type "Limit Value, User Defined" (LVU)

The correlation between input current and a measured magnitude can be set as follows:

If, for example, a under current set point should be established using the CFC logic, and the percentage of the measured current should be matched to a certain amp value, the following values are entered in window according to Figure 5-16:

The **Dimension** is A (amps). The **Conversion Factor** is 150: 150 A corresponds to 100 % input current. The limit value upon startup is set for 120 A.

Metered Values

For metered values, the determination of the polarity (+/−) is determined by the direction of power flow (Figure 5-17). The user may also define the units for pulsed metered values (**PMV**), the conversion factor, and the number of significant digits following the decimal point (Figure 5-17). If the event pulse option is selected, each individual impulse increases the counter by one. If the double current pulse option is selected, then each individual transition (positive or negative) increases the counter by one. If, for example, MVARh is entered as the units and 1000 is entered as the conversion factor, then 1000 impulses will result in a reading of one MVARh.
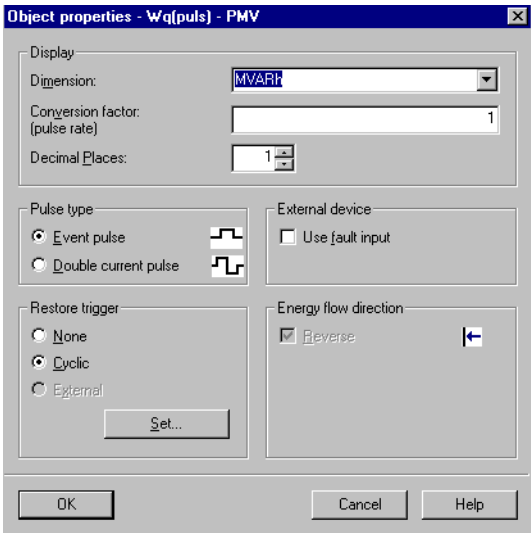
Figure 5-17   Information Properties Example for Information Type "Pulsed Metered Value" (PMV)

Entering Your Own Information

The information included in the configuration matrix is determined by the relay type and the configured functional scope. If necessary, the configuration matrix may include information groups or individual information defined and entered by the user. Such user defined groups and information may be deleted at any time, in contrast to predefined groups and information.

In order to insert a new information group, click on a cell within a group that is next to the location where the new group should be located. After pressing the *right* mouse button, a context menu should appear (Figure 5-18).
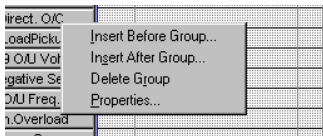
Figure 5-18   Dialog Box to Insert a New Information Group

If one of the first two alternatives is selected, a second dialog window opens, in which the name of the new information group is entered, in brief text and in long text (Figure 5-19). After clicking **OK**, the new group is positioned.
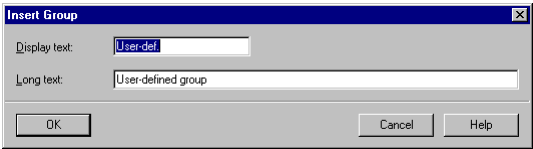
Figure 5-19   Entry of the Name of a User Defined Information Group

Information may be entered into the new information group using the information catalog (Figure 5-20). The information catalog is found in the menu bar under the **View**

option, or via an icon in the toolbar. User information may be entered into both the user defined groups and any other available information group.
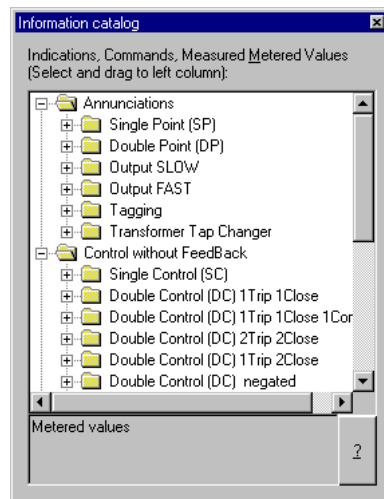
Figure 5-20   Information Catalog Window

The information catalog is basically structured the same way as the DIGSI® 4 Manager with folders and sub-folders. To proceed to information of sub-folders in the catalog, the user should click on a plus symbol or double-click on an folder icon. The designation of the initial levels of the catalog correspond to the information groups Annunciations, Commands, Measured Values and Counter Values.

To insert a specific information unit into an information group, it should first be selected in the catalog, and using the left mouse button, it should then be dragged from the information catalog window to a group area on the left of the matrix. After the mouse button is released, the new information unit is inserted into the selected group with a default name. In order to rename the user defined information, double-click on the field **display text** and **long text**.

Note:

When inserting information of the type **Control with FeedBack**, *two* new rows will be created within the group: one line for the actual command, and one for the associated feedback message.

Deleting Groups and Information

Only user defined groups and information may be deleted. To delete an entire group, click on the field containing the group designator, and then press the *right* mouse button to open the context menu, and select **Delete Group**. A confirmation window will appear (Figure 5-21).
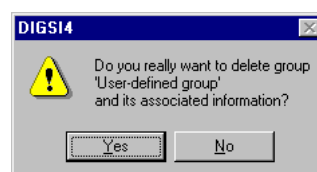
Figure 5-21   Configuration Window Before Deleting a User Defined Group

Click **Yes** if you actually want to delete the group.

Note:

When deleting a group, all information definitions within this group will be deleted.

To delete individual entries, click on **Information** in the line with the entry to be deleted. Then press the *right* mouse button to open the context menu, and select **Delete Information**. The remaining steps are the same as those for deleting a group.

5.2.4   Performing Configuration

Actual configuration is based on the entries made in the individual cells. While an entry can always be made by clicking on the cell with the left mouse button and then entering the appropriate information, the preferred method is to select a cell, press the *right* mouse button, and use the displayed pull down menu to make the entry.

In certain cases, the pull down menu will offer **X** (configured) or **_** (not configured) as the configuration choices. In other cases, more alternatives will be offered (e.g. **L** = latched, **U** = unlatched, and **_** = not configured). Entries resulting in an implausible configuration are blocked and inaccessible to the user.

Configuring Binary Inputs as Sources

Single point indications, double point indications, transformer tap changer indications, and pulse metered values can all be configured as binary inputs. In addition, whether or not binary inputs are activated by the presence of control voltage can be established. That is,

- "**H**" (**H**igh with voltage active): Control voltage at the binary input terminals activates the indication

- "**L**" (**L**ow with voltage active): Control voltage at the binary input terminals deactivates the indication

---

Note:

A single logical indication should not be configured to two binary inputs, since an OR-link of both signals is not ensured. The operating program allows only *one* link, and deletes the first link when a second is established. Use CFC to perform an "OR" instead.(

In addition, a single point indication cannot be configured to a binary input *and* to CFC as a source at the same time. In this case, an error message would be displayed. Click on **OK**, and select another configuration.
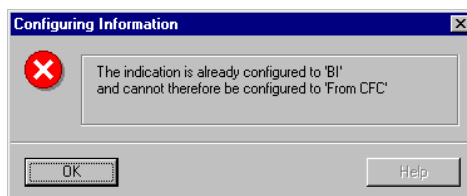
Figure 5-22   Error Message Resulting from Double Configuration

If a double point indication (DP) is configured to one binary input (e.g., feedback indications from switching devices), the next binary input is also set. If this configuration is undone, the second binary input is automatically deconfigured.

If a transformer tap changer indication is configured to a binary input, the next binary inputs in order are also configured. Their total number is the same as the number of bits configured for the transformer tap changer. If one of these inputs is deconfigured, all related binary inputs are automatically deconfigured.

Configuring a Function Key as a Source

The four function keys on the front of the relay may also be configured as sources in order to establish a link using CFC. In this situation, each function key may be linked with *only one* internal indication. A function key may be occupied because it has already been set as an operating function for the relay. As delivered from the factory , the device's function keys F1, F2, and F3 are preconfigured:

F1	operating messages
F2	primary measured values
F3	overview of the last eight fault messages

Note:

When an indication is configured to a function key, its factory-assigned function is deleted. Reestablishment of the factory default function of the F-keys is only possible by initializing the relay with a new factory parameter set created within DIGSI® 4. All device settings have to be reentered.

In order to configure a new indication, select one of the options (OPEN/CLOSE, ON/OFF, etc.) from the indication group in the information catalog and drag it to the left side of the matrix. Upon release, a new row appears in the matrix. If the mouse is positioned at the intersection of this row with column F, and the *right* mouse button is pressed, a context menu opens (Figure 5-23) in which the function key may be set as a source by clicking the proper choice.
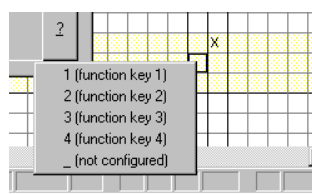
Figure 5-23   Selecting a Function Key

Configuring CFC as a Source

If certain information is created as a result of the implementation of a user defined logic function, this information must appear in the matrix as a source of CFC. Otherwise, this information will not be available to the user for processing by the CFC program.

The user may not configure information to CFC as a source if it is already configured to a binary input.

Warning!

CFC connection have to be reestablished after renaming of a display text of an user defined information. Within the CFC the old name is shown at the **right** column. Delete this connection. Make connection to the desired blocks using the renamed information.

Configuring Binary Outputs as a Destination

Up to ten (10) information units (commands and indications) may be configured to *one* binary output (output relay). One indication may be configured to up to ten (10) binary outputs (LEDs and output relays).

During configuration of binary outputs, the user may select, for each output relay (besides of the logic function itself), whether it should be latched (**L**) or unlatched (**U**). If latched is selected, the output relay remains engaged, even after the indication is no longer present. It must be manually reset by pressing the LED Reset button on the front panel of the relay, or via a binary input with the indication function ">Reset LED", or via the serial SCADA interface. If unlatched is selected, the relay disengages as soon as the indication disappears.

Binary Outputs for Switching Devices

The user must be cautious when configuring binary outputs for switching devices. For switching devices, the type of command (e.g., single or double commands, with or without feedback) is defined and configured to the output relay. If the preset command types are not correct, then appropriate command types can be selected from the Information catalog (see also "Entering Your Own Information" in the previous sub-section) and inserted into the Configuration Matrix.

Example:
Double **C**ommand with
2 Contacts (acc. Table 5-1)
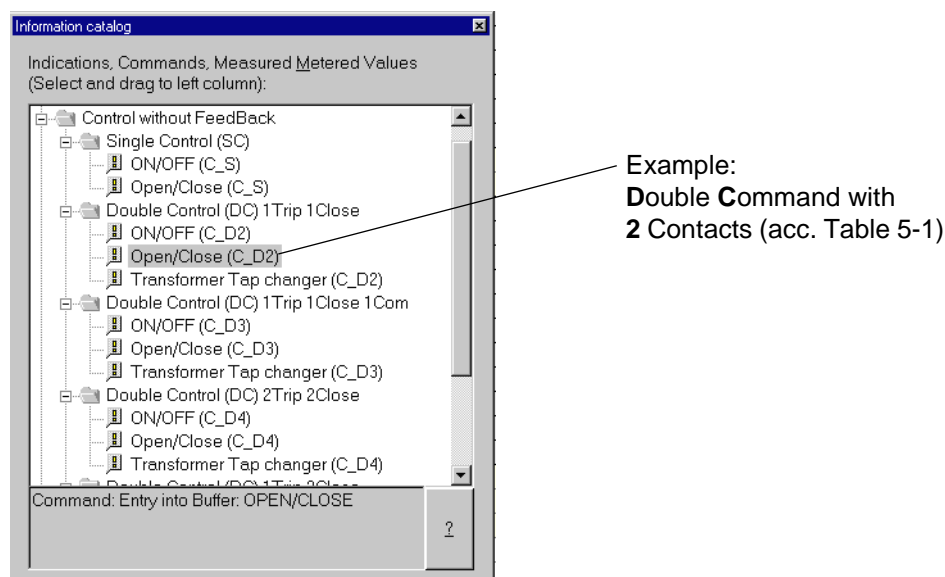
Figure 5-24   Window Information Catalog (Example: Different Command Types)

If a command with multiple outputs is configured, all binary outputs required in the matrix for the configuration are automatically defined. If one of these outputs is deconfigured, all other binary outputs associated with the command will be automatically deconfigured.

Please pay attention to the comments and switching examples in Section 5.2.1, particularly the fixed defined sequence of relay assignments (TRIP before CLOSE).

When configuring commands, the context menu is dependent on the type of command. In some cases, the selection latched/unlatched is not available. Instead, the alternatives are **X** (configured), **_** (not configured), and **F** (busy flag). The latter means, independent of the switching direction, an indication is always issued during activation of the switching device.

For double commands with a common output, a fourth alternative **C** (Common contact) appears. Using this, the binary output may be defined as the common relay (common contact). When this is the case, several double commands with common contacts may be assigned to the same common relay (common contact), thus saving binary outputs. This assumes the signals at the common outputs have the same potential.

Using the **Object Properties** dialog window, additional properties for commands issued to the switching device may be defined. Thus, the operating mode (pulse or latched) output of a switching command, the seal-in time for pulse commands, the output delay of the command, and feedback monitoring may be set (see Figure 5-25). The output delay is only relevant for equipment which removes an indication before the switching is completed.
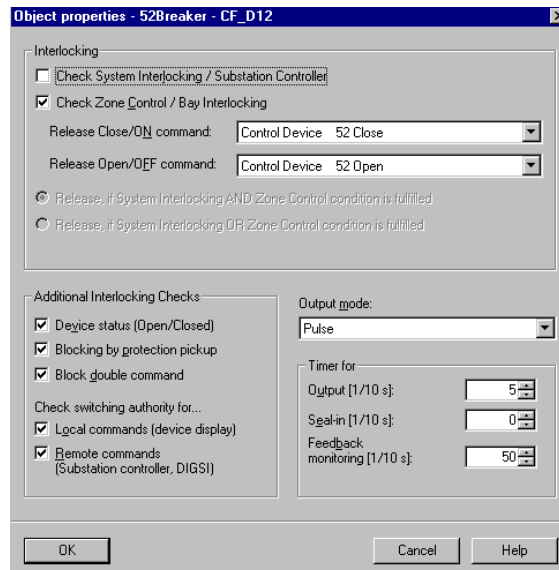
Figure 5-25   Dialog Box - Object Properties for a Command with Feedback (Example: Double
              Command with Single Trip Outputs and Double Close Outputs, CF_D12)

The conditional checks that should be conducted before execution of a switching command can also be defined:

- System Interlocking (Substation controller): in preparation, implemented as of Version 4.2.

- Zone controlled (Bay Specific Interlocking): Logic functions created with CFC in the relay are processed for interlocked switching.

- Device status (Open/Closed; scheduled/actual): The switching command is ignored and a corresponding indication is issued if the switching device is already in the desired position. If this check is activated, switching direction control occurs not only for interlocked, but also for non interlocked switching.

- Blocked by protection: CLOSE–switching command for switchgear is blocked as soon as one of the protective functions or elements in the relay has picked up. OPEN commands, in contrast, can always be executed. Please be aware, activation of thermal overload protection or sensitive ground fault detection can create and maintain a fault condition indication, and can therefore lead to the blocking of CLOSE commands. If the blocking by protection facility is disabled consider that a blocked restart of a tripped motor feeder is overridden. In this case the manual reclose of the motor feeder has to be interlocked by different means, i.e. CFC. One method would be to use the bay specific interlocking in CFC.

- Double operation: Parallel switching operations are blocked with respect to each other; while one switching operation is being conducted, a second one may not be performed.

- Switching Authority – Local commands: A local control switching command is only allowed if local control is enabled on the relay (via a setting).

- Switching Authority - Remote commands: A remote control switching command is only allowed if remote control is enabled on the relay (via a setting).

Configuring a LED Display as a Destination

Single point indications (SP), output indications (OUT), and internal single point indications (IntSP) may be configured to LEDs. When this is done, the user may select whether the indications are to be latched (**L**) or unlatched (**U**).

Up to ten (10) indications may be configured to a LED display. One indication may be configured to a maximum of ten (10) outputs (LEDs and output relays).

Configuring an Indication Buffer as a Destination

A maximum of three indication buffers are available for selection: Operation (Event Log) Buffer (**E**), Sensitive Ground Fault Buffer (**S**), and Trip Log (**T**). The indications from protective functions are firmly assigned to these indication buffers. For the others, Table 5-2 provides an overview of which indication type may be configured to which buffer.

Table 5-2   Overview of Indication Buffers

Information type ↓ \Message buffer →	E	S	T
Single Point Indications (SP)	X	X	X
Double Point Indications (DP)	X		
Output Indications (OUT)	X	X	X
Internal Single Point Indications (IntSP)	X	X	X
Internal Double Point Indications (DP)	X		
Transformer Tap Change Indications (TxTap)	X		

One of the following options should be selected for all configured indication types:

- **0** (on) – the indication is stored in the buffer with the time of its arrival
- **oo** (on/off) – the indication is stored in the buffer with the time of its arrival and departure
- **_** (not configured) – the indication is not stored in a buffer.

Configuring the SCADA Interface as a Destination

Depending on the SCADA interfaces connected to the relay, the types of information displayed in Table 5-3 may be configured. By placing an **X** in the matrix cell, the information is transferred to connected systems via the SCADA interface.

.

Table 5-3   Overview of SCADA Interfaces

Information Type ↓ \SCADA Interface →	Profibus	IEC
Single Point Indication (SP)	X	X
Double Point Indication (DP)	X	X
Output Indication (OUT)	X	X
Internal Single Point Indicator (IntSP)	X	X
Internal Double Point Indicator (IntDP)	X	X
Transformer Tap Change Indicator (TxTap)	X	
Command with/without Feedback (C_**)	X	X

Table 5-3   Overview of SCADA Interfaces

Information Type ↓ \SCADA Interface →	Profibus	IEC
Protective Measurement Value	X	
Protective Measurement Value with Time (MVT)	X	
Protective Measurement Value, User Defined (MVU)	X	
Pulsed Metered Value (PMV)	X	
Metered Value from Measurement Value (MVMV)	X	

Configuring CFC as a Destination

Single point, double point, and output indications, as well as limit and measured values, may be configured to CFC as the destination.

> **Warning!**
>
> CFC connection have to be reestablished after renaming of a display text of an user defined information. Within the CFC the old name is shown at the **left** column. Delete this connection. Make connection to the desired blocks using the renamed information.

Configuring the Default Display and Control Diagram as a Destination

All information, including limit values, may be configured, both in the default and control display. By placing an **X** in the matrix cell, the information may be used within the default and control control display. This feature is not available on the 7SJ61_62 series of relays.

Configuring Control Display as a Destination for Command Initiation

Single point and double point indications, transformer tap change indications, and all types of commands may be configured to the control display as the destination. These indications and commands then become available in the relay's control display for operational control.

Configuring the Measured Value Window as a Destination

In addition to the measured values available in the relay, user defined measured and limit values may be configured into the measured value window. These values then become available in the device display in the assigned measurement window.

Configuring the Metered Value Window as a Destination

In addition to the metered values available in the device, user defined pulse and metered values derived from the measured values may be configured into the metered value window so that they may be shown at the front display.

Retrieving Device Configurations from the Device Front

Retrieving the configurations is also possible from the device front. The user may access configuration information **Main Menu**: → **Settings** → **Masking (I/O)**.

The menu title **MASKING (I/O)** appears in the title bar. Configuration information regarding each (physical) input and output is indicated in the display.

Any new user defined information is also shown in the display once loaded into the relay from DIGSI® 4.

When selecting the **MASKING (I/O)** menu, either binary inputs, LEDs, or binary outputs may be selected. Selection of binary inputs is illustrated in Figure 5-26.

```
 ┌─────────────────────────┐                    ┌─────────────────────────┐
 │MASKING (I/O)   01/03    │                    │BINARY INPUTS    02/11   │
 │- - - - - - - - - - - - -│       ▶            │- - - - - - - - - - - - -│
 │▶Binary Inputs  ─>   1   │                    │ Binary Input 1─>    ─   │
 │ LED            ─>   2   │       ▼            │▶Binary Input 2─>    ─   │
 │ Binary Outputs ─>   3   │                    │                         │
 └─────────────────────────┘                    └─────────────────────────┘
```
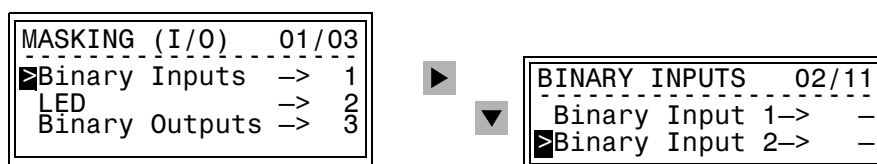
Figure 5-26   Reading the Configuration in the Display

Information regarding a binary input may be displayed by using the navigation keys to select the binary input. See Figure 5-27.

```
 ┌─────────────────────────┐
 │BINARY INPUT 2           │
 │- - - - - - - - - - - - -│
 │▶>Reset LED SP        H  │
 │                         │
 │                         │
 │- - - - - - - - - - - - -│
 │Status at Terminal   0   │
 └─────────────────────────┘
```
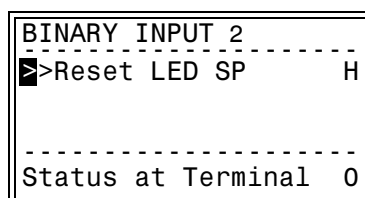
Figure 5-27   Selection of Binary Input 2

In Figure 5-27, information is displayed regarding binary input 2. The display for binary input 2 indicates that it is configured as the acknowledgment of LEDs using a single point indication with voltage active (High). The present conditions of binary input 2 is also given as 0 (not active). If binary input is active, a 1 is displayed.

Assignment of LEDs may be indicated at the relay, itself, using a replaceable labeling strip with plain text on the front panel located, directly next to the LEDs.

Preset Configurations   The pre-set configurations of the binary inputs and outputs are shown in the overview circuit figures (Appendix A.2).

The preset configurations for the LED displays upon relay delivery are listed in the following table.

Table 5-4   Preset Configuration for LED Display

LED	Descriptive Text	Brief Text	Message #	Comments
LED 1	Relay Tripped	Relay Tripped	511	One the protective functions initiated a trip.
LED 2	Pickup Phase A	Non-Directional Phase A Directional Phase A	1762 2692	Pickup by Aφ Element
LED 3	Pickup Phase B	Non-Directional Phase B Directional Phase B	1763 2693	Pickup by Bφ Element
LED 4	Pickup Phase C	Non-Directional Phase C Directional Phase C	1764 2694	Pickup by Cφ Element

Table 5-4   Preset Configuration for LED Display

LED	Descriptive Text	Brief Text	Message #	Comments
LED 5	Pickup G	Non-Directional G Directional G	1765 2695	Pickup by Ground Element
LED 6	Measurement Failure	Fault ΣI Fault I Symmetry Fault V Symmetry Fault I Rotation Fault V Rotation	162 163 167 175 176	Monitoring Message
LED 7				Not Configured

5.2.5   Transferring Metering Values

The transferring of metered values from the buffer of the device to SCADA or substation controller may be performed both cyclically and/or by external polling.

In the configuration matrix, click on **Options** and then on **Restore Metered Values**. A dialog box, which contains a register for editing the individual values for cyclical transferring will open.

Cyclical Restoration

Here, the user may specify the source of the cyclical trigger for the transfer. Also, the user may set the time interval and determine whether the metered value buffer should be deleted after transfer to the SCADA has taken place.
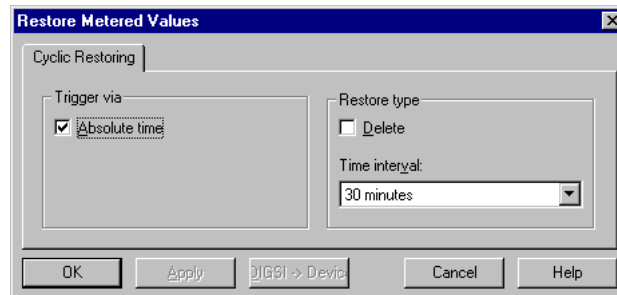
Figure 5-28   Dialog Box to Restore Metered Values and Program Cyclical Restoration

In the current version of DIGSI® 4, triggering occurs based on the programmed Absolute time.

5.2.6   Setting of Contact Chatter Blocking

Contact Chatter Blocking

The contact chatter filter checks whether the number of condition changes at a binary input exceeds a preset value during a predetermined time interval. If this occurs, the binary input will be blocked for a certain time, so the event list does not contain a large number of unnecessary entries. The setting values necessary for this feature may be entered in the selection window, as shown in Figure 5-29. The selection window may

be found from the open configuration matrix by clicking **Options** in the menu bar and then selecting **Chatter Blocking**.
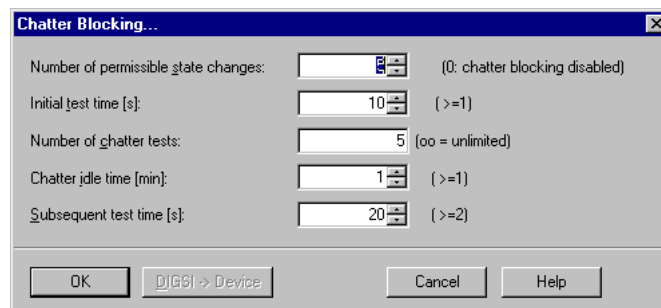
Figure 5-29   DIGSI$^{®}$ 4: Setting the Chatter Blocking Feature

Defining the Monitoring Criteria

The operating mode of the chatter blocking feature is determined by five settings:

- **Number of permissible state changes**
  This setting establishes how often the state of a binary input within the initial test time may change. If this number is exceeded, the binary input is or remains closed. If the setting is 0 the chatter blocking is disabled.

- **Initial Test Time** - Within this time interval (in seconds), the number of state changes of a binary input is checked. The time interval begins with the first activation of a signal to the binary input.

- **Number Of Chatter Tests**
  This number represents how many check cycles should be conducted before the binary input is finally blocked. Please consider that even a high set value can be reached over the normal life span of the device and could lead to blocking of the binary input. Therefore this value can also be set to infinity. For this enter the digit sequence of oo .

- **Chatter Idle Time** - If the number of state changes at a binary input is exceeded during the initial test time or the subsequent test time, the chatter idle time interval is initiated. The affected binary input is blocked for this time interval. The Chatter idle time setting is entered in minutes. This settings can only be programmed if the Number of chatter tests is not set to zero.

- **Subsequent Test Time** - Within this time interval, the number of state changes at a binary input is checked again. This interval begins after the chatter idle time interval has expired. If the number of condition changes is within allowable limits, the binary input is released. Otherwise, the idle interval is restarted, until the maximum number chatter tests is reached again. The Subsequent Test Time setting is entered in seconds. This settings can only be programmed if the Number Of Chatter Tests is not set to zero.

The settings for the monitoring criteria of the chatter blocking feature are set only once for all binary inputs; however, the status of the chatter suppression can be set individually for each binary input. See "Filtering / Contact Chatter Suppression" in Sub-section 5.2.3.

Note:

Chatter blocking cannot be activated for any of the standard protective indications.

The following should be noted:

- If there is contact chatter at a binary input and the input is blocked, the corresponding indication will be displayed with "CCF" (example: "`>Door open CCF ON`"). Also, the indication "`Contact chatter filter`" reports this condition. Both messages are shown in the operating buffer.

- Chattering of a single point indication is set as ON (asserted) if the binary input has been in an active state.

- Chattering of a single point indication is set as OFF (deasserted) if the binary input has been in an inactive state.

- If this behavior causes undesired results in individual situations, a blocking may be configured with the above-named indication in CFC.

- Chattering of a double point indication will be considered an "intermediate" condition.

5.3 Creating User Defined Functions with CFC

General
The 7SJ61 relay is capable of implementing user defined logic functions (PLC) which may be processed by the relay. The CFC feature (Continuous Function Chart) is needed to process user defined protective functions and logic conditions (e.g. interlocking conditions for switching devices) or to process measured values. Interlocking conditions and command sequences, for example, may be programmed, using predefined function modules, by persons without any specialized software programming abilities. A total of 21 functional modules (FM), with which the desired functions may be composed, are saved in a library. Detailed explanations are in the CFC manual, order number E50417–H1176–C098, or in the DIGSI® 4 manual, order number E50417–H1176–C097.

The creation of a logical PLC function is performed by means of a PC using application DIGSI® 4 and transferred via the user or service interface. In order to create user defined logic functions, the indications and measured values required by these functions must first be configured in the matrix with CFC as the source or destination (see Section 5.2).

CFC can be started by double-clicking on **CFC**. The names of all available CFC charts will appear. The desired CFC chart for processing can be selected via a double-click of the mouse. The CFC program will begin, and the chart will be displayed. If no chart is available yet, you can create a new chart via the menu **Create → CFC–Chart**.

Run-Time Properties
The functions to be implemented in CFC may be divided into four task levels:

- Measured Values: This task is processed cyclically every 600 milliseconds (**MV_BEARB** = measurement value processing) and might becomes slower if device is in pickup-stage.

- System Logic: Operation is triggered by events (i.e. these functions are processed for each change of state at one of the inputs). System logic has lower priority than a protection function and will be suppressed as soon as the relay picks up (**PLC1_BEARB** = slow PLC processing).

- Protective functions: These functions have the highest priority, and, like the system logic functions, are event-controlled and processed immediately after a change of state (**PLC_BEARB** = fast PLC processing).

- Switchgear Interlocking: This task is triggered by commands. In addition it is processed cyclically approximately every second. It might becomes slower if device is in pickup-stage (**SFS_BEARB** = interlocking).

The function to be implemented must be one of these four types. To implement a function from the **Settings → CFC** menu, activate the menu by selecting **Edit**, and then **Run Sequence**, and then the desired run-time level (See Figure 5-30).
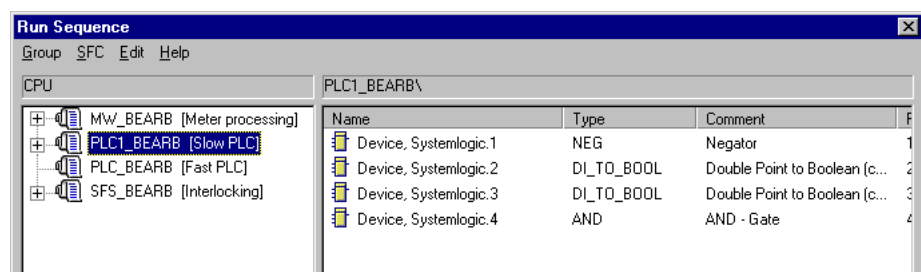
Figure 5-30   Establishing the Task Level

Within the Run Sequence menu, select **Edit**, and then **Predecessor for Installation**, to ensure that the function modules selected from the library will be implemented into the desired task level (Figure 5-31).
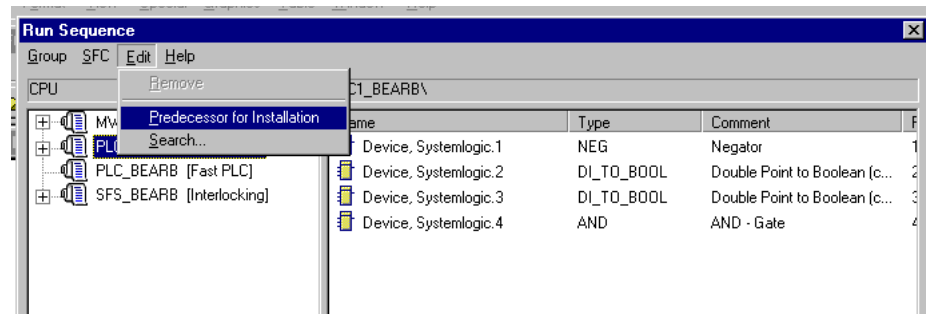
Figure 5-31   Assignment of Function Modules to the Selected Task Level

The proper assignment is important for several reasons. For example, if interlocking logic were to be set up in the measured values (Meter processing) run-time sequence level, indications would constantly be created by the cyclical processing, filling the buffer unnecessarily. On the other hand, the interlocking condition at the moment of a control operation may not be processed at the right time, since meter processing is done only every 600 ms.

Table 5-5   Selection Guide for Function Modules and Task Levels

Function Modules	Description	Task Level			
		MW_BEARB Meter processing	PLC1_BEARB Slow PLC	PLC_BEARB Fast PLC	SFS_BEARB Interlocking
ABSVALUE	Magnitude calculation	X	–	–	–
AND	AND-Gate	–	X	X	X
BOOL_TO_CO	Boolean to control (conversion)	–	X	X	–
BOOL_TO_DI	Boolean to Double Point	–	X	X	X
BUILD_DI	Create Double Point annunciat.	–	X	X	X
CMD_INF	Test	–	–	–	X
CONNECT	Connection	–	X	X	X
D_FF	D-Flipflop	–	X	X	X
DI_TO_BOOL	Double Point to Boolean	–	X	X	X
LIVE_ZERO	Live-zero, non linear Curve	X	–	–	–
LOWER_SETPOINT	Lower limit	X	–	–	–
NAND	NAND-Gate	–	X	X	X
NEG	Negator	–	X	X	X
NOR	NOR-Gate	–	X	X	X
OR	OR-Gate	–	X	X	X

Table 5-5   Selection Guide for Function Modules and Task Levels

Function Modules	Description	Task Level			
		MW_BEARB Meter processing	PLC1_BEARB Slow PLC	PLC_BEARB Fast PLC	SFS_BEARB Interlocking
RS_FF	RS-Flipflop	–	X	X	X
SR_FF	SR-Flipflop	–	X	X	X
TIMER	Timer	–	X	X	–
UPPER_SETPOINT	Upper limit	X	–	–	–
X_OR	XOR-Gate	–	X	X	X
ZERO_POINT	Zero suppression	X	–	–	–

Configuration Sheet

The configuration is performed within the configuration sheets (see Figure 5-32).
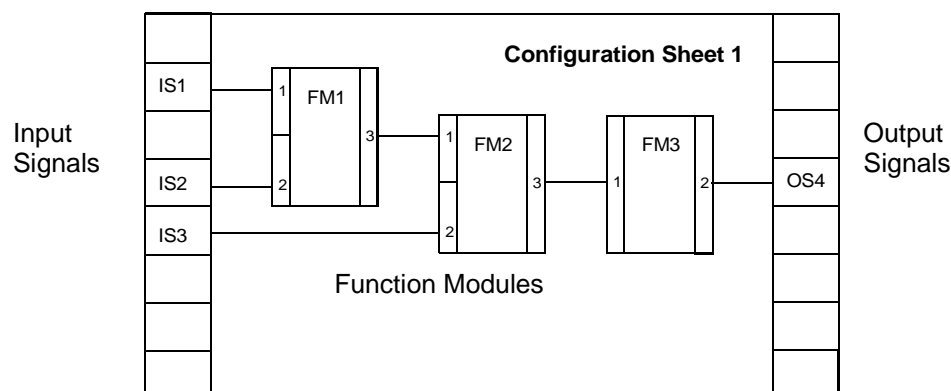
Figure 5-32   Principal Representation of Function Modules in a DIGSI® 4 Working Page

The left border column of the configuration sheet shows the inputs; the right border column shows the outputs of a function. In the above diagram the inputs are connected with input signals IS1 to IS3. These may be indications from the breaker (via binary inputs), from relay function keys, or from a protective function. The output signal (OS4 in the diagram) may control an output relay, for example, and can create entries in the message buffers, depending on the preset configuration.

Configuring and Connecting Function Modules

The default run-time sequence is determined by the sequence of the insertion of the logic modules. You may redefine the run-time sequence by pressing Ctrl – F11 on the PC keyboard. Please refer to the CFC manual. The necessary function modules (FM) are contained in a library located to the right of the configuration chart. The module also indicates to which of the four task levels (MW_BEARB, PLC1_BEARB, PLC_BEARB, SFS_BEARB) it is assigned. The modules possess at least one input and one output. In addition to these inputs and outputs, which are displayed on the configuration sheet, a module may have additional inputs. The additional inputs can be made visible by selecting the module title block, pressing the *right* mouse button, selecting the menu option **Number Of I/Os...** (see Figure 5-33), and then increasing the number.
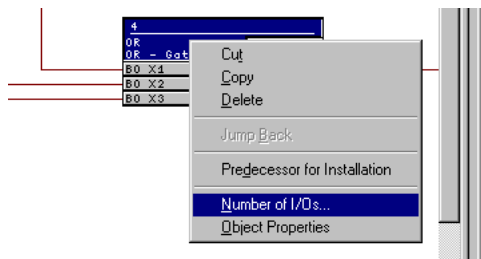
Figure 5-33   Example of an OR Lattice: Module Menu

Under the **Object Properties** menu, the user may edit the name of the module, insert a comment, or edit run-time properties and connection parameters.

Connecting modules with each other, and linking them with system input and output signals, is performed by selection of the desired modules input or output and subsequently pressing the right mouse button, and selecting the menu option **Insert Connection to Operand** (see Figure 5-34).
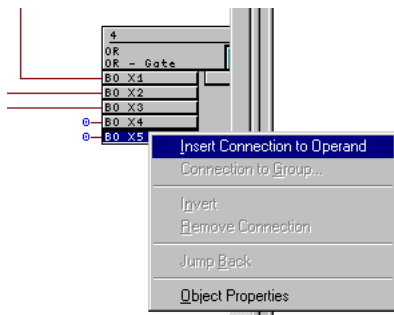
Figure 5-34   Example of Module Input Menu

A window with a list of input signals will appear. By selecting one of these signals and activating with **OK**, the selected signal is entered into the left border panel and, from there, a connection is created to the module input. Selection of an output is done in the same manner. A connection between two modules is established by a simple sequential clicking on the two connections.

If the link line display becomes unwieldy or impossible because of space limitations, the CFC editor creates a pair of connectors (target icons) instead. The link is recognizable via correlated numbering (see Figure 5-35).
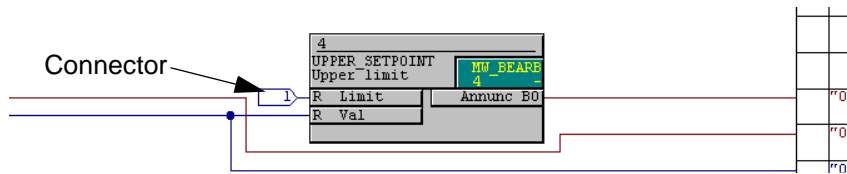
Figure 5-35   Connector

Events   Events (SP_Ev, DP_Ev) are <u>not</u> suitable for processing in CFC, and should therefore not be used as input signals.

For additional information please refer to Appendix A.7.

Consistency check In addition to the sample configuration chart 1, shown in Figure 5-36, other configuration sheets may exist. The contents of any particular configuration sheet is compiled by DIGSI$^®$ 4 into a program and processed by the protective device. For CFC charts developed by the user, syntactic correctness can be verified by clicking the menu command **Chart**, and then **Check Consistency**. The consistency check will determine if the modules violate conventions of various run-time levels, or any of the principles below.

Check of functional correctness must be performed manually.

The completed CFC chart can be saved via menu item **Chart**, and **Close**. Likewise, the CFC chart may be reopened and edited by clicking on **Chart**, selecting the appropriate chart, and clicking on **Open**.

Please be aware, certain limitations exist, because of memory space and processing power. The limits listed in Table 5-6 are generally applicable. The limits given in Table 5-7 are relay-specific. These limits must not be exceeded because adverse effects to the protective functionality (e.g. slower trip times) would result.

Table 5-6   Maximum Number of Charts and Inputs

Limit Description	Limit	Comment
Total number of all CFC charts for all processing areas	32	
Allowable number of CFC charts in a single processing area	16	
Total number of inputs on the left panel for all CFC charts in event-driven process areas	100[*]	Valid for process areas: **PLC1_BEARB** (system logic) **PLC_BEARB** (protective functions)
Maximum number of different inputs on the left panel for all CFC charts in event-driven process areas	50	Valid for process areas: **PLC1_BEARB** (system logic) **PLC_BEARB** (protective functions)

[*] If a message is used in two charts, it counts as two.

Table 5-7   Maximum Number of Modules per Process Area for SIPROTEC$^®$ 7SJ61

Process Area (running level)	Number of Blocks	Comment
MW_BEARB (Meter processing)	< 100	
PLC1_BEARB (Slow PLC Logic)	approx 30	Depends on the type of functional blocks used and the number of connections
PLC_BEARB (Fast PLC Logic)	approx 12	
SFS_BEARB (Interlocking)	< 100	

The limits are monitored by the DIGSI$^®$ 4 operating program. When 100 % of the allowed memory is used, DIGSI$^®$ 4 issues a warning message. See Figure 5-36.
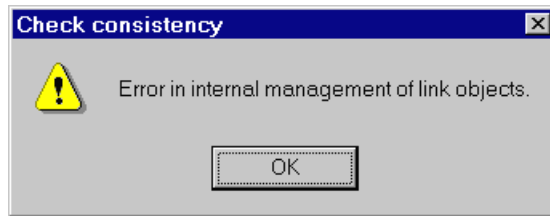
Figure 5-36   Warning message from DIGSI® 4 when 100 % of allowed memory is used

After acknowledgement of the warning, the register sheet **Compile** under **Option** → `Reports` can be accessed. By scrolling, an area can be reached in which statements are given regarding the memory usage, as a percentage of the portion reserved for CFC. In Figure 5-37 for example, an overload of 56 % is presented for the run-time level PLC_BEARB (specially noted), while the other running levels are within the allowed range.
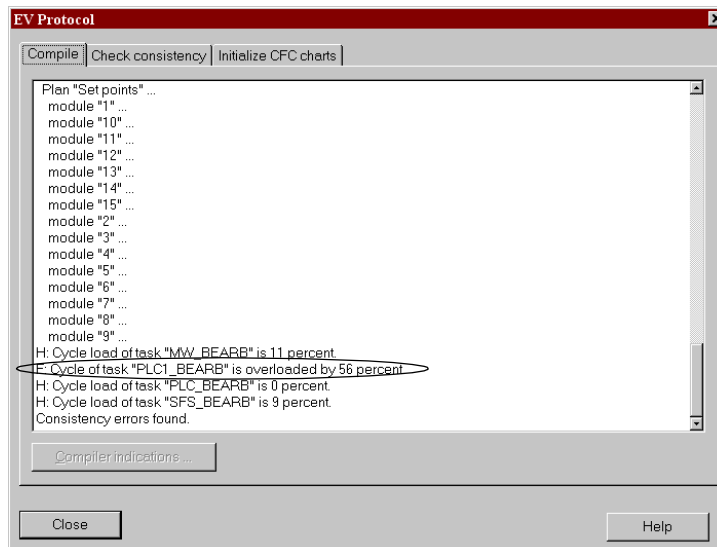
Figure 5-37   Reading the loading level for CFC–diagrams

The following contains a few examples. A summary of the CFC configurations provided at the factory is shown in Appendix A.6.

Example 1 (MW): Under Current Set Points (ANSI 37)

A configuration for low-current monitoring alarm (see Figure 5-38) which can be produced using CFC, should be a first example. This element may be used to detect operation without load, or to recognize open circuited conditions. By connecting measured current values with a limit function via an "OR" function, an indication may be generated which can be used to trip a circuit breaker.

- The configuration sheet is assigned to run-time sequence MW_BEARB.

- Four function modules (3-lower-value limit modules and an OR gate), are taken from the function module library and copied into the configuration sheet.

- In the left panel, the measurement values to be monitored (I_a, I_b, I_c in % of the nominal current) are each selected and connected with the measured value input of each limit module function.

- A lower limit setpoint value (IL<) is linked with the setpoint inputs of each of three limit sensor functions.

- The limit value function outputs are passed on to the OR gate.

- The output of the OR gate is connected to the right border column at annunciation "37−1 alarm".

The limit value message is triggered when the preset limit value is below the setpoint (low current) in at least one of the three phases. The hysteresis of the limit values is fixed and need not be entered (5 % of set point plus 0.5 % absolute).
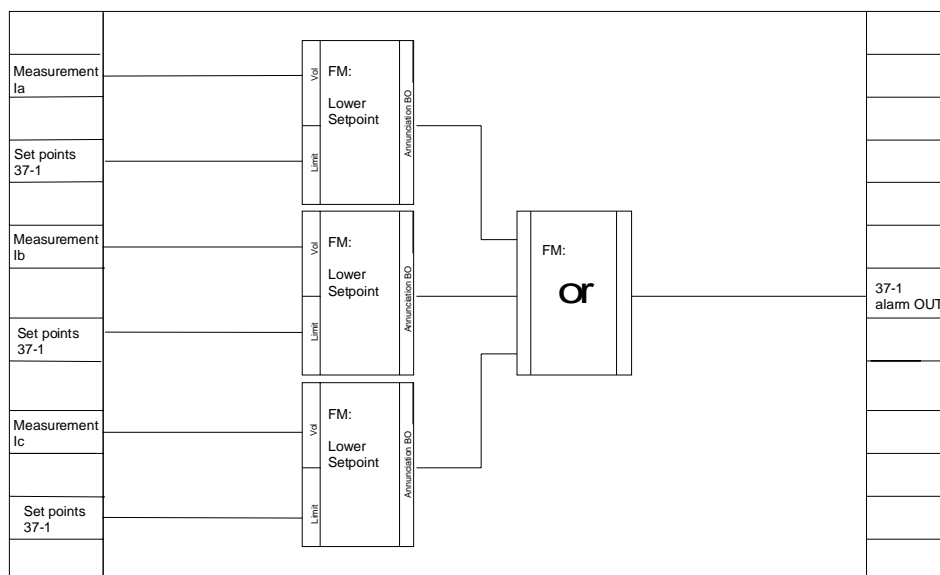
Figure 5-38   Under-Current Monitoring as an Example of User Defined Measurement Value Processing

Example 2: Isolation Switch Interlocking

Interlocking logic (see Figure 5-39) is to be implemented for the operation of an isolating switch using function key 4. The user must take the switch position indications of the corresponding isolation switch and the grounding switch into account. The CLOSE and TRIP indications from the auxiliary contacts of each switch are used.

- Function modules NOR (2 required), XOR, and AND are taken from the library and copied into the working page.

- The inputs of the AND gate are increased to 7.

- The CLOSE indications from the circuit breaker (CB) and from the grounding switch (GS) are supplied to the inputs of the NOR functions.

- The OPEN indications from the circuit breaker (CB) and from the grounding switch (GS) are supplied to the inputs of the AND function.

- The switch position indications from the disconnect switch (IS) are linked to the inputs of the XOR function.

- The outputs of the NOR and XOR gates are connected to the inputs of the AND function.

- Function key 4 is linked with an input of the AND function.

- The output of the AND gate is linked to the right border column at the command "Disconnector Close".
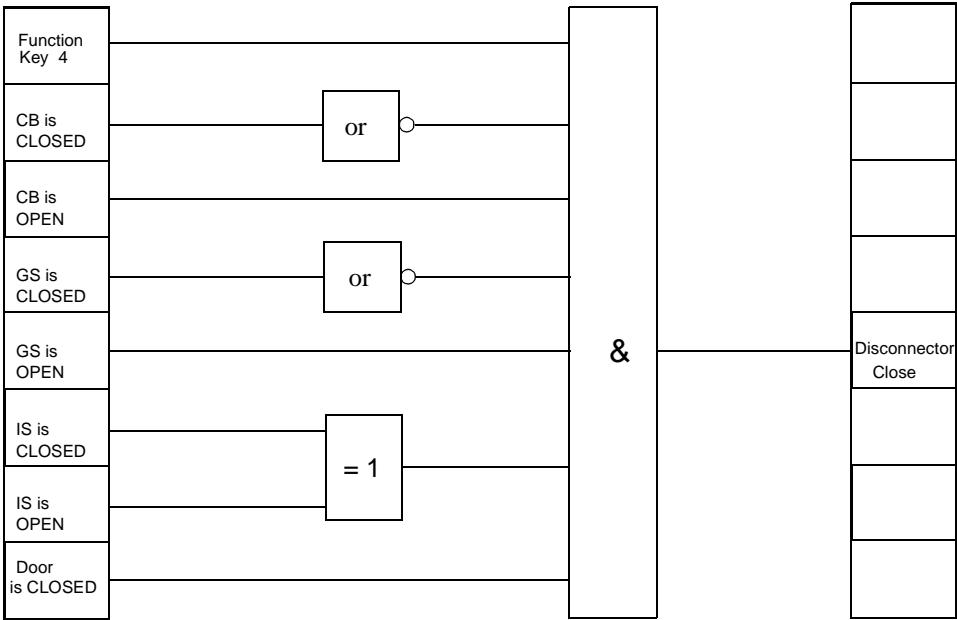
Figure 5-39   Interlocking an Disconnect Switch as an Example of a User Defined Interlock Protective Function

Example 3 (PLC1): Additional Logic

By using slow PLC processing, an additional, event-driven logic condition may be constructed which delivers indications regarding facility operating status. These indications may be passed externally via LEDs or relays, or used as input signals for further logical links. In the example (see Diagram 5-40), the output information indication from the circuit breaker interlocking logic (CB TRIP) and a joint indication from all protective element trip signals (Protection TRIP) are linked to a new "Circuit Breaker Trip" message. Furthermore, the single point indication (SP) **Test Oper.**, which may be coupled via a binary input, is coupled with an internal reusable "Test oper." message.
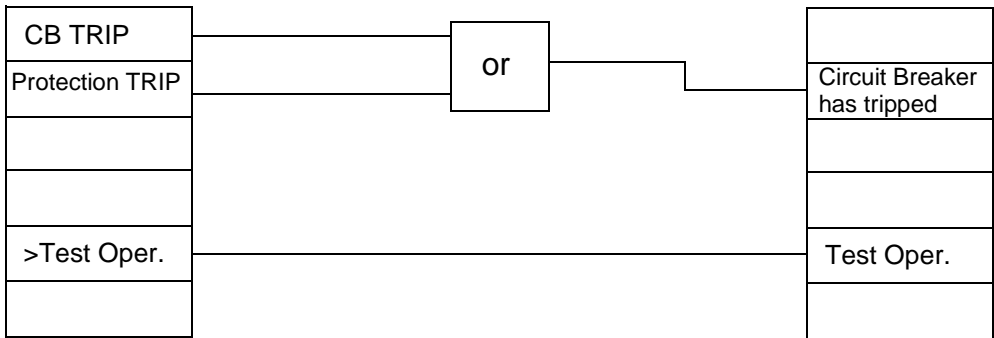
Figure 5-40   Additional Logic as an Example for a PLC_1 Event-Driven Logic Condition

5.4 Establishing a Default Display

Under normal conditions, a preset image is shown as the default display. It shows operating information and/or measured values of the protected equipment. Depending on the relay type, a number of predefined basic displays are available. Using the ▲ and ▼ keys, one of the displayed images may be selected (see example in the following figure), causing it to appear as the default display under normal conditions.

```
┌─────────────────────────┐
│A  473.3A   MAX 532.8A│
│B  479.6A   MAX 538.2A│
│C  470.9A   MAX 522.6A│
│N    0.2A              │
└─────────────────────────┘
```

Figure 5-41   Example of a Basic Display

5.5   Serial Ports

The device contains one or more serial ports — a PC-interface is integrated into the front panel. Depending on the model ordered, a rear service port and a SCADA port for connection of a substation control system are integrated. Certain standards are necessary for communication via these interfaces, which contain protection device identification, transfer protocol, and transfer speed.

Configuration of these interfaces is performed using the DIGSI® 4 software program. After opening the device, the user should click on **Setting** in the navigation window and double-click in the data window on **Serial Ports**. Next the user should select the specific data in the resulting dialog box (Figure 5-42). The dialog box contains a varying number of tabs (depending on the capabilities of the PC and the protection device) with setting options for the interfaces.
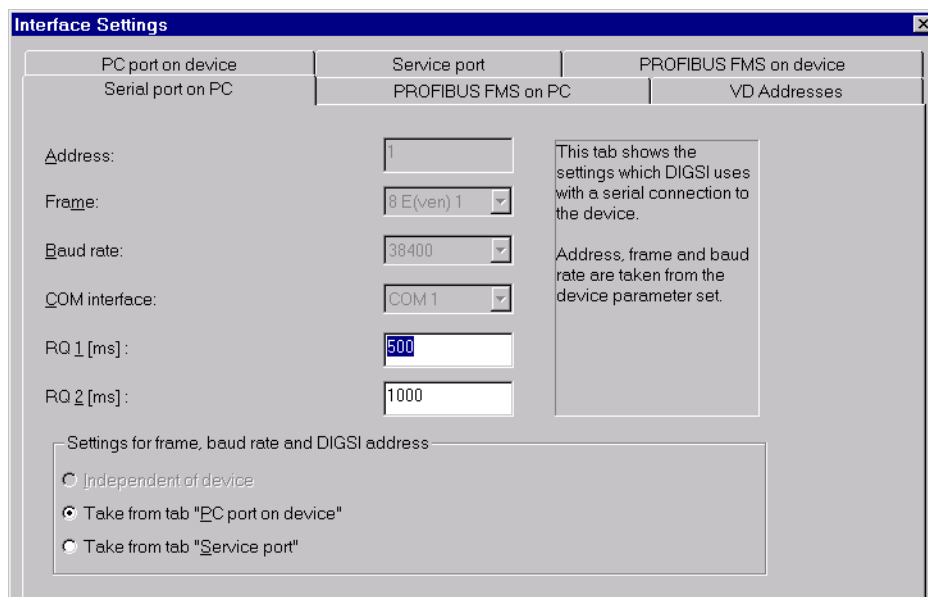
Figure 5-42   DIGSI® 4, Settings of the PC Interface

Serial Port on PC   In the first tab, the user should enter the communication port of the PC (**COM1, COM2,** etc.) which is connected to the 7SJ61 relay. Manual entry of settings for data format and baud rate can not be entered, since these values were taken from the "**PC port on device**" tab or the "**Service port**" tab (if present). In fact, many settings are read from DIGSI® 4 directly via the interface, and the corresponding setting fields are made inaccessible (see Figure 5-42). On the other hand, for those settings that must be entered by the user, the option **Independent of device** should be selected.

The settings RQ 1 and RQ 2 are intended for Siemens use only. Please do not modify these settings.

PC and Service Ports of the Protective Device   Settings for link addresses and maximum message gap appear in the **PC port on device** and **Service port** tab next to the settings for data format and transfer speed (example Figure 5-43).

Figure 5-43   DIGSI® 4, Settings for the PC Port on device

For the IEC communication, each SIPROTEC® device must have a unique IEC address assigned to it. There is a total of 254 IEC addresses available. Select an address from the pull-down menu **Address**. Only the addresses which are within the current address range and have not yet been issued are displayed.

The setting for the maximum telegram gap is only applicable when the device is to communicate using a modem via service port. A gap is the maximum allowable time duration of interrupted transmission within one telegram transmission. Transfer gaps are created when using modems with data compression, error correction, and baud rate differences. For good data transmission between modems, a setting of *1.0* sec is recommended. For poor connections, this value should be increased.

Large values slow down communications in case of errors. When using a direct PC connection, **Max. message gaps** may be set to *0.0* sec.

Note:

Do not use front port for modem communication!

Other Interfaces   Enter specific settings and addresses to identify devices in the other tabs, or check the preset values.

Device addresses are used by the system to identify each device and must be unique throughout the system. Detailed instructions for setting the interfaces are available in the "DIGSI® 4 Communications" manual.

If the user desires to expand or modify interfaces later, refer to the modification instructions for the interfaces, and if necessary for the hardware, see also instructions in Section 8.1.3 of this document.

Profibus FMS Connection

For a Profibus FMS connection between a SIPROTEC® device and the SICAM® SAS or DIGSI® 4, a minimum transfer rate of 500 kBaud is recommended for disturbance-free communication.

Signal Idle State

For optical connections, the signal idle state is preset for "light off." Modification of the signal idle state is accomplished in the tab for the interface settings (see Figure 5-44).
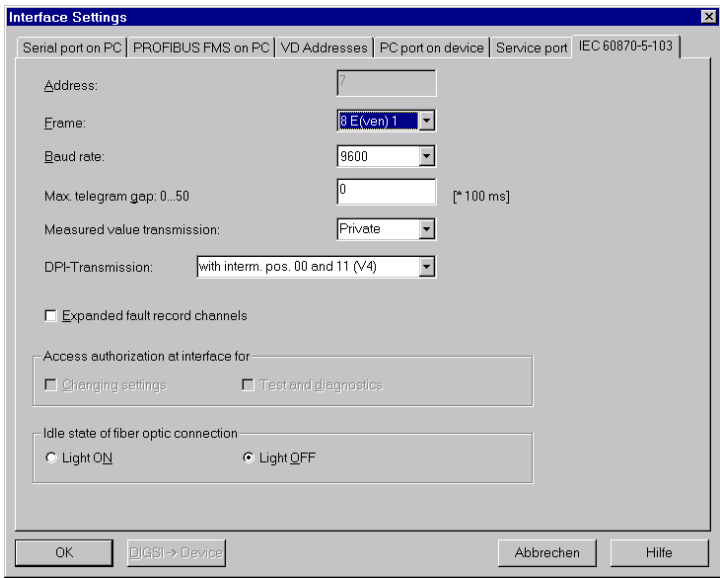
Figure 5-44   Settings for an Optical Interface

Reading and Modifying Interface Settings at the Device

Reading and partial modification of the most important interface settings is possible, using the operator interface at the device itself. The user may access the setting page for the interface via **MAIN MENU** through **Settings → Setup/Extras → Serial Ports**.

Under the menu title **SERIAL PORTS**, the user will find Front Port, System Port, and Service Port, and selections may be made using the ▼ navigation button. By pressing the ▶ button, the sub-menu for a particular interface can be accessed. The display and the ability to change settings directly at the device are the same at both the front and service interfaces. Figure 5-45 shows the operator interface, as an example.
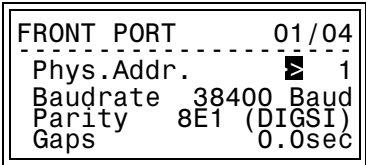
Figure 5-45   Reading and Setting the Front DIGSI Port at the Device Controls

The SCADA interface data may be displayed at the device, but can only be modified by DIGSI® 4.

5.6   Date and Time Stamping

Integrated date and time stamping allows for the exact evaluation of sequence of events (e.g. operations or error messages, or limit violations). The following clock settings are available:

- Internal RTC clock (Real Time Clock),

- External synchronization sources (DCF, IRIG B, SyncBox, IEC 60870-5-103, PROFIBUS),

- External minute impulses via binary input.

Note:

The device is delivered from the factory with the internal RTC clock selected as the time source, independent of whether the device is equipped with a SCADA interface or not.

Time Synchronization

Settings for time synchronization may be found in DIGSI® 4 under **Settings** → **Time synchronization** (Figure 5-46).
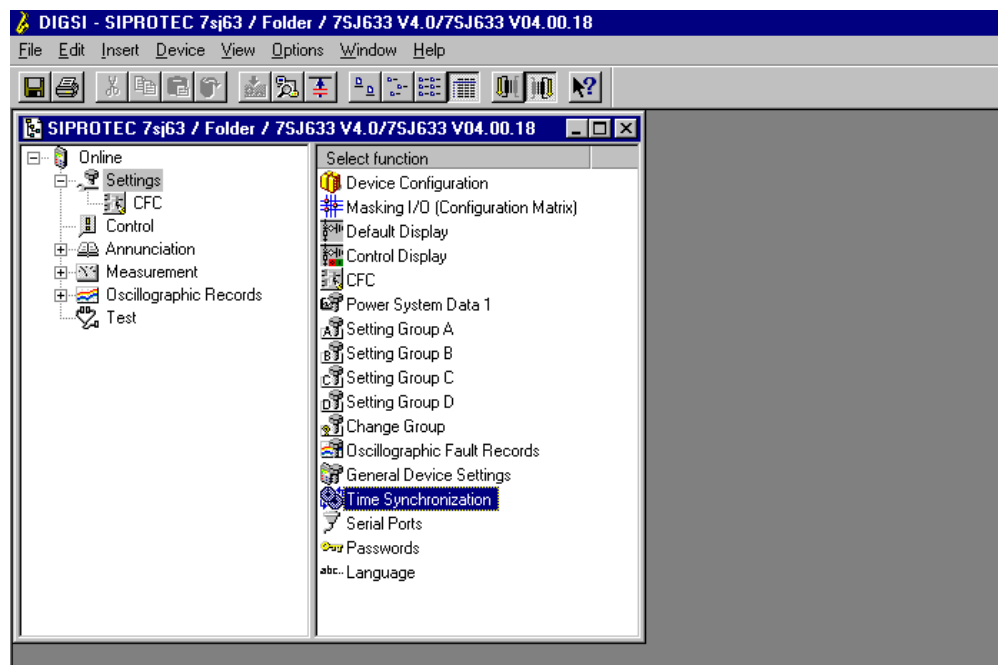
Figure 5-46   Setting Window inDIGSI® 4

To open the **Time Synchronization & Format** window, the user should double-click on **Time Synchronization**. See Figure 5-47.
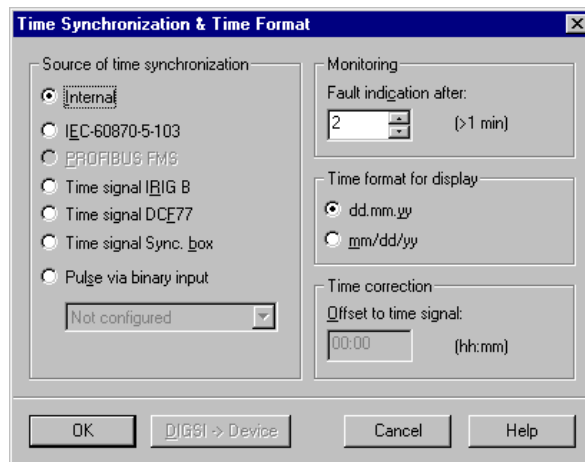
Figure 5-47   Dialog Window for Time Synchronization and Format in DIGSI® 4

Here the user may select the time standard for internal time stamping by selecting from the following modes:

Table 5-8   Operating Modes for Time Tracking

#	Operating Mode	Explanations
1	**Internal**	Internal synchronization using RTC (pre-set)
2	**IEC 60870–5–103**	External synchronization using SCADA interface (IEC 60870–5–103)
3	**PROFIBUS FMS**	External synchronization using PROFIBUS interface
4	**IRIG B Time signal**	External synchronization using IRIG B
5	**DCF77 Time signal**	External synchronization using DCF 77
6	SIMEAS Time signal **Sync. Box**	External synchronization using SIMEAS Sync. Box
7	**Pulse via binary input**	External synchronization with pulse via binary input

The RTC runs, even when the auxiliary voltage is absent, by means of an internal battery. During the devices powering up, or if the auxiliary voltage drops, this RTC is the synchronization source for the internal clock, independent of operating mode selected.

In "Internal" mode, the system time is controlled using only the RTC as the synchronization source. It may be set manually. The procedure for manual date/time setting is given in Section 7.2.1.

If an external source is selected, only the selected synchronization source is used. If the source fails, the internal clock continues unsynchronized.

If time synchronization is to take place via a control system, the option **IEC-60870–5–103** or **PROFIBUS FMS** must be selected (Figure 5-47).

When using radio clock signals, the user must take into account that it can take up to three minutes after device startup or restored reception for the received time signal to be decoded. The internal clock is not resynchronized until then.

With IRIG B, the year must be set manually, because this standard does not include a year value. *Note*: If a year number less than "91" is selected by mistake, the year "91" will be set upon first synchronization.

For synchronization using pulses via a binary input, the present device time will advance to 00 seconds of the next minute for values greater than 30 seconds when the positive slope of the pulse arrives. For second values less than 30, the device time will be set to 00 seconds of the current minute. Because this signal is not monitored, each pulse has a direct effect on the internal clock.

Synchronization Offset

The "Synchronization Offset" (**Offset**) setting allows correlation of the time signal received from the radio clock to local time (time zone). The maximum settable offset is ± 23 h 59 min = ±1439 min.

Annunciation Due to Missing Synchronization

The tolerance time (**Error Time** / **Fault indication after**) for time synchronization fault indicates how long cyclical synchronization may be absent until an alarm is given.

External or internal synchronization normally occurs every minute. (An exception is synchronization using a pulse via binary inputs because the signals may arrive several minutes apart.) The setting for the tolerance time must, therefore, always be at least two minutes. Under poor radio clock reception conditions, the user may delay the trigger of the "fault" status condition even longer.

Changing the Synchronization Mode

When changing synchronization mode, the hardware will re-synchronize to the new source within one second. This causes breakdown of cyclical synchronization, and the internal clock will be disrupted — as at startup — until the new synchronization source takes over.

After modification to the synchronization offset in the time signal/operating mode, or when changing year in IRIG B, the cyclical synchronization is not lost, but there is a jump. To call attention to this, the time value causing a jump is reported with "Time interruption ON" — without the synchronization offset, and subsequently with "Time interruption OFF" — with the synchronization offset.

Operating Messages from the Timing System

After the "Time interruption ON" message, the user must take into account that the clock will jump. This message is issued under the following circumstances:

− If a synchronization interruption lasts longer than the monitoring interval mentioned above, or as mentioned above, if the operating mode is changed;

− If a time jump is anticipated. The time value of the message is shown without the jump.

The message "Time interruption OFF" is triggered:

− When the synchronization is re-established (e.g., after a break in reception by the radio clock);

− Directly after a time jump. The time value of the message contains the time differential caused by the jump, in contrast to the previous "Time interruption ON" message, thus allowing determination of the jump interval.

Time Format

The time display may be set using either the European format (DD.MM.YY) or the US format (MM/DD/YY).

■

Functions

6

This chapter describes the numerous functions available on the SIPROTEC® 7SJ61 relay. The setting options for each function are defined, including instructions for reporting setting values and formulas where required.

Regionalization   The SIPROTEC® 7SJ61 devices are offered in regional versions. The prepared func-
tions are adapted to the technical requirements of the regions. The user should pur-
chase only the functional scope that is needed.

Table 6-1   Regionalization

Function	Region DE Germany	Region Worldwide Worldwide	Region US USA
Language	German	English	American English
Frequency	50 Hz	50 Hz / 60 Hz Default 50 Hz	60 Hz
Unit of distance given by Fault Locator	km	km / Miles Default km	Miles
Disk-emulation for reset characteristics of inverse time-overcurrent elements (emulation of (electromechanical elements)	–	only for ANSI Curves	X
Characteristic curves for inverse time-overcurrent elements IEC Curves	 X	 X Default IEC Characteristic Curves	 –
ANSI Curves	–	X	X
Automatic Reclosing	X	–	–
Automatic Reclosing with zone sequence coordination	–	X	X

Legend

(X) – Selectable Option

(–) – Function not available for this region

6.1   General

A few seconds after the device is powered up, the default display will appear showing measured values by the 7SJ61 protective relay.

The settings associated with the various device functions may be modified using the controls on the front panel of the device or by using the operator interface in DIGSI® 4 in conjunction with a personal computer. Password No. 5 is required to modify individual settings.

From the Device Front

Select the MAIN MENU by pressing the MENU key. Using the ▼ key, select *Settings*, and then press the ▶ key to navigate to the SETTINGS display (see Figure 6-1).

In the **SETTINGS** display, use the ▼ key to select the desired function, and then use the ▶ key to navigate to that function (e.g., use the ▼ key to select the **P.System Data1** function, and then use the ▶ key to navigate to the **P.SYSTEM DATA1** display, as shown in Figure 6-2.

In general, an item number appears in the menu list to the right of each selection. Navigation can be accomplished using the item number in place of the ▲ and ▼ keys. This feature is particularly helpful in large menus (e.g., setting lists). Based on the example above, from the **MAIN MENU**, the **SETTINGS** display can be accessed by pressing 4 on the keypad, and then the **P.SYSTEM DATA1** display can be accessed by pressing 0 3 on the keypad.

```
     ┌─────────────────────┐
     │MAIN MENU      04/05 │
     │---------------------│
  ▼  │Annunciation  ─>    1│
     │Measurement   ─>    2│          ┌─────────────────────┐
     │Control       ─>    3│   ▶      │SETTINGS       03/11 │
     │███████████████████4█│          │---------------------│
     │Test/Diagnose ─>    5│       ▼  │Device Config.─>   01│
     └─────────────────────┘          │Masking (I/O) ─>   02│
                                      │█P.System█Data1─>██03│
                                      │Group A       ─>   04│
                                      └─────────────────────┘
```
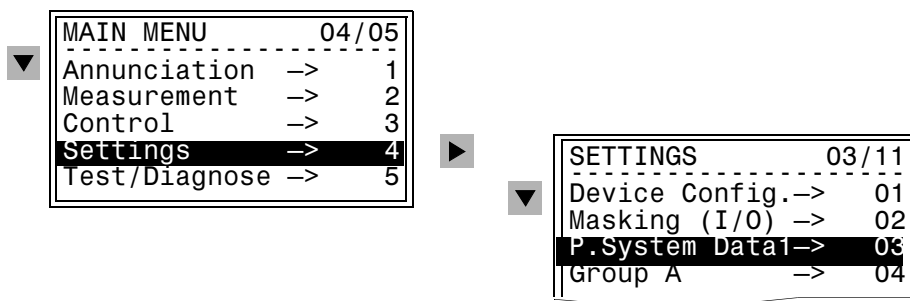
Figure 6-1   Example of Navigation From The Front Control Panel

Each setting contains a four-digit address number followed by the setting title as shown in Figure 6-2. The value of the current setting is displayed in the line just below the setting address number and title. The value may be text (Figure 6-2, setting 0201) or numerical (Figure 6-2, setting 0203).

```
┌─────────────────────┐
│P.SYSTEM DATA1  01/16│
│---------------------│
│0201 CT Starpoint    │
│     towards Line    │
│0203 Vnom PRIMARY    │
│     12.00kV         │
└─────────────────────┘
```

Figure 6-2   Example of Power System Data Display

Settings are selected using the ▲ and ▼ keys. When the ENTER key is pressed, the user is prompted for a password. The user should enter Password No. 5 and then press the ENTER key. The current value of the setting appears in a text box, with a blinking text insertion cursor.

Note:

The factory default password is **000000**.

Text Values   A text setting may be modified using the ▲ and ▼ keys to select one of two or more options.

Numerical Values (including ∞)   A numerical setting may be modified by overwriting the current value using the numerical keypad. See Figure 6-3. A value of "*infinity*" may be entered by pressing the decimal key twice. The "∞"–symbol will appear in the display.

If the number entered is not within allowable limits, the maximum or minimum allowable value will appear in the lower portion of the display. To enter a new, allowable value, the ENTER key should be pressed again.

Note that measured values and limit values must be entered in secondary quantities when using the front control panel of the device.

Confirmation   Any modification to a setting value must be confirmed by pressing the ENTER key. A blinking asterisk is an indication that setting modification mode is still open. Other modifications can be made to settings, even in sub-menus (if present), as long as setting modification mode is still open. The actual modification of settings occurs once setting modification mode is closed (see below, "Exiting the Setting Modification Mode").

```
┌─────────────────────┐
│P.SYSTEM DATA1  02/16│
│---------------------│
│0202 Vnom PRIMARY    │
│     ▶12.00kV        │
└─────────────────────┘
```
▼   Example for numerical setting:
ENTER

```
┌───────────────────┐
│  PW Settings?     │
│      =-------      │
└───────────────────┘
```
Enter password No. 5 and confirm with ENTER

```
┌─────────────────────┐
│0203        ┌─ ─ ─┐  │
│Vnom PRIMARY  15.00  │
│            └─ ─ ─┘  │
└─────────────────────┘
```
Enter the new value and confirm with ENTER

```
┌─────────────────────┐
│P.SYSTEM DATA  ✳02/16│
│---------------------│
│0203 Vnom PRIMARY    │
│     ▶15.00kV        │
└─────────────────────┘
```
The modified setting value appears in the list; a blinking asterisk in the title bar indicates setting modification mode is still open.
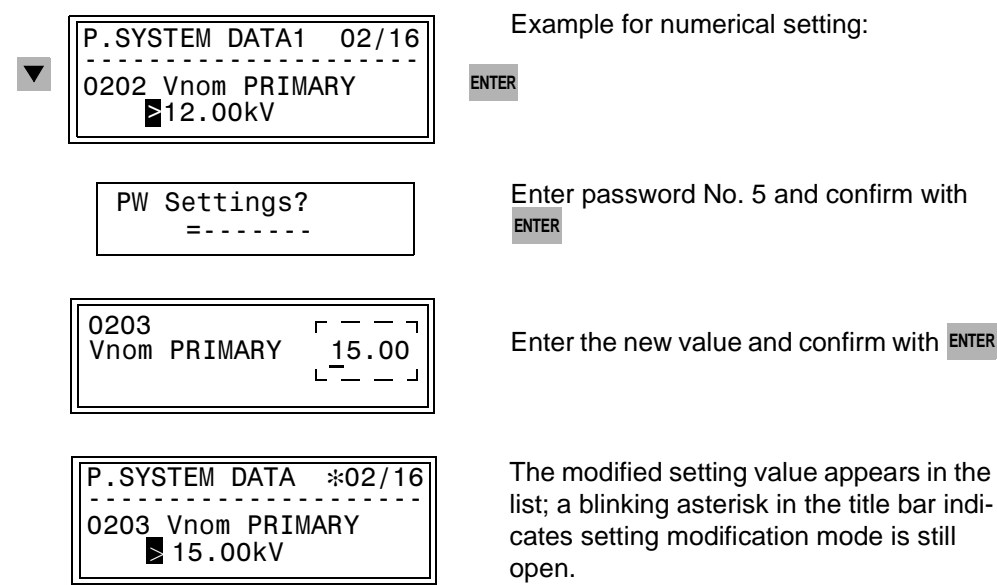
Figure 6-3   Example of Setting Modification Using the Front Control Panel

If a setting modification is not confirmed with the ENTER key, the original value reappears after one minute, and a message window appears after three minutes notifying the user that the setting modification period has expired. When the ENTER key is pressed, a further message window appears, notifying the user that the setting modifications were discarded. Further modification of settings is possible by pressing the ENTER key and reentering the password.

Exiting the Setting Modification Mode

If an attempt is made to exit setting modification mode using the ◄ key or the MENU key, the message **Are you sure?** will be displayed followed by the responses **Yes, No,** and **Escape** (see Figure 6-4). If the response **Yes** is selected, modification of settings can be confirmed by pressing the ENTER key. To cancel pending modifications to settings and exit setting modification mode, the response **No** must be selected. Press the ► key until the response **No** is highlighted. Press the ENTER key to confirm and exit. Incorrect entries may be retracted in this manner. To remain in the setting modification mode, press the ► key until the response **Escape** is highlighted. Press the ENTER key to confirm, and the user can remain in setting modification mode without downloading modifications .

```
Are you sure?
▶Yes No Escape
```
ENTER

```
Settings are ok
        ▶Continue
```
ENTER
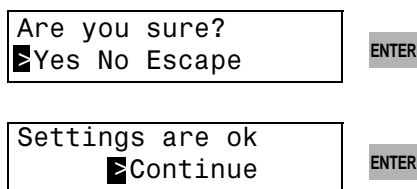
Figure 6-4   Ending Setting Modification Mode Using the Front Control Panel

From PC with DIGSI® 4

Using DIGSI® 4 to modify settings.

To select a function, the user should double-click on **Settings**, and then double-click on the desired setting function (e.g., **Power System Data 1** is selected by double-clicking **Settings**, and then double-clicking **Power System Data 1** as illustrated in Figure 6-5).
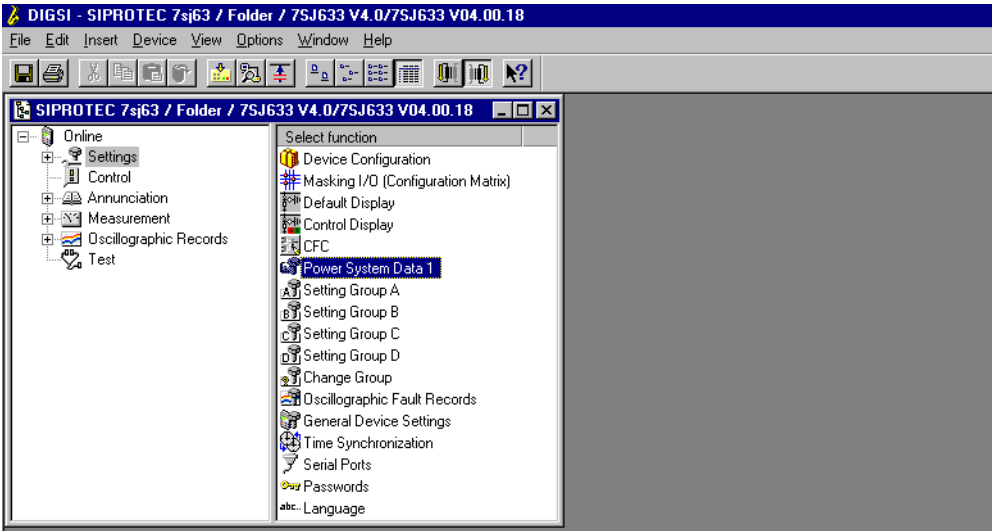
Figure 6-5   Navigating Using DIGSI® 4 — Example

A dialog box associated with the selected function is displayed (e.g., if **Power System Data 1** function is selected, the dialog box shown in Figure 6-6 will appear). If a function contains many settings, the dialog box may include multiple windows. In this situation, the user can select individual windows via tabs located at the top of the dialog box (e.g., In Figure 6-6, tabs exist for **Power System**, **CT's**, **VT's**, and **Breaker**).
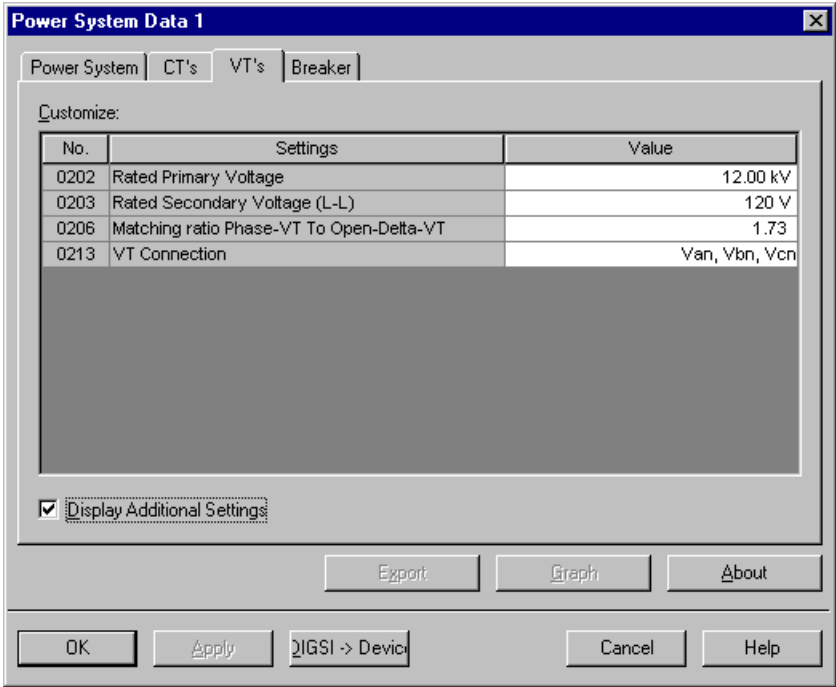
Figure 6-6   Power System Data Dialog Box in DIGSI® 4 — Example

The left column of the dialog box (identified as the **No.** column) contains the four-digit address number of the setting. The middle column of the dialog box (identified as the **Settings** column) contains the title of the setting, and the right column of the dialog box (identified as the **Value** column) contains the current value of the setting in text

or numerical format. When the mouse cursor is positioned over a numerical field in the **Value** column, the allowable range is shown.

To modify a setting, the user must click on the setting value which is displayed in the **Value** column.

Text Values

When a text setting value is selected, a pull-down menu of possible setting options is displayed. To modify the setting, the user simply clicks on the desired option. The pull-down menu closes, and the new setting value appears in the **Value** column.

Numerical Values (including ∞)

When a numerical setting value is selected, the setting is modified using the number keys, if applicable, with a decimal comma (not a decimal point). A value of **"infinit**y" may be entered by pressing the small **o** key twice. The setting modification is confirmed by clicking on **Apply**, or the user may select another setting to modify.

If the value entered is outside the allowable range, a message block appears on the screen describing the error and displaying the acceptable range of values. To acknowledge the message, the user should click **OK**, and the original value reappears. A new entry can be made or another setting value can be modified.

Primary or Secondary Values

Setting values can be entered and displayed in primary terms or secondary terms, as desired. DIGSI® 4 automatically performs the conversions based on the settings entered for the transformer data and conversion ratios.

To switch between primary values and secondary values:

❑ Click on **Options** in the menu bar, as shown in Figure 6-7.

❑ Click on the desired alternative.
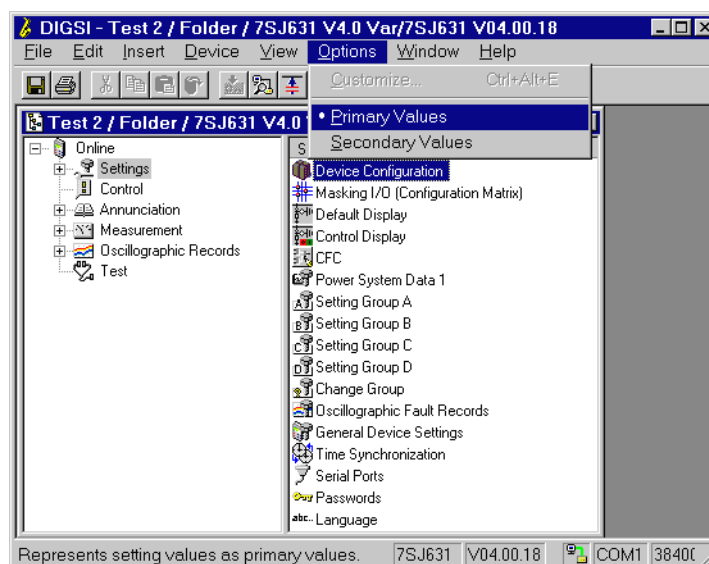
Figure 6-7   Selection of Primary or Secondary Value Entry — Example

Additional Settings

Those settings that are modified only in special cases are typically hidden. They may be made visible by checking on **Display Additional Settings**.

Confirmation

Each entry may be confirmed by clicking **Apply**. Valid values are accepted automatically when another field is selected.

The final acceptance of a modified setting takes place once setting modification mode is exited (see below "Exiting the Setting Modification Mode").

The dialog box may be closed by clicking **OK**. Once closed, another function may be selected for setting modification, or the user can exit setting modification mode.

Exiting the Setting Modification Mode

In order to transfer the modified setting values to the relay, the user should click on **DIGSI** → **Device**. The user will be prompted for Password No. 5. After entering the password and confirming with **OK**, data is transferred to the relay where modifications become effective.

6.1.1 Power System Data 1

The device requires certain basic data regarding the protected equipment, so that the device will be compatible with its desired application. Phase sequence data, nominal system frequency data, CT&PT ratios and their physical connections, as well as, breaker operating times and minimum current thresholds are selected in the **Power System Data 1** display.

To modify these settings from the front of the device, the user should press the MENU key and wait for the **MAIN MENU** to appear. From the **MAIN MENU**, the user should use the ▼ key to select **Settings**, and then use the ▶ key to navigate to the **SETTINGS** display. To obtain the **P.System Data1** display, the user should use the ▼ key to select **P.System Data1** in the **SETTINGS** display, and then press the ENTER key.

To modify settings associated with **Power System Data 1** using DIGSI® 4, the user should double-click **Settings**, and then **Power System Data 1**, and the desired selection options will be displayed.

Polarity of Current Transformers

At address 0201 **CT Starpoint**, the polarity of the wye-connected current transformers is specified (see Figure 6-8 for options). Modifying this setting also results in a polarity reversal of the ground current inputs I_N or I_{NS}.
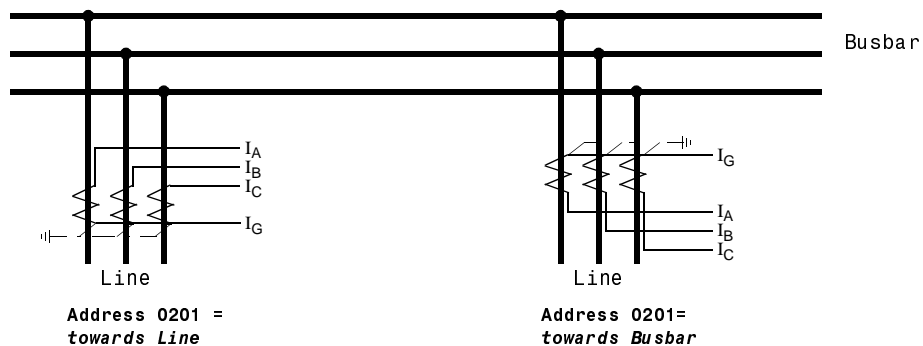
Figure 6-8   Current Transformer Polarity

CT's Nominal Values

At addresses 0204 **CT PRIMARY** and 0205 **CT SECONDARY**, information is entered regarding the primary and secondary ampere ratings of the current transformers. It is important to note that the primary ampere rating of the current transformers is based on the actual tapped connection of the current transformers' secondary winding (i.e. for a 1200/5 ampere multi-ratio current transformer connected at a 600/5 ampere tap, the user should enter a value of **600** for **CT PRIMARY** and a value of **5** for **CT SECONDARY**). It is also important to ensure that the rated secondary current of the current transformer matches the rated current of the device, otherwise the device will incorrectly calculate primary amperes.

CT's Ratios

Data describing the connection of the current transformers is entered at addresses 0207 and 0208.

Address 0207 corresponds to the factor by which the ground current (I_N) must be adjusted relative to the phase current.

- When the secondary ground current corresponds to the residual current of three wye-connected current transformers (Appendix Section A.3, Figure A-8), Address 0207 is set to **1**.

- When the ground current is obtained from an independent neutral current transformer (Appendix Section A.3, Figure A-10), address 0207 is then set equal to the ratio of the neutral current transformer ratio to the phase current transformer ratio.

<u>Example:</u>

Phase current transformer   500 A/5 A
Neutral current transformer   300 A/5 A

$$\text{Address } 0207 = \frac{300/5}{500/5} = 0.600$$

Address 0208 corresponds to the factor by which the sensitive ground current (I_{Ns}) must be adjusted relative to the phase current.

- In models with sensitive ground current detection where an independent current transformer is used to supply I_{Ns} (Appendix Section A3, Figures A-11 and A-12), address 0208 is set equal to the ratio of the neutral current transformer ratio to the phase current transformer ratio.

<u>Example:</u>

Phase current transformer   500 A/5 A
Neutral current transformer   60 A/1 A

Adaptation for sensitive ground current detection:

$$\text{Address } 0208 = \frac{60/1}{500/5} = 0.600$$

Phase Rotation

Address 0209 **PHASE SEQ.** is used to establish phase rotation. The default phase sequence is "abc". For systems that use a phase sequence of "acb", address 0209 should be set accordingly. A temporary reversal of rotation is also possible using binary inputs (see Section 6.12).

Trip and Close Command Duration

Address 0210 `Tmin TRIP CMD` is used to set the minimum time the tripping contacts will remain closed. This setting applies to all protective functions that initiate tripping.

Address 0211 `Tmax CLOSE CMD` is used to set the maximum time the closing contacts will remain closed. This setting applies to the integrated reclosing function and must be long enough to allow the circuit breaker contacts to reliably engage. An excessive duration causes no problem since the closing command is interrupted in the event another trip is initiated by a protective function.

Current Flow Monitoring

Address 0212 `BkrClosed I MIN` corresponds to the threshold value of the integrated current flow monitoring system. This setting is used by several protective functions (e.g., breaker failure protection, overload protection, and restart block for motors). If the threshold value set at address 0212 is exceeded, the circuit breaker is considered closed.

The threshold value setting applies to all three phases, and takes precedence over all other protective functions.

With regard to breaker failure protection, the threshold value must be set at a level below the minimum fault current for which breaker failure protection must operate. On the other hand, the current threshold should not be set more sensitive than necessary to avoid extended resetting times on transient phenomena of the current transformers after interruption of high short–circuit currents. A setting of 10% below the minimum fault current for which breaker failure protection must operate is recommended.

When using the device for motor protection, overload protection, and restart blocking; the protective relay can distinguish between a running motor and a stopped motor, as well as take into account the varying motor cool-down behavior. Under this application, the set value must be lower than the minimum no-load current of the motor.

Nominal Frequency

Address 0214 `Rated Frequency` corresponds to the frequency at which the protected equipment operate. The setting is dependent on the model number of the relay purchased, and must be in accordance with the nominal frequency of the power system.

6.1.1.1 Settings

In the list below, the setting ranges and default setting values for the pickup currents are for a device with a nominal current rating I_N = 5 A. For a nominal current rating I_N = 1 A, divide the Setting Options values and Default Setting values by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	Setting	Setting Options	Default Setting	Comment
201	CT Starpoint	towards Line towards Busbar	towards Line	Location of CT starpoint
204	CT PRIMARY	10 ~ 50000 A	100 A	CT Rated Primary Current
205	CT SECONDARY	1 A 5 A	5 A[1]	CT Rated Secondary Current
207	CT N / CT Ph	0.010 ~ 1.000	1.000	Neutral CT to Phase CT conversion factor
208	CT Ns / CT Ph	0.001 ~ 1.000	1.000	Neutral I_{Ns} CT to Phase CT conversion factor

Addr.	Setting	Setting Options	Default Setting	Comment
209	PHASE SEQ.	A B C A C B	A B C	Phase sequence
210	TMin TRIP CMD	0.01 ~ 32.00 s	0.15 s	Minimum Trip Command Duration
211	TMax CLOSE CMD	0.01 ~ 32.00 s	1.00 s	Maximum Close Command Duration
212	Bkr Closed I MIN	0.20 ~ 5.00 A	0.20 A[1])	Closed Breaker Min. Current Threshold
214	Rated Frequency	50 Hz 60 Hz	60 Hz[1])	Nominal frequency

[1]) depending of the ordering code, please refer to Table 6-1

6.1.1.2 Information

F#	LCD-Text	Comment
5145	>Reverse Rot.	Activation of Reverse Rotating Field Processing
5147	Rotation ABC	Rotating Field ABC
5148	Rotation ACB	Rotating Field ACB

6.1.2 Setting Groups

Purpose of Setting Groups

A setting group is nothing more than a collection of setting values to be used for a particular application. In the 7SJ61 relay, four independent setting groups (A ~ D) are possible. The user can switch back and fourth between setting groups locally, via binary inputs (if so configured), via the operator or service interface using a personal computer, or via the system interface.

A setting group includes the setting values for all functions that have been selected as *Enabled* during configuration (see Chapter 5). While setting values may vary among the four setting groups, the selected functions of each setting group remain the same.

Multiple setting groups allows a specific relay to be used for more than one application. While all setting groups are stored in the relay, only one setting group may be active at a given time.

If multiple setting groups are not required, Group A is the default selection, and the following paragraph is not applicable.

If multiple setting groups are desired, address 0103 **Grp Chge OPTION** must be set to *Enabled* in the relay configuration. Refer to chapter 5.

Copying Setting Groups

In most cases, only a few settings will vary from setting group to setting group. For this reason, an option exists to copy stored setting values from one setting group to another setting group using DIGSI® 4:

To copy the setting values from setting group to another setting group, the user should highlight the setting group in the list whose setting values are to be copied. Next, the user should go to the menu bar, click on **Edit** and select **Copy** (see Figure 6-9).
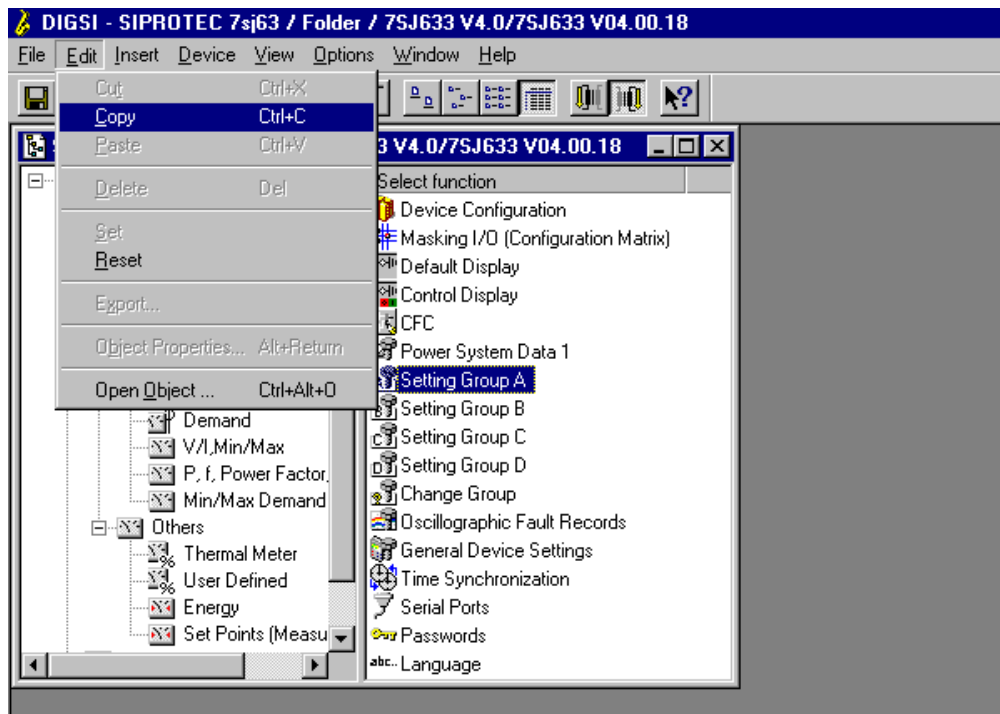
Figure 6-9   Copying a Setting Group in DIGSI® 4

The next step is to highlight the name of setting group in the list into which the setting values should be copied. The user should go to the menu bar, click on **Edit** and select **Paste**. A confirmation box will appear (see Figure 6-10). Select **Yes** to copy the setting values.

Note:

All existing setting values in the setting group that has been copied to will be overwritten. An inadvertent copy operation can be reversed by closing and reopening the DIGSI® 4 session without saving changes.
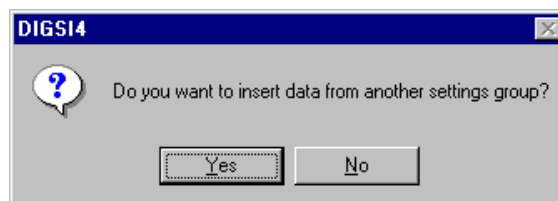
Figure 6-10   DIGSI® 4: Confirmation before Copying a Setting Group

Setting groups may be copied more easily using the "Drag & Drop" feature. To use the "Drag & Drop" feature, the name of the setting group in the list whose setting values are to be copied should be highlighted. Holding down the left mouse button, the cursor can then be dragged to the name of the setting group into which the setting values are to be copied.

After copying setting groups, it is only necessary to modify those setting values that are to be set differently.

Restoring Factory Settings

The factory settings may be restored for a modified setting group. To restore factory settings to a setting group, the name of the setting group whose settings are to be restored should be highlighted. Next, the user should select the menu option **Edit** and then click on **Reset**. A confirmation box appears, and the user should click on **Yes** to confirm restoration of factory settings.

Note:

All setting values in the setting group being restored to factory settings will be overwritten. An inadvertent reset operation can be reversed by closing and reopening the DIGSI® 4 session without saving changes.

Switching between Setting Groups

The procedure to switch from one setting group to another during operations is described in Sub-section 7.2.2. The option of switching between several setting groups externally via binary inputs is described in Subsection 8.1.2.

Addr.	Setting	Setting options	Default Setting	Comment
301	ACTIVE GROUP	Group A Group B Group C Group D	Parameter group A	Active is
302	CHANGE to	Group A Group B Group C Group D Binary input Via protocol	Parameter group A	Activation

6.1.2.1   Information

F #	LCD-Text	Comment
7	>Set Group Bit0	>Parameter group selection (Select Bit 0)
8	>Set Group Bit1	>Parameter group selection (Select Bit 1)

6.1.3   Power System Data 2

General protective data (**P.SYSTEM DATA2**) includes settings associated with all functions rather than a specific protective or monitoring function. In contrast to the **P.SYSTEM DATA1** as discussed in Sub-section 6.1.1, these settings can be changed over with the setting groups. To modify these settings, the user should select **SETTINGS** menu option *Group A* (setting group A), and then **P.System Data2**.

The other setting groups are *Group B, Group C,* and *Group D*, as described in Subsection 6.1.2.

Definition of nominal rated values	At address 1102 **I PRIMARY OP.,** the nominal current (phase) of the protected equipment is entered. (e.g., motors). This value do not effect pickup settings. They are generally used to show values in reference to full scale. For example, if a CT ratio of 600/5 is selected and the full load current of a motor is 550 amps, a value of 550 amps should be entered for **PRIMARY OPERATING CURRENT** if monitoring in reference to full load current is desired. 550 amps are now displayed as 100 % in the percentage metering display. (Subsection 6.1.1).

Recognition of Running Condition (only for motors)	Address 1107 **I MOTOR START**, is used for motor protection applications and corresponds to the minimum starting current of the protected motor. The current setting entered at address 1107 enables the device to determine if the protected motor is in start-up mode, thus allowing the device to properly perform the start-up time monitoring and overload protection functions.

In determining the setting for address 1107, the following should be considered:

- A setting must be selected that is lower than the actual motor start-up current under all load and voltage conditions.

- Because the thermal cure of the overload protection is "frozen" (held constant) during motor start-up, the setting must be high enough to allow operation of the overload protection at higher load current levels.

6.1.3.1 Settings

In the list below, the setting ranges and default setting values are for a device with a nominal current rating I_N = 5 A. Consider the current transformer ratios when setting the device with primary values

For a nominal current rating I_N = 1 A:

− For the pickup current (I MOTOR START) , divide the Setting Options values and default setting values by 5.

− For the Ground resistance and reactance ratios, multiply Setting Range and Setting Increments by 5!

Addr.	Setting	Setting Options	Default Setting	Comments
1102	I PRIMARY OP.	10 ~ 50,000 A	100 A	Nominal operating current of primary equipment
1107	I MOTOR START	3.00 ~ 50.00 A	12.50 A[1]	Motor start-up current

[1]) depending of the ordering code

6.1.3.2 Information

F#	LCD-Text	Comment
533	IA =	Primary interrupted current Phase A
534	IB =	Primary interrupted current Phase B
535	IC =	Primary interrupted current Phase C
501	Device Pickup	Pickup (protection)
511	Device Trip	device trip (general)
126	Prot ON/OFF	Protection On/Off (IEC60870-5-103)

F#	LCD-Text	Comment
561	Man.Clos.Detect	Manual Close Detection (Impulse)
356	> Manual Close	Manual Close
2720	> Enable ANSI#-2	> Enable 50/67-(N)-2 (override 79 blk)
4601	> 52-a	contact is open if breaker is open
4602	> 52-b	contact is open if breaker is closed

6.2   Overcurrent Protection (50, 50N, 51, 51N)

General

Time-overcurrent protection is the main protective function of the 7SJ61 relay. It may be enabled or disabled for phase or ground faults, and may be configured with various time-overcurrent characteristic curves.

There are four definite time (Instantaneous elements with optional timers) and two inverse time-overcurrent elements in the device. The definite time elements include two phase elements and two ground elements. The definite time (Instantaneous) phase elements are designated 50-2 and 50-1, whereas the definite time (Instantaneous) ground elements are designated 50N-2 and 50N-1. The inverse time elements include a phase element designated as 51 and a ground element designated as 51N.

All overcurrent elements, inverse and definite time, enabled in the device may be blocked via an external signal to the binary inputs of the device. Removal of the external signal to the binary input will re-enable these elements. Also, a feature described as **Manual Close Mode** can be configured to improve fault clearing times associated with Switch-on-to-Fault Conditions. Under this situation, the time delay may be bypassed for one of the three time-overcurrent phase elements and one of the three time-overcurrent ground elements via an impulse from the external control switch, thus resulting in high speed tripping. This impuls is prolonged by a period of 300 ms. The phase and ground elements utilized for high speed tripping in this situation are selected at addresses 1213 and 1313 respectively.

Pickup and delay settings may be quickly adjusted to system requirements via Cold Load Pickup function (see Section 6.3).

Tripping by the 50-1, 51, 50N-1, and 51N elements may be blocked for inrush conditions by utilizing the inrush restraint feature (see Section 6.4).

6.2.1   Description of Instantaneous Overcurrent Protection

6.2.1.1   Definite Time, Instantaneous Overcurrent Protection (50, 50N)

The 50-2 and 50N-2 overcurrent elements, phase and ground currents are compared separately with the pickup values of the 50-2 and 50N-2 relay elements. Currents above the pickup values are detected and recorded within the protective relay. After the user-configured time delay has elapsed, a trip signal is issued.

Figure 6-11 shows the logic diagram for the 50-2 and 50N-2 protection.

The 50-1 and 50N-1 overcurrent elements, phase and ground currents are compared separately with the pickup values of the 50-1 and 50N-1 relay elements. Currents above the pickup values are detected and recorded within the protective relay. After the user-configured time delay has elapsed, a trip signal is issued.

If the inrush restraint feature is enabled (see Section 6.4), and an inrush condition exist, no tripping takes place, but a message is recorded and displayed indicating when the overcurrent element time delay elapses.

Different messages are recorded and displayed appear depending on whether tripping takes place or the time delay expires without tripping.

The dropout value of the definite time, time-overcurrent elements is roughly equal to 95 % of the pickup value for currents greater than or equal to 30 % of the nominal current of the device.

Figure 6-12 shows the logic diagram for the 50-1 and 50N-1 protection.

Pickup and delay settings for the 50-1, 50-2, 50N-1, and 50N-2 elements may be individually programmed.
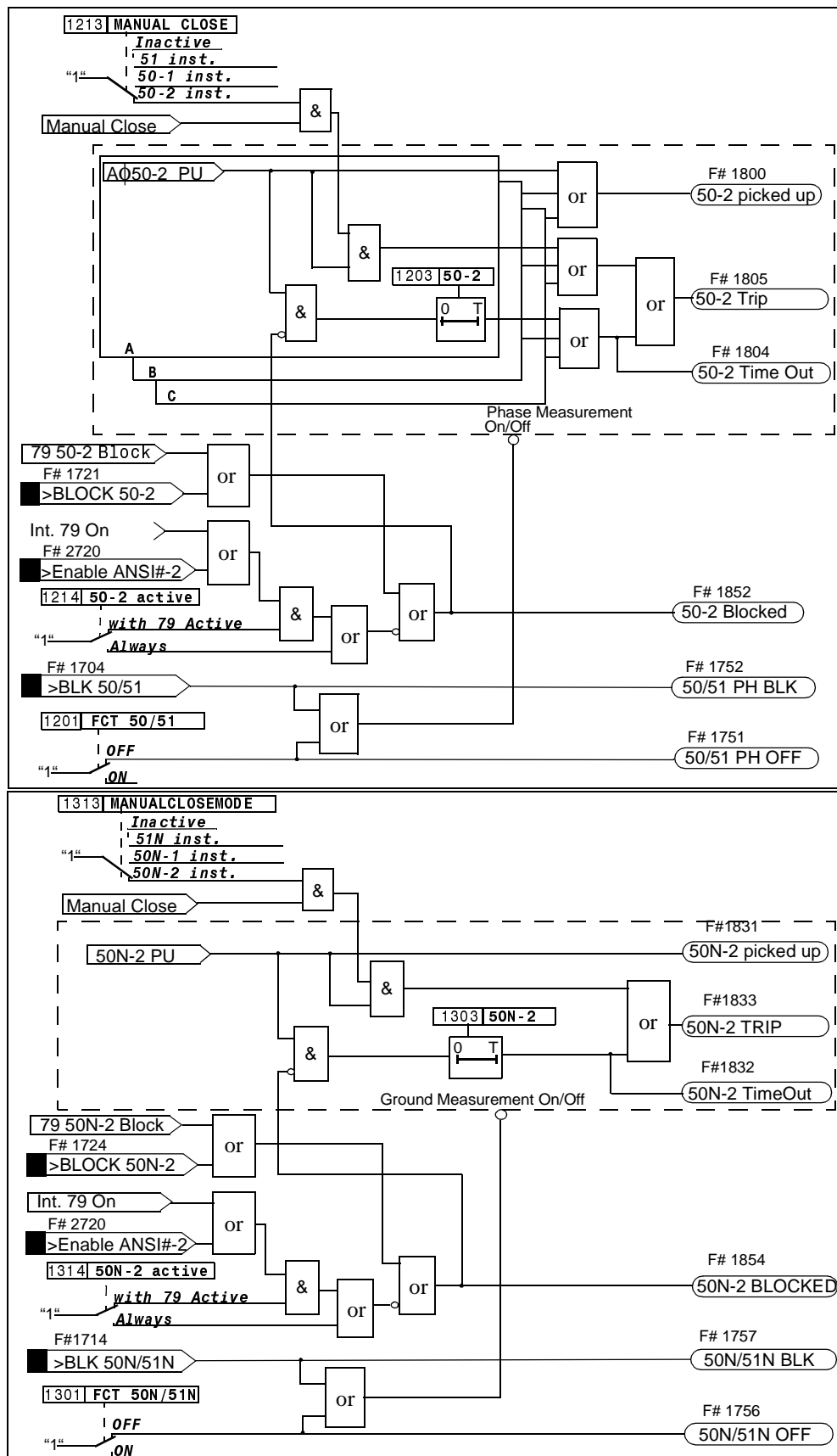
Figure 6-11   Logic Diagram for 50-2 and 50N-2 Relay Elements
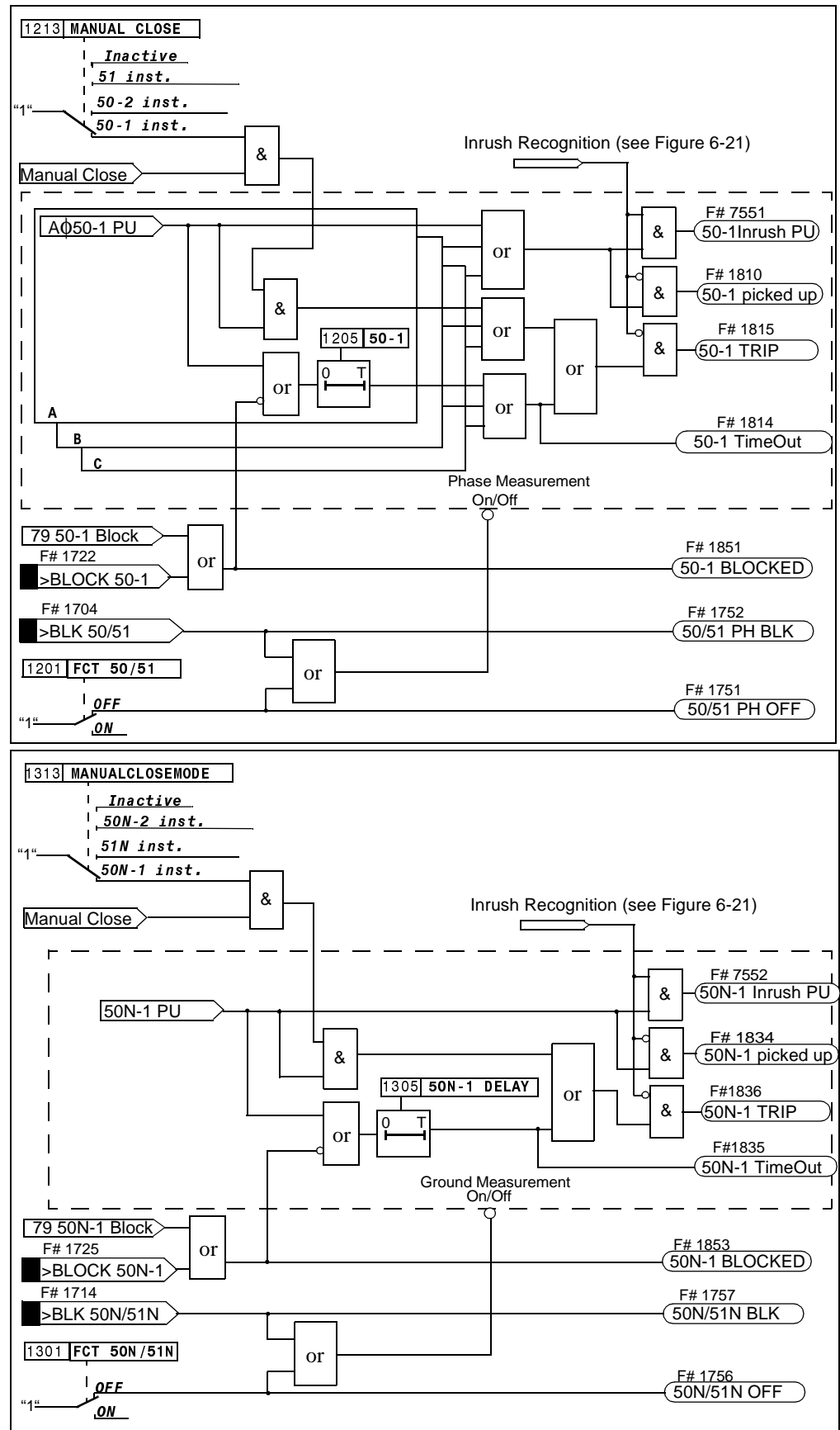
Figure 6-12   Logic Diagram for the 50-1 and 50N-1 Relay Elements

6.2.1.2   Inverse Time-Overcurrent Protection (51, 51N)

Inverse time-overcurrent protection, the 51 and 51N relay elements may contain IEC characteristic curves or ANSI characteristic curves depending on the model ordered. A user-specified curve may also be applied to the inverse-overcurrent relay elements. The curves and associated formulas are given in Technical Specifications (Figures 10-1 to 10-3 in Section 10.3). During configuration of the 51 and 51N characteristic curves, the definite time relay elements (50-2, 50-1, 50N-2, and 50N-1) are enabled (see Subsection 6.2.1.1).

Pickup and Tripping

Each phase and ground current is separately compared with the pickup values of the 51 and 51N relay elements. When the current in the 51 and 51N relay elements exceeds the corresponding pickup value by a factor of 1.1, the element picks up and a message is displayed and recorded within the device. Pickup of a 51 or 51N relay element is based on the rms value of the fundamental harmonic. When the 51 and 51N elements pickup, the time delay of the trip signal is calculated using an integrated measurement process. The calculated time delay is dependent on the actual fault current flowing and the selected time-current characteristic curve. Once the time delay elapses, a trip signal is issued.

If the inrush restraint feature is enabled (see Section 6.4), and an inrush condition exist, no tripping takes place, but a message is recorded and displayed indicating when the overcurrent element time delay elapses.

The characteristic curves of the 51 and 51N relay elements may be selected independently of each other. In addition, pickup, time multipliers, and time dials for the 51 and 51N elements may be individually set.

Figure 6-13 shows the logic diagram for the 51 and 51N protection.

Dropout for IEC Curves

Dropout of an element using an IEC curve occurs when the current decreases to about 95 % of the pickup value. When an element using an IEC curve drops out, the relay element immediately resets.

Dropout for ANSI Curves

Dropout of an element using an ANSI curve occurs when the current decreases to about 95 % of the pickup value if instantaneous reset is selected, or 90 % of the pickup value if disk emulation is selected. When instantaneous reset is selected, reset of the element occurs without delay. When disk emulation is selected, reset occurs just as it would for an electromechanical relay utilizing an induction disk.

For disk emulation, the reset process begins after fault current is interrupted. Reset corresponds to the unwinding of an induction disk. A subsequent pickup of the device element prior to full reset will result in a reduced tripping time delay. The reduced tripping time delay will be based on the degree to which the device had reset when the subsequent pickup occurred. When the current in the relay element is between 90 % and 95 % of the pickup value following dropout, neither disk movement in the tripping or reset direction is simulated. When the current in the relay elements falls below 5 % of the pickup value, disk emulation is canceled and full reset takes place.

Disk emulation offers advantages when the inverse time, time-overcurrent relay elements must be coordinated with conventional electromechanical overcurrent relays located toward the source.

User Specified Curves

When user specified curves are utilized, the time-current characteristic curve may be defined point by point. Up to 20 pairs of values (current, time) may be entered. The

relay element then approximates the curve using linear interpolation.

When utilizing user specified time-current curves, the reset curve may user specified as well. This is advantageous when the inverse time, time-overcurrent protection must be coordinated with conventional electromechanical overcurrent relays located toward the source. If user specified reset curves are not utilized, the relay element drops out when current decreases to about 95 % of the relay element's pickup value, and immediate reset takes place.
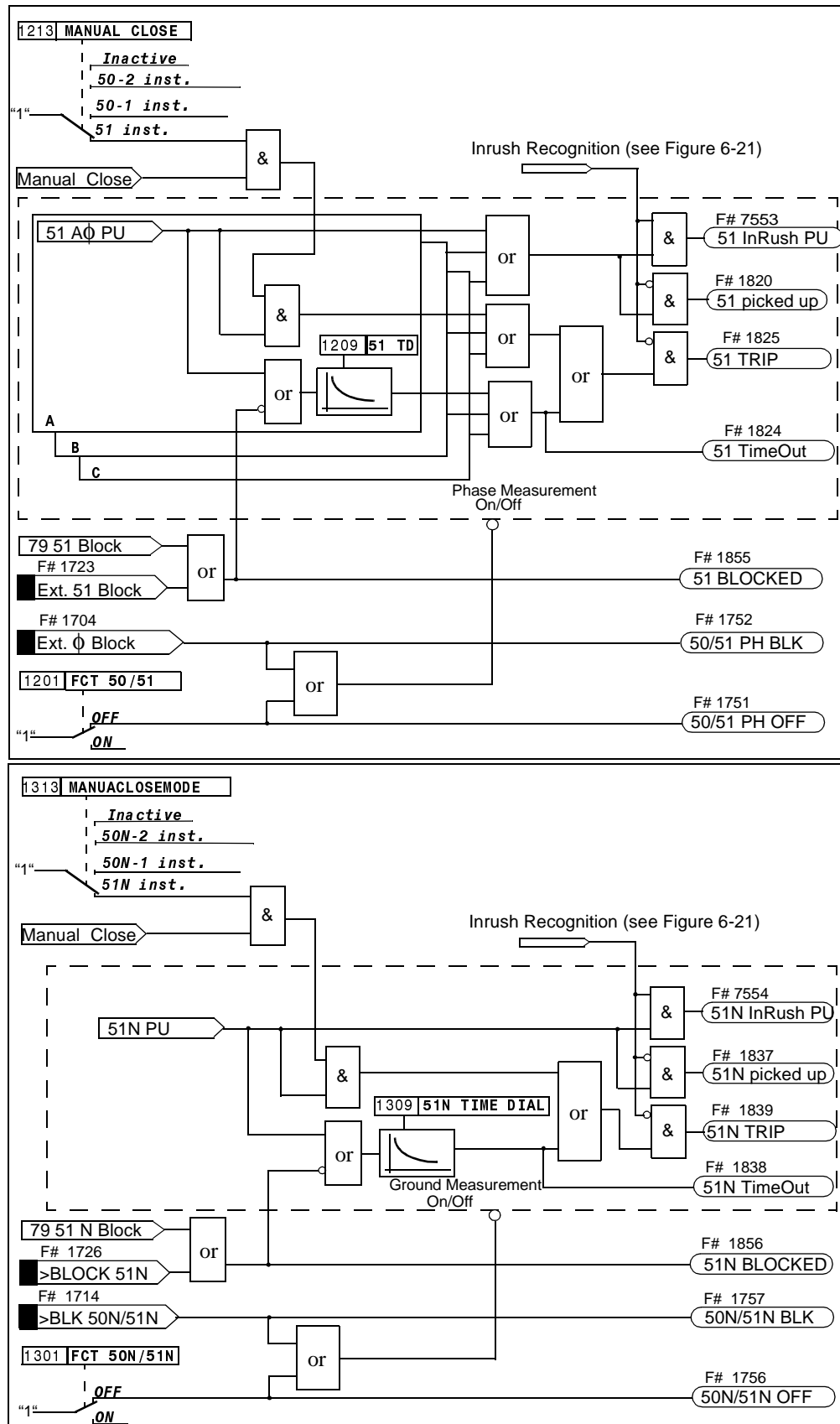
Figure 6-13　Logic Diagram of 51 and 51N Relay Elements

6.2.1.3 Reverse Interlocking Bus Protection

Application Example

The pickup of a time-overcurrent relay element may be blocked via binary inputs. At the users option, the binary inputs can be set up to block tripping when DC voltage is applied or when DC voltage is removed. Reverse interlocking allows for faster protection by eliminating the need for time-current coordination. Reverse interlocking is often used, for example, at generating stations in applications where a station supply transformer supplied from the transmission grid serves internal loads of the generation station via a medium voltage bus with multiple feeders (see Figure 6-14).

When the 7SJ61 relay is used as the source-side relay in a reverse interlocking scheme, a short time delay must be set for the 50-2 element so that a load-side relay has the chance to block tripping (Figure 6-14). The load-side relay should pickup immediately for down-line faults so that a blocking signal is immediately sent to the source-side relay's binary inputs. The load-side protective device can then initiate a time delayed trip, as long as the time delay is less than the time delay settings of the source-side relay's 50-1 and 50N-1 relay elements and the time multiplier settings of the source-side relay's 51 and 51N relay element. The source side relay's 50-1, 50N-1, 51 and 51N relay elements will provide redundant protection against faults in the load side relay's zone of protection since their associated time delay settings are greater than the load side relay's time delay setting.

Pickup messages generated by the load-side relay are passed to a binary input of the source-side relay as input message "`>50-2 block.`".
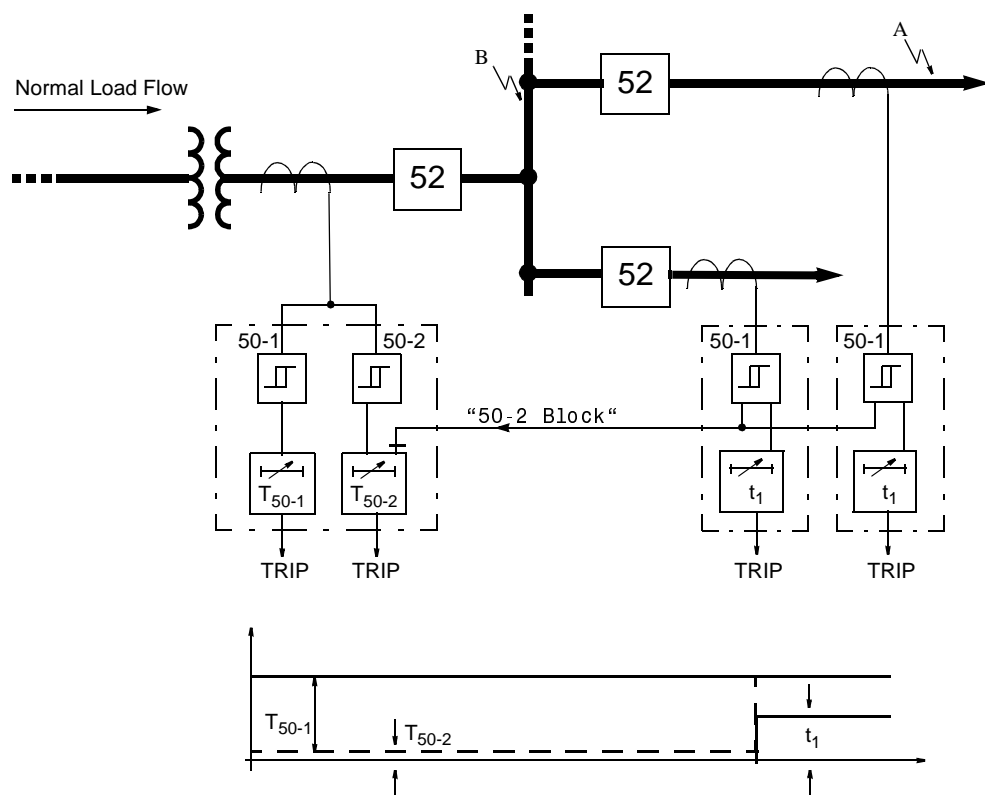
Fault Location B: Source-side Trip Time = T_{50-2} = Source side 50-2 Delay

Fault Location A: Load-side Trip Time = t_1
   Source-side Backup Trip Time = T_{50-1} = Source-side 50-1 Delay

Figure 6-14   Reverse Interlocking Protection Scheme

6.2.2   Programming Time-Overcurrent Settings

6.2.2.1   Programming Settings for Time-Overcurrent Phase Protection

General
The functions associated with time-overcurrent protection were established during configuration of protective functions (Section 5.1) at address 0112 **Charac. Phase**. If address 0112 was set to *Definite Time only*, then only the settings for the definite-time elements are available.

At address 1201 **FCT 50/51**, phase time-overcurrent protection may be switched *ON* or *OFF*.

50-2 Relay Element
The pickup and delay of the 50-2 relay element are set at addresses 1202 **50-2 PICKUP** and 1203 **50-2 DELAY** respectively. The 50-2 relay element is typically utilized for protection against high magnitude faults. For this reason, the relay element pickup is often set high while the delay is set short. It is always important to set the

pickup and delay such that operation of the 50-2 element will coordinate with other protective equipment in the system.

Below is an example of how a 50-2 relay element might be set to protect a power transformer in a radial distribution system against high magnitude internal faults:

Example: Transformer used to supply distribution bus with the following data:

Base Transformer Rating	16 MVA
Transformer Impedance (Z_{TX})	10 %
Nominal High Side Voltage	110 kV
Nominal Low Side Voltage	20 kV
Transformer Connection	Delta-Grounded Wye
High Side Fault MVA	1,000 MVA
High Side Current Transformer Ratio	100 A / 1 A
Low Side Current Transformer Ratio	500 A / 1 A

Based on the data above, the following are calculated:

Three-phase high side fault current @ 110kV	5250 A
Three-phase low side fault current @ 20kV	3928 A
Three-phase low side fault current @ 110kV	714 A
Transformer full load current @ 110kV ($I_{Base-110kV}$)	84 A
Transformer full load current @20kV ($I_{Base-20kV}$)	462 A
High side current transformer ratio (CTR-HS)	100 A / 1 A
Low side current transformer ratio (CTR-LS)	500 A / 1 A

The minimum pickup setting for the 50-2 element can be governed by a single inequality:

$$\text{50-2 Pickup} > \frac{1}{Z_{TX}} \times \frac{I_{Base-110kV}}{\text{CTR-HS}}$$

If the pickup of the 50-2 relay element is set according to the inequality above, the 50-2 element will never pickup for a fault beyond the transformer's low-side bushings, even if changing system conditions increase the high side fault MVA. Using the inequality above as a guide, a setting of 10.00 amperes is chosen for the 50-2 element.

At address 1203, a short time delay should be entered to prevent inrush currents from initiating false trips.

For motor protection, the 50-2 relay element must be set smaller than the smallest phase-to-phase fault current and larger than the largest motor starting current. Since the maximum motor starting current is generally on the order of 1.6 times the nominal motor current, the 50-2 phase element should be set as follows:

$$1{,}6 \cdot I_{startup} < \text{50-2 Pickup} < I_{\phi\phi-Min}$$

The potential increase in starting current caused by overvoltage conditions is already accounted for by the 1.6 factor. The 50-2 phase element may be set with no delay since, unlike the transformer, no saturation of the cross reactance occurs in a motor.

If the reverse interlocking principle is used (see Subsection 6.2.1.3), the 50-2 element can be employed in a high speed bus protection scheme. With a brief safety delay entered at address 1203 (50 ms), the 50-2 element can be blocked for faults beyond the

bus feeder breakers. The 50-1 element or 51 element will serve as redundant protection for the bus. The pickup values of both the 50-2 unit and the 50-1 or 51 unit are set equal to each other. The time delay associated with the 50-1 or 51 element is then time-coordinated with the individual bus feeder devices.

The delay set at address 1203 is in addition to the 50-2 pickup time. The delay of the 50-2 element may be set to ∞. The 50-2 element will then pickup and generate a message, but will never trip. If the 50-2 element is not required at all, then the pickup value should be set to ∞, thus preventing pickup, trip, and the generation of a message.

50-1 Relay Element

The pickup value of the 50-1 relay element (set at address 1204 **50-1 PICKUP**) should be set above the maximum anticipated load current. Pickup due to overload should never occur since the 50-1 relay element is designed only for fault protection. For this reason, a setting equal to 120 % of the expected peak load is recommended for line protection, and a setting equal to 140 % of the expected peak load is recommended for transformers and motors.

If the 7SJ61 relay is used to protect transformers with large inrush currents, the energization stabilization feature may be used to prevent a false trip of the 50-1 relay element. The configuration data for the inrush restraint feature is programmed at address block 22 (see Subsection 6.4.2).

The delay of the 50-1 element is set at address 1205 **50-1 DELAY** and should be based on system coordination requirements.

The delay set at address 1205 is in addition to the 50-1 element's pickup time. The delay of the 50-1 element may be set to ∞. The 50-1 element will then pickup and generate a message, but will never trip. If the 50-1 element is not required at all, then the pickup value should be set to ∞, thus preventing pickup, trip, and the generation of a message.

51 Relay Element With IEC Curves

Pickup of the 51 relay element will occur for currents greater than or equal to 110 % of the 51 element's pickup value, and may or may not occur for currents between 100 % and 110 % of the 51 element's pickup value. Dropout of the 51 relay element occurs when the current decreases to 95 % of the 51 element's pickup value.

The pickup of the 51 element is set at address 1207 **51 PICKUP**. As is the case for the 50-1 relay element, the pickup value of the 51 relay element should be set above the maximum anticipated load current. Pickup due to overload should never occur since the 51 relay element is designed only for fault protection. For this reason, a setting equal to 120 % of the expected peak load is recommended for line protection, and a setting equal to 140 % of the expected peak load is recommended for transformers and motors.

The 51 element time multiplication factor is set at address 1208 **51 TIME DIAL** and should be based on system coordination requirements.

The time multiplication factor may be set to ∞. The 51 element will then pickup and generate a message, but will never trip. If the 51 element is not required at all, address 0112 should set to *Definite Time only* during protective function configuration (see Section 5.1).

51 Relay Element With ANSI Curves

Pickup of the 51 relay element will occur for currents greater than or equal to 110 % of the 51 element's pickup value, and may or may not occur for currents between 100 % and 110 % of the 51 element's pickup value. Dropout of the 51 relay element occurs when the current decreases to 95 % of the 51 element's pickup value. If *Disk Emulation* is selected at address 1210 **51 Drop-out**, then reset occurs according to the reset curve as described in Subsection 6.2.1.2.

The pickup of the 51 element is set at address 1207 **51 PICKUP**. As is the case for the 50-1 relay element, the pickup value of the 51 relay element should be set above the maximum anticipated load current. Pickup due to overload should never occur since the 51 relay element is designed only for fault protection. For this reason, a setting equal to 120 % of the expected peak load is recommended for line protection, and a setting equal to 140 % of the expected peak load is recommended for transformers and motors.

The corresponding time dial is set at address 1209 **51 TIME DIAL** and should be based on system coordination requirements.

The time dial may be set to ∞. The 51 element will then pickup and generate a message, but will never trip. If the 51 element is not required at all, address 0112 should set to *Definite Time only* during protective function configuration (see Section 5.1).

Manual Close Mode

When a circuit breaker is closed into a faulted line, a high speed trip by the circuit breaker is often desired. The manual closing feature is designed to remove the delay from one of the time-overcurrent elements when a circuit breaker is manually closed into a fault. The time delay may be bypassed for one of the three time-overcurrent phase elements and one of the three time-overcurrent ground elements via an impulse from the external control switch, thus resulting in high speed tripping. This impuls is prolonged by a period of 300 ms. Address 1213 **MANUAL CLOSE** can be set such that the delay is defeated for the 50-2 element, the 50-1 element, the 51 element, or none of the elements (*Inactive*). Defeating the delay on just one of the three elements allows control over what level of fault current is required to initiate high speed tripping of a circuit breaker that is closed into a fault.

External control switch

If the manual closing signal is not from a 7SJ61, that is, neither via the built-in operator interface nor via a series interface, but, rather, directly from a control switch, this signal must be passed to a 7SJ61 binary input, and configured accordingly so that the element selected for high speed tripping will be effective.

Internal control function

The manual closing information must be routed via CFC (interlocking task-level) using the CMD_Information block, if the internal control function is used (see Figure 6-15).
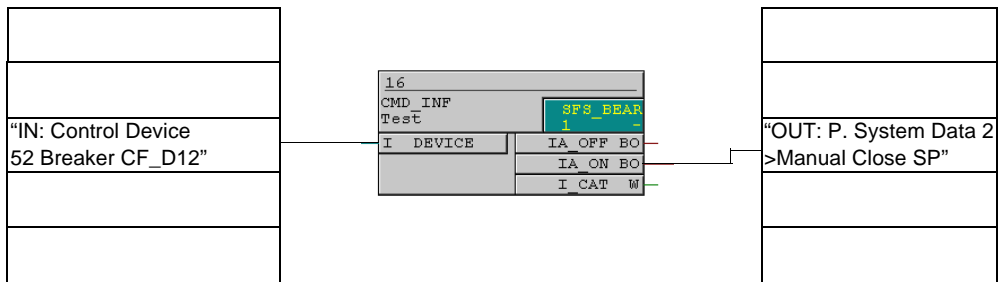
Figure 6-15   Example for manual close feature using the internal control function

Interaction with Automatic Reclosing Equipment

At address 1214 **50-2 active**, it can be specified whether or not the 50-2 elements should be supervised by the status of an internal or external automatic reclosing device. If address 1214 is set to *with 79 active*, the 50-2 elements will not operate unless automatic reclosing is not blocked. If address 1214 is set to *Always*, the 50-2 elements will always operate.

When reclosing occurs, it is desirable to have high speed protection against temporary faults. With address 1214 set to **with 79 active**, the 50-2 elements may be set for high speed tripping. If the fault still exists after the first reclose, the 50-2 elements can be blocked and the 50-1 and/or 51 elements will provide time delay tripping. For those situations where reclosing is disabled, the 50-2 elements are defeated and the 50-1 and/or 51 elements provide time delay tripping. In summary, setting address 1214 to **with 79 active** defeats one-shot, high-speed tripping via the 50-2 element for those situations where automatic reclosing is disabled.

When an external automatic reclosing device is utilized, a signal indicating that the device is enabled must be transmitted to the 7SJ61 relay via a binary input.

User Specified Characteristic Curves

When using DIGSI® 4 to modify settings, a dialog box is available to enter up to twenty pairs of values for a characteristic curve (see Figure 6-16).

Figure 6-16   Entry of a User Specified Characteristic Curve in DIGSI® 4

In order to represent the curve graphically, the user should click on **Characteristic**. The pre-entered curve will appear as shown in Figure 6-17.

The characteristic curve shown in the graph can be modified by placing the mouse cursor over a point on the curve, holding down the left mouse button, and dragging the data point to the desired new position. Releasing the mouse button will automatically update the value in the value table.

The upper limits of the value ranges are shown by dotted lines at the top and right extremes of the coordinate system. If the position of a data point lies outside these limits, the associated value will be set to "infinity".
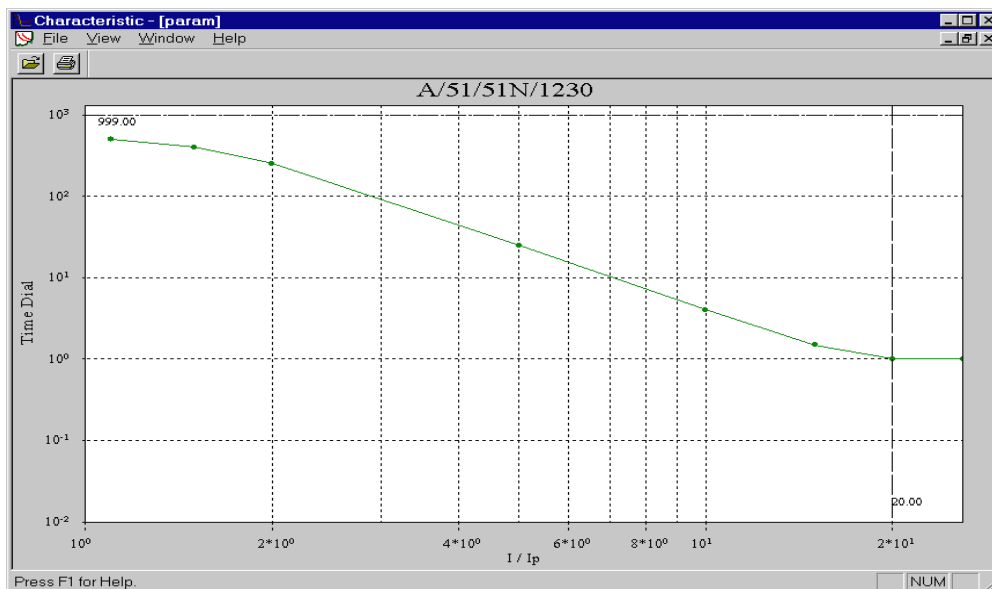
Figure 6-17   Visualization of a User Specified Characteristic Curve in DIGSI® 4

If address 0112 was set to **User Defined Pickup Curve** or **User Defined Pickup and Reset Curve** during configuration of the user-specified curve option, a maximum of 20 value pairs (current and time) may be entered at address 1230 **51/51N** to represent the time-current characteristic curve associated with the 51 element. This option allows point-by-point entry of any desired curve.

If address 0112 was set to **User Defined Pickup and Reset Curve** during configuration of the user-specified curve option, additional value pairs (current and reset time) may be entered at address 1231 **MofPU Res T/Tp** to represent the reset curve associated with the 51 element.

Current and time values are entered as multiples of the address 1207 and 1208 settings. Therefore, it is recommended that addresses 1207 and 1208 be initially set to **1.00** to simplify the calculation of these ratios. Once the curve is entered, the settings at addresses 1207 and 1208 may be modified if necessary.

Upon delivery of the device, all time values are set at ∞, preventing pickup of the device from initiating a trip signal.

When entering a user-specified curve, the following must be observed:

− Enter the data points in ascending order. The time overcurrent functions will sort the data points by current values in ascending order. The graphical representation displays the data points in the order they are entered.

− As few as 10 pairs of numbers may be entered at the user's option. Each unused pair must then be marked as unused by entering "∞" as for the time and current values. It is important to view the curve to ensure that it is clear and constant.

− Current flows which are less than the *smallest* current value entered will not lead to an extension of the tripping time beyond the time associated with the smallest current value entered. The characteristic curve (see Figure 6-18) represents constant tripping time for currents less than the *smallest* current value entered.

− Current flows which are greater than the *largest* current value entered will not lead to a reduction of the tripping time below the time associated with the largest current value entered. The characteristic curve (see Figure 6-18) represents constant tripping time for currents greater than the *largest* current value entered.

The time and current value pairs are entered at address 1231 to recreate the drop-down curve. The following must be observed:
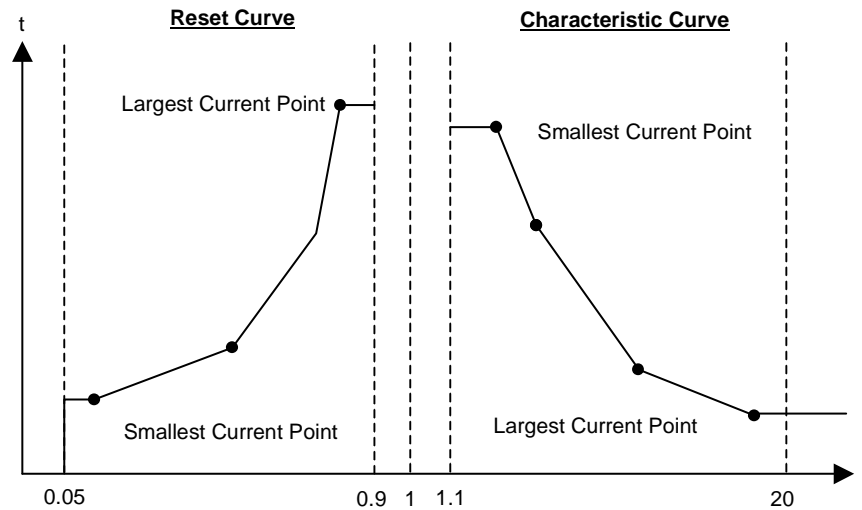
Figure 6-18   Use of a User-Specified Curve

− Current flows which are greater than the *largest* current value entered will not lead to an extension of the reset time beyond the time associated with the *largest* current value entered. The reset curve (see Figure 6-18) represents constant reset time for currents larger than the largest current value entered.

− Current flows which are less than the *smallest* current value entered will not lead to a reduction of the reset time below the time associated with the *smallest* current value entered. The reset curve (see Figure 6-18) represents constant reset time for currents smaller than the smallest current value entered.

− Current flows less than 0.05 * 51 pickup setting will cause immediate reset.

6.2.2.2   Settings for Phase Overcurrent Protection

In the list below, the setting ranges and default setting values for the pickup currents are for a device with a nominal current rating $I_N = 5$ A. For a nominal current rating $I_N = 1$ A, divide the Setting Options values and Default Setting values by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	Setting Title	Setting Options	Default Setting	Comments	Configuration				
					Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1201	FCT 50/51	ON OFF	ON	Time-overcurrent protection enabling	X	X	X	X	X

Addr.	Setting Title	Setting Options	Default Setting	Comments	Configuration				
					Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1202	50-2 PICKUP	0.50 ~ 175.00 A	10.00 A	Pickup setting of the 50-2 element	X	X	X	X	X
1203	50-2 DELAY	0.00 ~ 60.00 sec	0.00 sec	Delay setting of the 50-2 element	X	X	X	X	X
1204	50-1 PICKUP	0.50 ~ 175.00 A	5.00 A	Pickup setting of the 50-1 element	X	X	X	X	X
1205	50-1 DELAY	0.00 ~ 60.00 sec	0.50 sec	Delay setting of the 50-1 element	X	X	X	X	X
1207	51 PICKUP	0.50 ~ 20.00 A	5.00 A	Pickup setting of the 51 element		X	X	X	X
1208	51 TIME DIAL	0.05 ~ 3.20 sec	0.50 sec	Time multiplier T Ip, IEC and User Defined Curves		X		X	X
1209	51 TIME DIAL	0.50 ~ 15.00	5.00 sec	Time dial setting, ANSI			X		
1210	51 Drop-out	Instantaneous Disk Emulation	Disk Emulation	Characteristics of 51 dropout		X			X
1211	51 IEC CURVE	Normal Inverse Very Inverse Extremely Inverse Long Inverse	Normal Inverse	Characteristic curve (IEC)		X X X X			
1212	51 ANSI CURVE	Very Inverse Inverse Short Inverse Long Inverse Moderately Inverse Extremely Inverse Definite Inverse	Very Inverse	Characteristic curve (ANSI)			X X X X X X X		
1213	MANUAL CLOSE	50-2 Instantaneously 50-1 Instantaneously 51 Instantaneously Inactive	50-2 Instantaneously	Selection of high speed tripping element when manual closing feature is used	X	X	X	X	X
1214	50-2 active[1])	Always with 79 active	Always	Criteria for operation of 50-2 element	X	X	X	X	X
1230	51/51N			51 user defined characteristic curve values				X	X
1231	MofPU Res T/ Tp			51 reset user defined curve values					X

[1]) only available with 79 function is enabled

6.2.2.3 Information List for Phase Overcurrent Protection

F#	LCD-Text	Comment
1761	50(N)/51(N) PU	50(N)/51(N) O/C GENERAL PICKUP
1791	50(N)/51(N)TRIP	50(N)/51(N) GENERAL TRIP

F#	LCD-Text	Comment
1751	50/51 PH OFF	50/51 O/C switched OFF
1752	50/51 PH BLK	50/51 O/C is BLOCKED
1753	50/51 PH ACT	50/51 O/C is ACTIVE
1762	50/51 Ph A PU	50/51 Phase A picked up
1763	50/51 Ph B PU	50/51 Phase B picked up
1764	50/51 Ph C PU	50/51 Phase C picked up
1800	50-2 picked up	50-2 picked up
1805	50-2 TRIP	50-2 TRIP
1810	50-1 picked up	50-1 picked up
1815	50-1 TRIP	50-1 TRIP
1820	51 picked up	51 picked up
1825	51 TRIP	51 TRIP
1866	51 Disk Pickup	51 Disk emulation Pickup
1804	50-2 TimeOut	50-2 Time Out
1814	50-1 TimeOut	50-1 Time Out
1824	51 Time Out	51 Time Out
1851	50-1 BLOCKED	50-1 BLOCKED
1852	50-2 BLOCKED	50-2 BLOCKED
1855	51 BLOCKED	51 BLOCKED
1704	>BLK 50/51	>BLOCK 50/51
1721	>BLOCK 50-2	>BLOCK 50-2
1722	>BLOCK 50-1	>BLOCK 50-1
1723	>BLOCK 51	>BLOCK 51

6.2.2.4 Programming Settings for Time-Overcurrent Ground Protection

General
The functions associated with time-overcurrent protection were established during configuration of protective functions (Section 5.1) at address 0113. If address 0113 was set equal to *Definite Time only*, then only the settings for the definite-time elements are available.

At address 1301 **FCT 50N/51N**, ground time-overcurrent protection may be switched **ON** or **OFF** independent of the phase time-overcurrent protection.

Pickup values, time delays, and characteristic curves for ground protection are set separately from the pickup values, time delays and characteristic curves associated

with phase protection. Because of this, relay coordination for ground faults is independent of relay coordination for phase faults, and more sensitive settings can often be applied to ground protection.

50N-2 Relay Element

The pickup and delay of the 50N-2 relay element are set at addresses 1302 **50N-2 PICKUP** and 1303 **50N-2 DELAY** respectively. The same considerations apply for these settings as did for 50-2 settings discussed earlier.

The delay set at address 1303 is in addition to the 50N-2 element's pickup time. The delay of the 50N-2 element may be set to ∞. The 50N-2 element will then pickup and generate a message, but will never trip. If the 50N-2 element is not required at all, then the pickup value should be set to ∞, thus preventing pickup, trip, and the generation of a message.

50N-1 Relay Element

The pickup value of the 50N-1 relay element (set at address 1304 **50N-1 PICKUP**) should be set below the minimum anticipated ground fault current in the relay's zone of protection.

If the 7SJ61 relay is used to protect transformers or motors with large inrush currents, the energization stabilization feature may be used to prevent a false trip of the 50N-1 relay element. The configuration data for the energization stabilization feature is programmed at address block 22 (see Subsection 6.4.2).

The delay of the 50N-1 element is set at address 1305 **50N-1 DELAY** and should be based on system coordination requirements.

The delay set at address 1305 is in addition to the 50N-1 element's pickup time. The delay of the 50N-1 element may be set to ∞. The 50N-1 element will then pickup and generate a message, but will never trip. If the 50N-1 element is not required at all, then the pickup value should be set to ∞, thus preventing pickup, trip, and the generation of a message.

51N Relay Element with IEC Curves

Pickup of the 51N relay element will occur for currents greater than or equal to 110 % of the 51N pickup value, and may or may not occur for currents between 100 % and 110 % of the 51 element's pickup value. Dropout of the 51N relay element occurs when the current decreases to 95 % of the 51N element's pickup value.

The pickup value of the 51N element is set at address 1307 **51N PICKUP**. As is the case for the 50N-1 relay element, the pickup value of the 51N relay element should be set below the minimum anticipated ground fault current in the relay's zone of protection.

The 51N element time multiplication factor is set at address 1308 **51N TIME DIAL** and should be based on system coordination requirements.

The time multiplication factor may also be set to ∞. The 51N element will then pickup and generate a message, but will never trip. If the 51N element is not required at all, address 0113 should be set to *Definite Time Only* during protective function configuration (see Section 5.1).

51N Relay Element with ANSI Curves

Pickup of the 51N relay element will occur for currents greater than or equal to 110 % of the 51N pickup value, and may or may not occur for currents between 100 % and 110 % of 51N pickup value. Dropout of the 51N relay element occurs when the current decreases to 95 % of the 51N element's pickup value. If *Disk Emulation* is selected at address 1310 **51N RESET**, then reset occurs according to the reset curve as described in Subsection 6.2.1.2.

The pickup of the 51N element is set at address 1307 **51N PICKUP**. As is the case for the 50N-1 relay element, the pickup value of the 51N relay element should be set below the minimum anticipated ground fault current in the relay's zone of protection.

The corresponding time dial is set at address 1309 **51N TIME DIAL** and should be based on system coordination requirements.

The time dial may be set to ∞. The 51N element will then pickup and generate a message, but will never trip. If the 51N element is not required at all, address 0113 should be set to *Definite Time Only* during protective function configuration (Section 5.1).

Manual Close Mode   When a circuit breaker is closed into a faulted line, a high speed trip by the circuit breaker is often desired. The relay's manual closing feature is designed to remove the delay from one of the time-overcurrent elements when a circuit breaker is manually closed into a fault. The time delay may be bypassed for one of the three time-overcurrent phase elements and one of the three time-overcurrent ground elements via an impulse from the external control switch, thus resulting in high speed tripping. This impuls is prolonged by a period of 300 ms. Address 1313 **MANUALCLOSEMODE** can be set such that the delay is defeated for the 50N-2 element, the 50N-1 element, the 51N element, or none of the elements (*Inactive*). Defeating the delay on just one of the three elements allows control over what level of fault current is required to initiate high speed tripping of a circuit breaker that is closed into a fault.

If the manual closing signal is not from a 7SJ61, that is, neither via the built-in operator interface nor via a series interface, but, rather, directly from a control acknowledgment switch, this signal must be passed to a 7SJ61 binary input, and configured accordingly so that the element selected for high speed tripping will be effective.

Interaction with Automatic Reclosing Equipment   At address 1314 **50N-2 active**, it can be specified whether or not the 50N-2 elements should be supervised by the status of an internal or external automatic reclosing device. If address 1314 is set to *with 79 active*, the 50N-2 elements will not operate unless automatic reclosing is enabled. If address 1314 is set to *Always*, the 50N-2 elements will always operate.

User-Specified Curves   If address 0113 was set to *User Defined Pickup Curve* or *User Defined Pickup and Reset Curve* during configuration of the user-specified curve option, a maximum of 20 value pairs (current and time) may be entered at address 1330 **50N/51N** to represent the time-current characteristic curve associated with the 51N element. This option allows point-by-point entry of any desired curve.

If address 0113 was set to *User Defined Pickup and Reset Curve* during configuration of the user-specified curve option, additional value pairs (current and reset time) may be entered at address 1331 **MofPU Res T/TEp** to represent the reset curve associated with the 51N element.

Current and time values are entered as multiples of the address 1307 and 1308 settings. Therefore, it is recommended that addresses 1307 and 1308 be initially set to 1.00 to simplify the calculation of these ratios. Once the curve is entered, the settings at addresses 1307 and 1308 may be modified if necessary.

Upon delivery of the device, all time values are set at ∞, preventing pickup of the device from initiating a trip signal.

When entering user-specified curve data, the same instructions apply as in Subsection 6.2.2.1 for the phase elements.

6.2.2.5 Settings for Ground Overcurrent Protection

In the list below, the setting ranges and default setting values for the pickup currents are for a device with a nominal current rating I_N = 5 A. For a nominal current rating I_N = 1 A, divide the Setting Options values and Default Setting values by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	LCD-Text	Setting Options	Default Setting	Comments	Configuration				
					Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1301	FCT 50N/51N	ON OFF	ON	Time-overcurrent protection enabling	X	X	X	X	X
1302	50N-2 PICKUP	0.25 ~ 175.00 A	2.50 A	Pickup setting of the 50N-2 element	X	X	X	X	X
1303	50N-2 DELAY	0.00 ~ 60.00 sec	0.10 sec	Delay setting of the 50N-2 element	X	X	X	X	X
1304	50N-1 PICKUP	0.25 ~ 175.00 A	1.00 A	Pickup setting of the 50N-1 element	X	X	X	X	X
1305	50N-1 DELAY	0.00 ~ 60.00 sec	0.50 sec	Delay setting of the 50N-1 element	X	X	X	X	X
1307	51N PICKUP	0.50 ~ 20.00 A	1.00 A	Pickup setting of the 51N element		X	X	X	X
1308	51N TIME DIAL	0.05 ~ 3.20 sec	0.20 sec	Time multiplier T IGp, IEC and User Defined Curves		X		X	X
1309	51N TIME DIAL	0.50 ~ 15.00	5.00 sec	Time dial setting, ANSI			X		
1310	51N RESET	Instantaneous Disk Emulation	Disk Emulation	Characteristics of 51N dropout			X		X
1311	51N IEC CURVE	Inverse Very Inverse Extremely Inverse Long Inverse	Inverse	Characteristic curve (IEC)		X X X X X			X X X X X
1312	51N ANSI CURVE	Very Inverse Inverse Short Inverse Long inverse Moderately Inv. Extremely Inverse Definite Inverse	Very inverse	Characteristic curve (ANSI)			X X X X X X X		

Addr.	LCD-Text	Setting Options	Default Setting	Comments	Configuration				
					Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1313	MANUALCLOSEMODE	50N-2 Instantaneously 50N-1 Instantaneously 51N Instantaneously Inactive	50N-2 Instantaneously	Selection of high speed tripping element when manual closing feature is used	X	X	X	X	X
1314	50N-2 active	Always with 79 active	Always	Criteria for operation of 50N-2 element	X	X	X	X	X
1330	50N/51N			51N user defined characteristic curve values				X	X
1331	MofPU Res T/TEp			51N user defined characteristic curve reset values					X

6.2.2.6 Information List for Ground Overcurrent Protection

F#	LCD-Text	Comment
1761	50(N)/51(N) PU	50(N)/51(N) O/C PICKUP
1791	50(N)/51(N)TRIP	50(N)/51(N) TRIP

F#	LCD-Text	Comment
1756	50N/51N OFF	50N/51N is OFF
1757	50N/51N BLK	50N/51N is BLOCKED
1758	50N/51N ACT	50N/51N is ACTIVE
1831	50N-2 picked up	50N-2 picked up
1833	50N-2 TRIP	50N-2 TRIP
1834	50N-1 picked up	50N-1 picked up
1836	50N-1 TRIP	50N-1 TRIP
1837	51N picked up	51N picked up
1839	51N TRIP	51N TRIP
1867	51N Disk Pickup	51N Disk emulation picked up
1832	50N-2 TimeOut	50N-2 Time Out
1835	50N-1 TimeOut	50N-1 Time Out
1838	51N TimeOut	51N Time Out
1765	50N/51NPickedup	50N/51N picked up
1853	50N-1 BLOCKED	50N-1 BLOCKED
1854	50N-2 BLOCKED	50N-2 BLOCKED

F#	LCD-Text	Comment
1856	51N BLOCKED	51N BLOCKED
1714	>BLK 50N/51N	>BLOCK 50N/51N
1724	>BLOCK 50N-2	>BLOCK 50N-2
1725	>BLOCK 50N-1	>BLOCK 50N-1
1726	>BLOCK 51N	>BLOCK 51N

6.3   Dynamic Cold Load Pick-Up Function (50c, 50Nc, 51Nc)

General

With the dynamic cold load pick-up feature, it is possible to dynamically increase the pickup values of the overcurrent relay elements when dynamic cold load pickup conditions are anticipated (i.e. after a long period of zero voltage). By allowing pickup settings to increase dynamically, it is not necessary to incorporate dynamic cold load capability in the normal pickup settings, and overcurrent protection may be set more sensitive.

> *Note:*
>
> Dynamic Cold Load Pickup is in addition to the 4 setting groups (A to D), which are configured separately.

6.3.1   Description of Dynamic Cold Load Pick-Up Function

Effect

The dynamic cold load pick-up function is enabled at address 1701. When using it , there are two primary methods used by the device to determine if the protected equipment is de-energized:

- Via a binary input, an auxiliary contact in the circuit breaker can be used to determine if the circuit breaker is open or closed. If the circuit breaker is open, the equipment will be considered de-energized. If this method is chosen, address 1702 **Start Condition** should be set to *Breaker Contact*.

- The current flow monitoring threshold (Subsection 6.1.1) may be used to determine if the equipment is de-energized. If this method is chosen, address 1702 should be set to *No Current*.

If the device determines the protected equipment is de-energized via one of the methods above, then the higher pickup values will become effective for the relay elements once a specified time delay has elapsed. The **CB Open Time**, set at address 1703 , controls how long the equipment can be de-energized before the dynamic cold load pick-up function is activated. Figure 6-20 shows the logic diagram for dynamic cold load pick-up function. When the protected equipment is re-energized (i.e. the device receives input via a binary input that the circuit breaker is closed or the current flowing through the circuit breaker increases above the current flow monitoring threshold set at address 0212), a second time delay referred to as the **Active Time** is initiated. Once the **Active Time** elapses, the pickup values of the relay elements return to their normal settings. The **Active Time** is set at address 1704 and controls how long dynamic cold load pick-up settings remain in place once the equipment is re-energized. Upon re-energizing of the equipment, if the measured current values are below the normal pickup settings, an alternative time delay referred to as the **Stop Time** is also initiated. As in the case with the **Active Time**, once the **Stop Time** elapses, the pickup values of relay elements change from the dynamic cold load pickup values to their normal settings. The **Stop Time** is set at address 1705 and controls how long dynamic cold load pick-up settings remain in place given that measured currents are below the normal pickup settings. This **Stop Time** is typically set very short since the actual measurement of currents indicates dynamic cold load conditions will not inadvertently pickup the relay elements. To defeat the **Stop Time** from switching the relay element pickup settings back to normal, it may be set to ∞ or blocked via a binary input.

If a relay element picks up while the dynamic settings are enabled, elapse of the **Active Time** or **Stop Time** will not restore the normal pickup settings until drop out of the relay element occurs based on the dynamic settings.

If the dynamic cold load pick-up function is blocked via a binary input, all triggered timers will be immediately reset and all normal settings will be restored. If blocking occurs during an on-going fault with dynamic cold load pick-up functions enabled, the timers of all overcurrent relay elements will be stopped, and then restarted based on their normal duration.

During power up of the protective relay with an open circuit breaker, the time delay set at address 1703 **CB Open Time** is started, and is processed using the normal settings. Therefore, when the circuit breaker is closed, the normal settings are effective.

Figure 6-19 shows a timing diagram, Figure 6-20 describes the logic for cold load pick-up function.
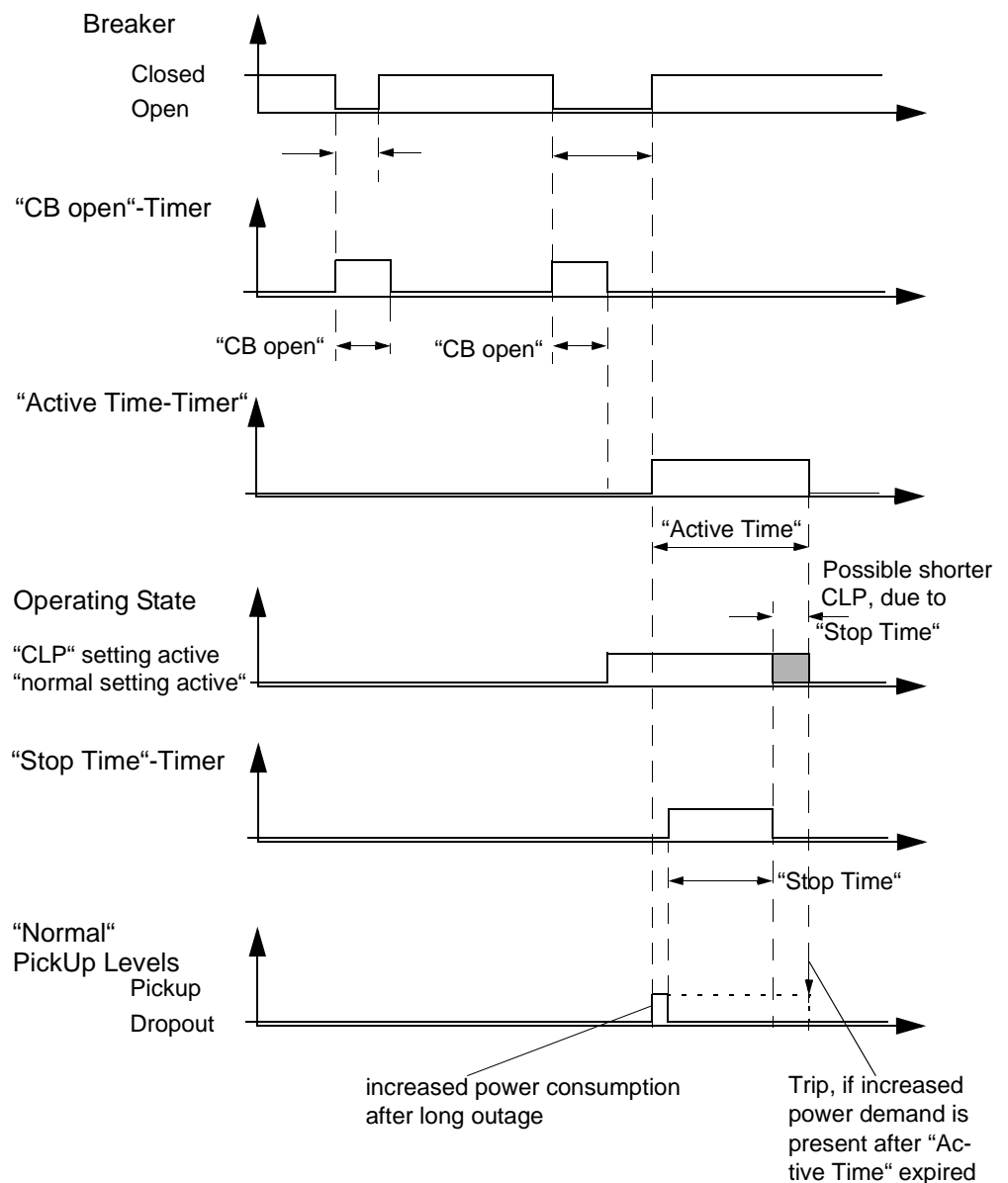
Figure 6-19   Cold Load Pickup Timing Sequence
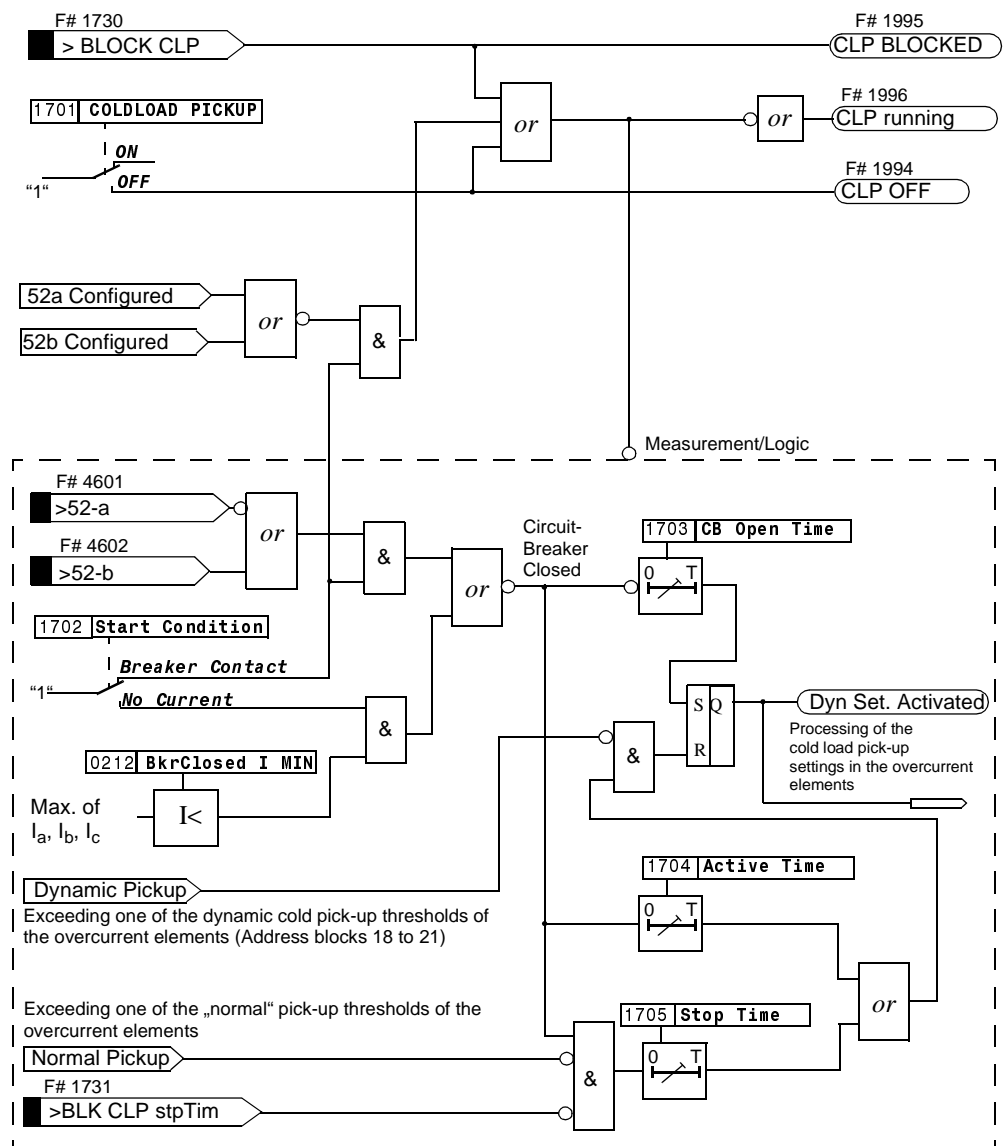
Figure 6-20   Logic Diagram for Dynamic Cold Load Pickup Feature

6.3.2   Programming Settings

General

Dynamic cold load Pickup feature can only be enabled if address 0117 **Coldload Pickup** was set to **Enabled** during configuration of protective functions. If the function is not required, address 0117 should be set to **Disabled**.

Time Delays

There are no specific procedures on how to set the time delays at addresses 1703 **CB Open Time**, 1704 **Active Time** and 1705 **Stop Time**. These time delays must be based on the specific loading characteristics of the equipment being protected, and should be selected to allow the brief overloads associated with dynamic cold load conditions.

Phase Elements   The dynamic pickup values and time delays associated with non-directional overcurrent phase protection are set at address block 18.

The dynamic pickup and delay settings for the 50-2 element are set at addresses 1801 **50c-2 PICKUP** and 1802 **50c-2 DELAY** respectively; the dynamic pickup and delay settings for the 50-1 element are set at addresses 1803 **50c-1 PICKUP** and 1804 **50c-1 DELAY** respectively; and the pickup, time multiplier (for IEC curves), and time dial (for ANSI curves) settings for the 51 element are set at addresses 1805 **51c PICKUP**, 1806, and 1807 respectively (**51c TIME DIAL**).

Ground Elements   The dynamic pickup values and time delays associated with non-directional overcurrent ground protection are set at address block 19.

The dynamic pickup and delay settings for the 50N-2 element are set at addresses 1901 **50Nc-2 PICKUP** and 1902 **50Nc-2 DELAY** respectively; the dynamic pickup and delay settings for the 50N-1 element are set at addresses 1903 **50Nc-1 PICKUP** and 1904 **50Nc-1 DELAY** respectively; and the pickup, time multiplier (for IEC curves), and time dial (for ANSI curves) settings for the 51N element are set at addresses 1905 **51Nc PICKUP**, 1906, and 1907 respectively (**51Nc T-DIAL**).

6.3.2.1   Settings for Dynamic Cold Load Adjustments

In the list below, the setting ranges and default setting values for the pickup currents are for an equipment with a nominal current rating $I_N = 5$ A. For a nominal current rating $I_N = 1$ A, divide the Setting Options values and Default Setting values by 5. Consider the current transformer ratios when setting the equipment with primary values.

Addr.	Setting	Setting Options	Default Setting	Comment	Configuration				
					Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1701	COLD LOAD PICKUP	OFF ON	OFF	Dyn. Cold Load Setting Adj. On/Off	X	X	X	X	X
1702	Start Condition	No Current Breaker Contact	No Current	Dyn. Cold Load Setting Adj. Arming Condition	X	X	X	X	X
1703	CB Open Time	0 ~21600 s	3600 s	Dyn. Cold Load Setting Adj. Arming Time	X	X	X	X	X
1704	Active Time	1 ~21600 s	3600 s	Dyn. Cold Load Setting Adj. Active Time	X	X	X	X	X
1705	Stop Time	1 ~600 s	600 s	Dyn. Cold Load Setting Adj. Active Time With Normal I	X	X	X	X	X

Addr.	CLP–Setting	Setting Options	Default Setting	Addr.	Normal Setting	Configuration				
						Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1801	50c-2 PICKUP	0.50 ~ 175.00 A	50.00 A	1202	50-2 PICKUP	X	X	X	X	X
1802	50c-2 DELAY	0.00 ~ 60.00 sec.	0.00 sec.	1203	50-2 DELAY	X	X	X	X	X
1803	50c-1 PICKUP	0.50 ~ 175.00 A	10.00 A	1204	50-1 PICKUP	X	X	X	X	X
1804	50c-1 DELAY	0.00 ~ 60.00 sec.	0.30 sec.	1205	50-1 DELAY	X	X	X	X	X
1805	51c PICKUP	0.50 ~ 20.00 A	7.50 A	1207	51 PICKUP		X	X	X	X
1806	51c TIME DIAL	0.05 ~ 3.20 sec.	0.50 sec.	1208	51 TIME DIAL, IEC		X		X	X
1807	51c TIME DIAL	0.5 ~ 15.00	5.00 sec.	1209	51 TIME DIAL, ANSI			X		

Addr.	Setting	Setting Options	Default Setting	Addr.	Normal Setting	Configuration				
						Definite Time Only	IEC Curve	ANSI Curve	User Defined Pickup	User def. Reset
1901	50Nc-2 PICKUP	0.25 ~ 175.00 A	35.00 A	1302	50N-2 PICKUP	X	X	X	X	X
1902	50Nc-2 DELAY	0.00 ~ 60.00 sec.	0.00 sec.	1303	50N-2 DELAY	X	X	X	X	X
1903	50Nc-1 PICKUP	0.25 ~ 175.00 A	7.50 A	1304	50N-1 PICKUP	X	X	X	X	X
1904	50Nc-1 DELAY	0.00 ~ 60.00 sec.	0.30 sec.	1305	50N-1 DELAY	X	X	X	X	X
1905	51Nc PICKUP	0.50 ~ 20.00 A	5.00 A	1307	51N PICKUP		X	X	X	X
1906	51Nc T-DIAL	0.05 ~ 3.20 sec.	0.50 sec.	1308	51N TIME DIAL, IEC		X		X	X
1907	51Nc T-DIAL	0.5 ~ 15.00	5.00	1309	51N TIME DIAL, ANSI			X		

6.3.2.2 Information List for Dynamic Cold Load Setting Adjustments

F#	LCD-Text	Comment
1994	CLP OFF	Cold-Load-Pickup switched off
1995	CLP BLOCKED	Cold-Load-Pickup is blocked
1996	CLP running	Cold-Load-Pickup is running
1997	Dyn set. ACTIVE	Dynamic settings are active
1730	>BLOCK CLP	>Block Cold-Load-Pickup
1731	>BLK CLP stpTim	>Block Cold-Load-Pickup stop timer

6.4   Inrush Restraint

General

When the 7SJ61 relay is installed to protect a power transformer, large magnetizing inrush currents will flow when the transformer is energized. These inrush currents may be several times the nominal transformer current, and, depending on the transformer size and design, may last from several milliseconds to several seconds.

Although pickup of the relay elements is based only on the fundamental harmonic component of the measured currents, false device pickup due to inrush is still a potential problem since, depending on the transformer size and design, the fundamental harmonic comprises a large component of the inrush current.

6.4.1   Description of Inrush Restraint

Principle

The 7SJ61 features an integrated inrush restraint function that may be utilized when the device is installed at or near a transformer. It supervises the "normal" tripping of all directional and non-directional overcurrent relay elements with the exception of the 50-2, 50N-2, 67-2 and 67N-2 relay elements. For example, when a transformer is energized the current levels may exceed the normal pickup of the overcurrent elements set in the device. If inrush conditions are identified (the 2nd harmonic content of current exceeds the value of setting at address 2202 **2nd HARMONIC**), special inrush messages are created within the device that will block tripping of the overcurrent elements. Note, that only the tripping elements are affected by harmonic inrush detection, the pickup values and corresponding timers continue to operate normally. If inrush conditions are still present after the tripping time delay has elapsed, a corresponding message is displayed and recorded, but the overcurrent tripping is blocked. (see Figures 6-12 and 6-13).

Inrush current contains a relatively large second harmonic component which is nearly absent during a short-circuit fault. Inrush current detection, therefore, is based on the evaluation of the second harmonic component present during inrush conditions. For frequency analysis, digital filters are used to conduct a Fourier analysis of all three phase currents and the ground current. As soon as the second harmonic component of the current flowing in a specific phase or ground relay element exceeds a set value, tripping is blocked for that element (does not apply to 50-2, 50N-2, 67-2, and 67N-2 elements). Since quantitative analysis of the harmonic components of the current flowing through a specific relay element cannot be completed until a full cycle of inrush current has been measured, inrush restraint blocking, and the associated inrush detection message, is automatically delayed by one cycle. It is important to note, however, that the tripping time delays associated with the relay elements are started immediately after pickup of the relay element, even if the inrush conditions are detected. If inrush blocking drops out during the time delay, tripping will occur when the time delay of the element elapses. If inrush blocking drops out after the time delay has elapsed, tripping will occur immediately. Therefore, utilization of the inrush restraint feature will not result in any additional tripping delays. If a relay element drops out during inrush blocking, the associated time delay will reset.

Cross Blocking

Since inrush restraint operates individually for each phase, inrush restraint will not block tripping in situations where a power transformer is energized into a single-phase fault and inrush currents are detected on the unfaulted phases. This feature provides maximum protection, however, inrush restraint can be configured to allow inrush detection on one phase to block tripping by the elements associated with the other phas-

es. This is referred to as cross-blocking and can be enabled at address 2203. Inrush currents flowing in the ground path will not cross-block tripping by the phase elements.

The cross-blocking function may also be limited to a particular time interval, which can be set at address 2204. After expiration of this time interval, the cross-blocking function will be disabled.
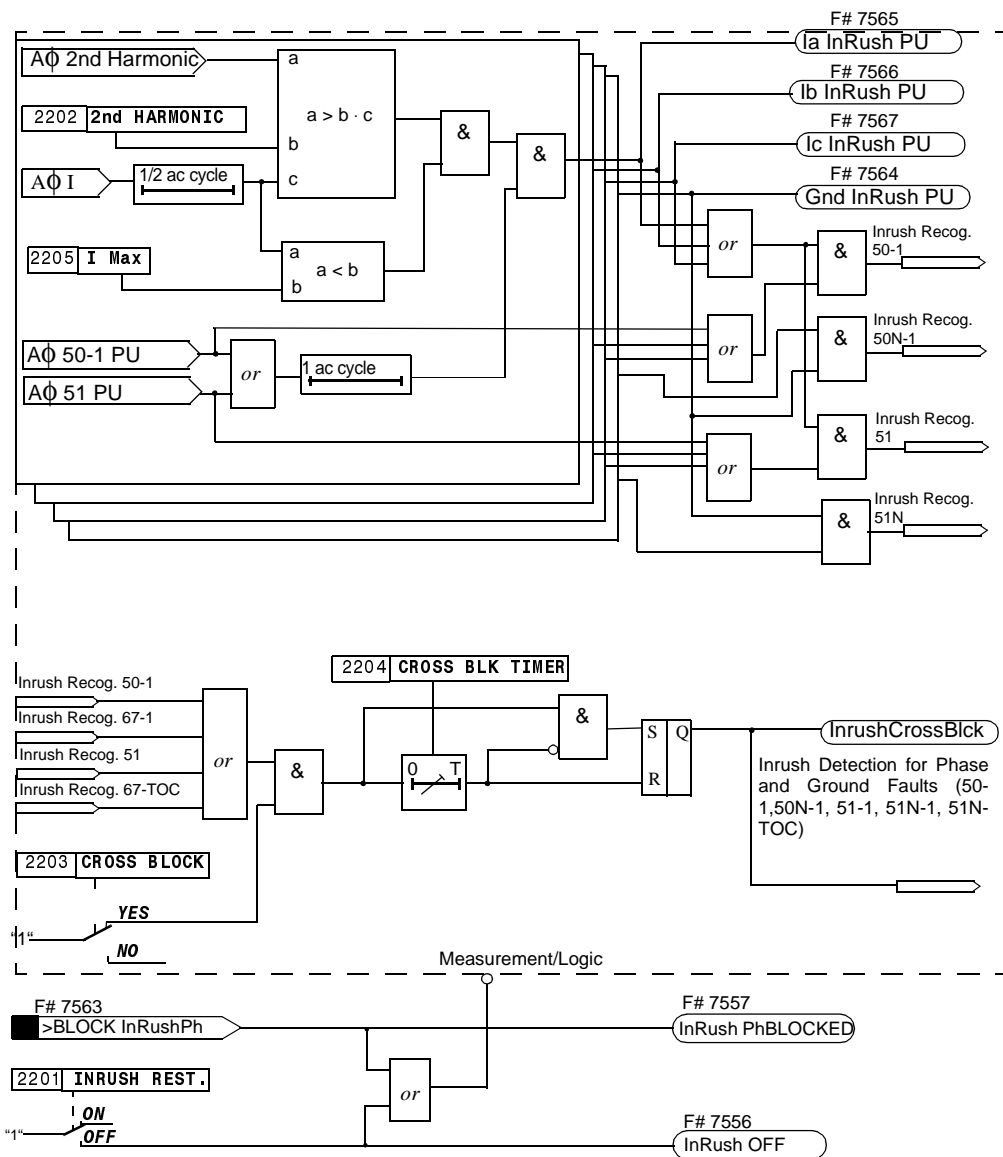
Figure 6-21   Logic Diagram for Inrush Restraint

The maximum current **I Max** where inrush restraint can operate is set at address **2205.** If energizing the protected equipment results in a current that exceeds the **I Max** setting value, inrush restraint based on detection of second harmonic currents will no longer occur.

6.4.2 Programming Settings

Inrush restraint will only operate, and is only accessible, if enabled at address 0122 **Inrush Restraint** during configuration of protective functions. If the function is not required, address 0122 should be set to ***Disabled***. The function may be switched ***ON*** or ***OFF*** at address 2201 **INRUSH REST.**.

Upon delivery from the factory, the device is programmed to initiate inrush restraint when the second harmonic component of the measured current exceeds 15 % of the total current. This value is identical for all phases and ground, and may be modified at address 2202 **2nd HARMONIC**. Under normal circumstances, this setting will not need to be changed. However, in special situations, this setting may be as low as 10 %.

If cross-blocking is desired, it can be enabled at address 2203 **CROSS BLOCK**. Cross-blocking can be activated for a specified amount of time, entered at address 2204 **CROSS BLK TIMER**.

The maximum current where inrush restraint can operate is set at address 2205 **I Max**.

6.4.2.1 Settings for Inrush Restraint (Stabilization)

In the list below, the setting range and default setting value for I Max are for an equipment with a nominal current rating I_N = 5 A. For a nominal current rating I_N = 1 A, divide the Setting Options values and Default Setting value for I Max by 5. Consider the current transformer ratios when setting the equipment with primary values.

Ad-dress	LCD-Text	Setting options	Default Setting	Comment
2201	INRUSH REST.	OFF ON	OFF	Switch-on Inrush stabilization
2202	2nd HARMONIC	10 ~ 45%	15%	Component of 2nd harmonic for Inrush recognition
2203	CROSS BLOCK	No Yes	No	Blocking per crossblock function
2204	CROSS BLK TIMER	0.00 ~ 180.00 sec.	0.00 sec.	Blocking time for crossblock function
2205	I Max	1.50 ~ 125.00 A	37.50 A	Maximum current for inrush recognition

6.4.2.2 Information List for Inrush Restraint (Stabilization)

F#	LCD-Text	Comment
1840	PhA InrushBlk	Phase A trip blocked by inrush detection
1841	PhB InrushBlk	Phase B trip blocked by inrush detection
1842	PhC InrushBlk	Phase C trip blocked by inrush detection
1843	INRUSH X-BLK	Cross blk: Ph Cross blocked PhY
7551	50-1 InRushPU	50-1 InRush picked up
7552	50N-1 InRushPU	50N-1 InRush picked up
7553	51 InRushPU	51 InRush picked up
7554	51N InRushPU	51N InRush picked up
7556	InRush OFF	InRush OFF
7557	InRushPhBLOCKED	InRush Phase BLOCKED
7558	InRush Gnd BLK	InRush Ground BLOCKED
7564	Gnd InRush PU	Ground InRush picked up
7565	Ia InRush PU	Phase A InRush picked up
7566	Ib InRush PU	Phase B InRush picked up
7567	Ic InRush PU	Phase C InRush picked up
7563	>BLOCK InRushPh	>BLOCK InRush Phase

6.5 Sensitive Ground Fault Detection (50Ns, 51Ns)

General

Sensitive ground fault detection may be used in isolated or compensated systems to detect ground faults. In solidly or low-resistance grounded systems, sensitive ground fault detection is used to detect high impedance ground faults. Sensitive ground fault detection may be used for alarming and annunciation, or may be allowed to initiate tripping. Programmable timers are supplied to supervise the alarming and tripping.

Because of its high sensitivity, ground fault detection is not suited for detection of high magnitude ground faults (over about 1.6 A at the sensitive ground fault detection relay terminals). The overcurrent protection functions are preferred for this application (Section 6.2).

6.5.1 Description of Sensitive Ground Fault Detection

Current Elements

The current elements associated with sensitive ground fault detection typically operate for low magnitudes of zero sequence current. They are typically applied in systems where ground fault currents are limited by neutral resistors.

There are two current elements used for sensitive ground fault protection. A definite time element similar to the 50N-2 element is used, as well as an element that may be operated with either a fixed time delay (similar to the 50N-1 element) or with a user defined curve (similar to the 51N-TOC element).

Logic

Figure 6-22 illustrates the condition logic for the sensitive ground fault pickup. Ground fault pickup may be switched **ON** or **OFF**, or into **Alarm Only** condition at address 3101 **Sens. Gnd Fault**. When ground fault protection is **ON**, tripping is possible. The entire function may be blocked via a binary input. Switching off or blocking means the measurement logic (shown in Figure 6-23) is deactivated, therefore, time delays and messages are reset.
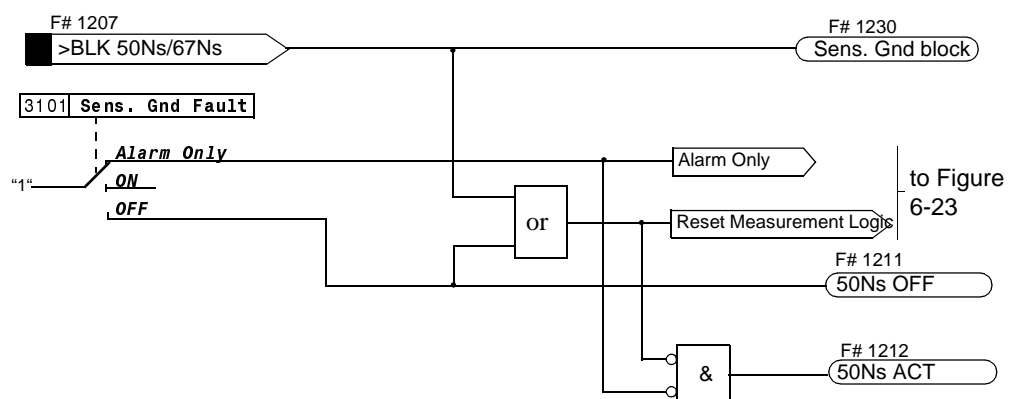
Figure 6-22   Activation of Sensitive Ground Fault Detection
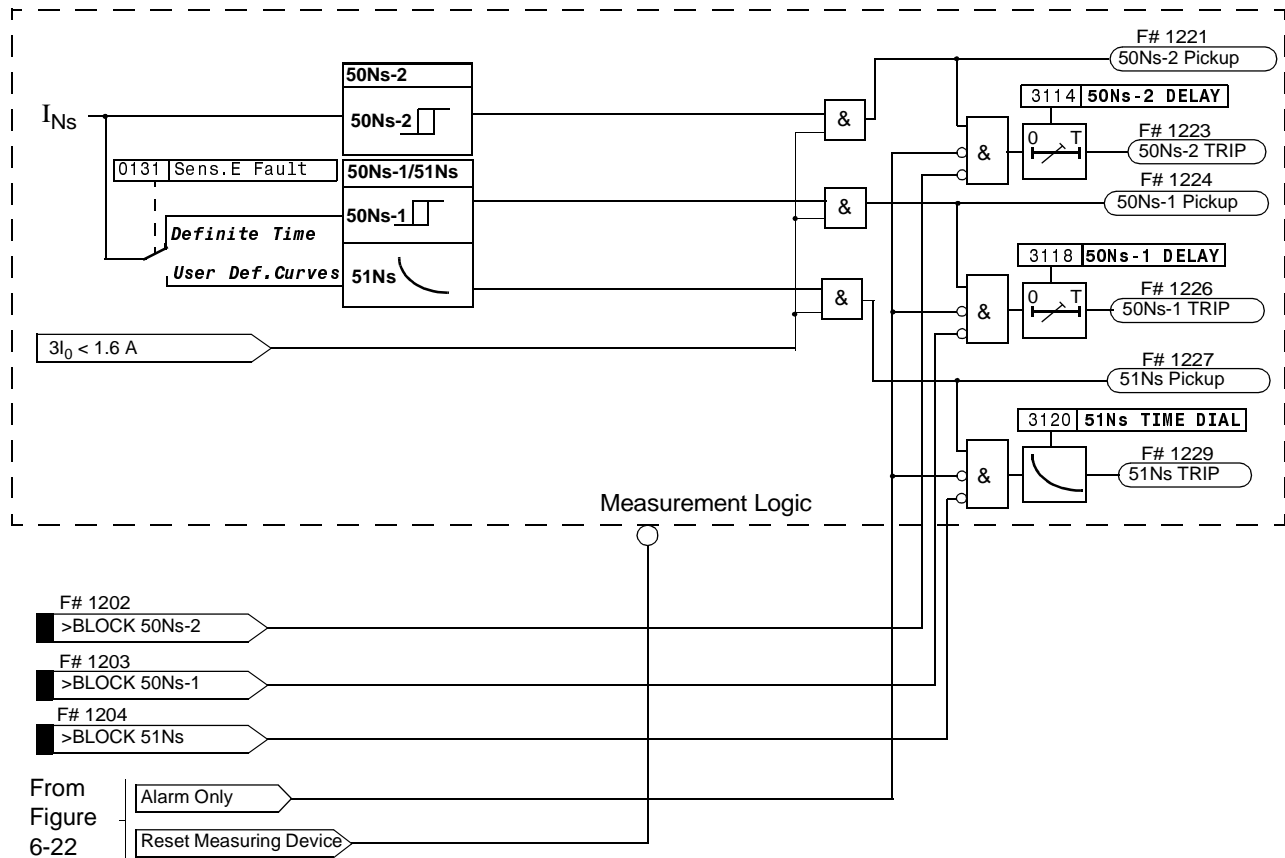
Figure 6-23   Logic Diagram for Sensitive Ground Fault Detection

6.5.2   Programming Settings

General Settings
During configuration of protective functions, address 0131 **Sens.Gnd Fault** should be set to **Definite Time only** if the inverse characteristic is not required, **User Defined Pickup Curve** if both a definite time and inverse time characteristic are required, and **Disabled** if the function is not required at all.

Address **0208 CT Ns/CT Ph** contains the conforming factor for the zero sequence current inputs.

Sensitive ground fault detection may be switched **ON**, **OFF**, or to **Message Only**, at address 3101 **Sens.Gnd Fault**. If sensitive ground fault protection is switched **ON**, both tripping and message reporting is possible.

Current Elements, General
The two time-overcurrent elements are set at addresses 3113 through 3122. These elements operate from the zero sequence current. They typically operate, therefore, only in grounded systems (solid or low resistance), or for motors connected to an un-grounded bus where the entire system capacitance supplies zero sequence current to the motor ground connection, but the ground current in the ground connection is insignificant because of the low motor capacitance.

50Ns–2 Element
The 50Ns-2 element pickup and delay settings are entered at addresses 3113 **50Ns-2 PICKUP** and 3114 **50Ns-2 DELAY** respectively. Pickup and time out of the 50Ns-

2 element can result just in the generation of a message, or in both the generation of a message and tripping. The latter is only possible if address 3101 is set to *ON*.

50Ns-1 / 51Ns Element

If configured as *Definite Time only* at address 0131, the 50Ns-1 element will be enabled. The pickup and delay settings for the 50Ns-1 element are at addresses 3117 **50Ns-1 PICKUP** and 3118 **50Ns-1 DELAY** respectively.

User Defined Curve

If a user defined curve is configured at address 0131, it should be noted that the device will not necessarily pickup until the current exceeds 110 % of the pickup value, as is standard for inverse curves.

Entry of the value pair (current and time) is a multiple of the settings at addresses 3119 **51Ns PICKUP** and 3120 **51Ns TIME DIAL**. Therefore, it is recommended that addresses be initially set to 1.00 for simplicity. Once the curve has been entered, the settings at addresses 3119 and 3120 can be modified if desired.

As delivered, The default settings for all current values is ∞. They are, therefore, not enabled—and no pickup or tripping of these protective functions will occur.

Up to 20 pairs of values (current and time) may be entered at address 3131 **M.of PU TD**. The device then approximates the curve, using linear interpolation. The following must be observed:

– The value pairs should be entered in increasing sequence. If desired, fewer than 20 pairs may be entered. In most cases, about 10 pairs is sufficient to define the curve accurately. Each unused pair must then be marked as unused by entering "∞" as the limit value. The user must ensure the value pairs produce a clear and constant curve.

– Current flows less than the smallest current value entered will not lead to an extension of the tripping time. The pickup curve (see Figure 6-24) continues, from the smallest current point parallel to the current axis.

– Current flows greater than the highest current value entered will not lead to an abbreviation of the tripping time. The pickup curve (see Figure 6-24) continues, from the largest current point parallel to the current axis.
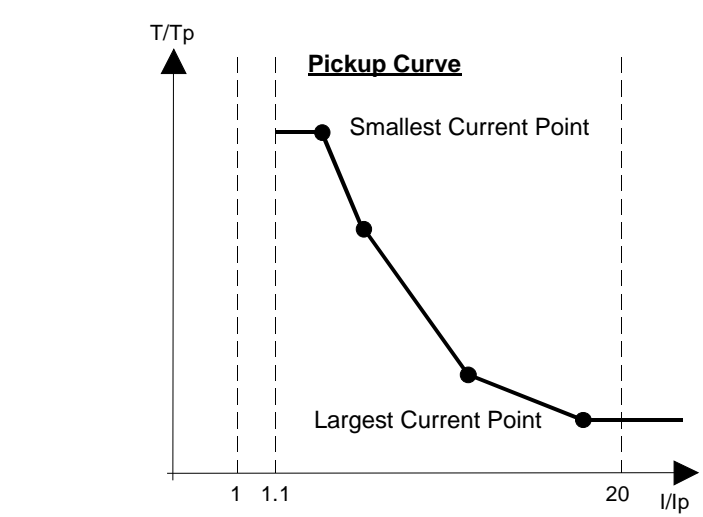
Figure 6-24   Use of a User Defined Curve

6.5.2.1 Settings for Sensitive Ground Fault Detection

The current-based setting ranges and Default Setting values are independent of the nominal current rating of the device. The sensitive ground fault detection measures the current at a special, sensitive input. In general, current-based settings can be entered in primary terms with consideration given to the ratio of the applicable current transformer. However, problems related to the resolution of the pickup currents can occur when very small settings and small primary currents are involved. The user is therefore encouraged to enter settings for the sensitive ground fault detection in secondary terms.

Addr.	LCD-Text	Setting options	Default Setting	Comment	Configuration	
					Definite Time only	User Defined Pickup
3101	Sens. Gnd Fault	OFF ON Alarm Only	OFF	Sensitive ground fault pickup	X	X
3113	50Ns-2 PICKUP	0.003 ~ 1.500 A	0.300 A	50Ns-2 Pickup	X	X
3114	50Ns-2 DELAY	0.00 ~ 320.00 sec	1.00 sec	50Ns-2 Time Delay	X	X
3117	50Ns-1 PICKUP	0.003 ~ 1.500 A	0.100 A	50Ns-1 Pickup	X	
3118	50Ns-1 DELAY	0.00 ~ 320.00 sec	2.00 sec	50Ns-1 Time delay	X	
3119	51Ns PICKUP	0.003 ~ 1.400 A	0.100 A	51Ns Pickup		X
3120	51Ns TIME DIAL	0.10 ~ 4.00 sec	1.00 sec	51Ns Time Dial		X
3131	M.of PU TD			Multiples of PU Time-Dial		X

6.5.2.2 Information List for Sensitive Ground Fault Detection

F#	LCD-Text	Comment
1211	50Ns/67Ns OFF	50Ns/67Ns is OFF
1212	50Ns/67Ns ACT	50Ns/67Ns is ACTIVE
1221	50Ns-2 Pickup	50Ns-2 Pickup
1223	50Ns-2 TRIP	50Ns-2 TRIP
1224	50Ns-1 Pickup	50Ns-1 Pickup
1226	50Ns-1 TRIP	50Ns-1 TRIP
1227	51Ns Pickup	51Ns picked up
1229	51Ns TRIP	51Ns TRIP
1230	Sens. Gnd block	Sensitive ground fault detection BLOCKED
1202	>BLOCK 50Ns-2	>BLOCK 50Ns-2
1203	>BLOCK 50Ns-1	>BLOCK 50Ns-1
1204	>BLOCK 51Ns	>BLOCK 51Ns
1207	>BLK 50Ns/67Ns	>BLOCK 50Ns/67Ns

6.6 Negative Sequence Protection (46)

General Negative sequence protection detects unbalanced loads on the system. In addition, it may be used to detect interruptions, faults, and polarity problems with current transformers. It is particularly useful in detecting phase-to-ground, phase-to-phase, and double phase-to-ground faults with magnitudes lower than the maximum load current.

Use with Motors The application of negative sequence protection to motors has a special significance. The negative sequence currents associated with unbalanced loads create counter-rotating fields in three-phase induction motors, which act on the rotor at double frequency. Eddy currents are induced at the rotor surface, and local overheating of the rotor begins to take place. In addition, the threat of thermal overload exists when the motor is supplied by unbalanced system voltages. Because the motor represents a small impedance to negative sequence voltages, small voltage imbalances can lead to large negative sequence currents.

6.6.1 Description of Negative Sequence Protection

6.6.1.1 Determination of Unbalanced Load

The negative sequence protection feature of the 7SJ61 relay uses filtering to dissect the phase currents into their symmetrical components. If the negative sequence component of the phase currents is at least 10% of the nominal device current, and all phase currents are less than four (4) times the nominal device current, then the negative sequence current is fed into three time-overcurrent relay elements, two of which are definite time (see Figure 6-25) and one of which contains an inverse time characteristic (see Figure 6-26).

Refer to phase rotation via binary input section 6.1.1.1 and 6.12.

6.6.1.2 Definite Time Elements (46-1, 46-2)

The two definite time elements are designated 46-2 and 46-1. Each of the two definite time elements will generate a message and initiate a time delay when picked up. Once either time delay elapses, a trip signal is initiated. Figure 6-25 illustrates the definite time characteristic when the 46-1 element is set with a more sensitive pickup value while the 46-2 element is set with a shorter tripping delay.
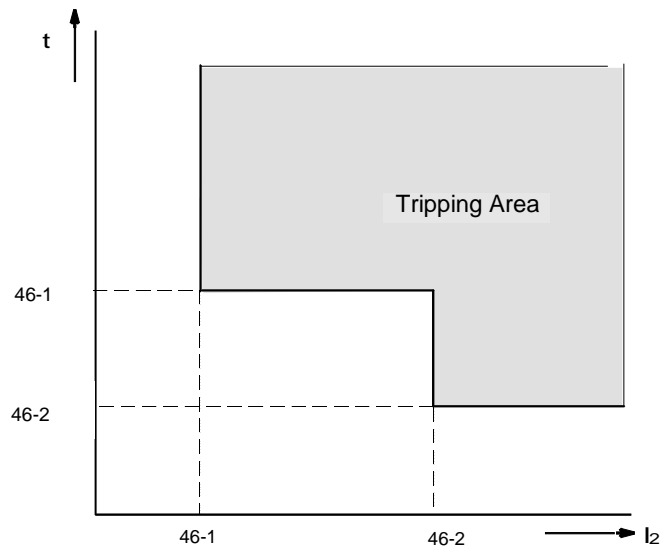
Figure 6-25   Definite Time Characteristic for Negative Sequence Protection

6.6.1.3   Inverse Time Element (46-TOC)

The inverse time element is designated 46-TOC and can operate with IEC or ANSI characteristic tripping curves depending on the model ordered. The curves and associated formulas are given in the Technical Specifications (Figures 10-4 and 10-5 in Section 10.8). When programming the inverse time curve, the definite time elements are available (see Subsection 6.6.1.2).

Pickup and Tripping

When the negative sequence current exceeds the pickup setting of the 46-TOC element by 110%, the element picks up, generates a message, and initiates time delayed tripping based on the selected characteristic curve. Once the corresponding time interval on the curve elapses, a tripping signal is initiated. The characteristic curve is illustrated in Figure 6-26.

Drop Out for IEC Curves

When IEC curves are used, the 46-TOC element drops out when the negative sequence current decreases to 95 % of the pickup setting. The time delay resets immediately in anticipation of another pickup.

Drop Out for ANSI Curves

When ANSI curves are used, the 46-TOC element may drop out immediately when the negative sequence current decreases to 95 % of the pickup setting, or disk emulation may be used to simulate the unwinding of an electromechanical induction disc.

If disk emulation is selected, the drop out begins when the current decreases to 90 % of the pickup value, and reset proceeds in accordance with the selected reset curve. When the negative sequence current is between 90 % and 95 % of the pickup setting, neither forward nor reverse movement of the disk is simulated. When the negative sequence current falls below 5 % of the pickup value, disk emulation is terminated and immediate reset takes place. Figure 6-26 illustrates the overall tripping characteristic.
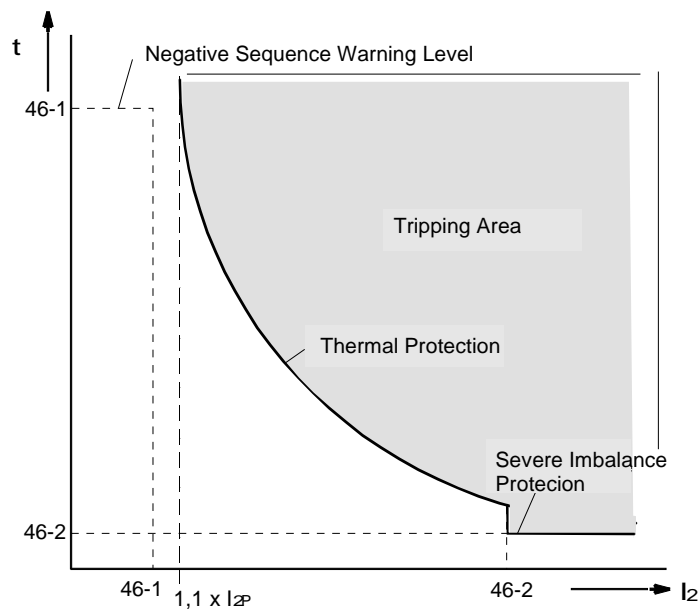
Figure 6-26   Inverse Time Characteristic for Negative Sequence Protection
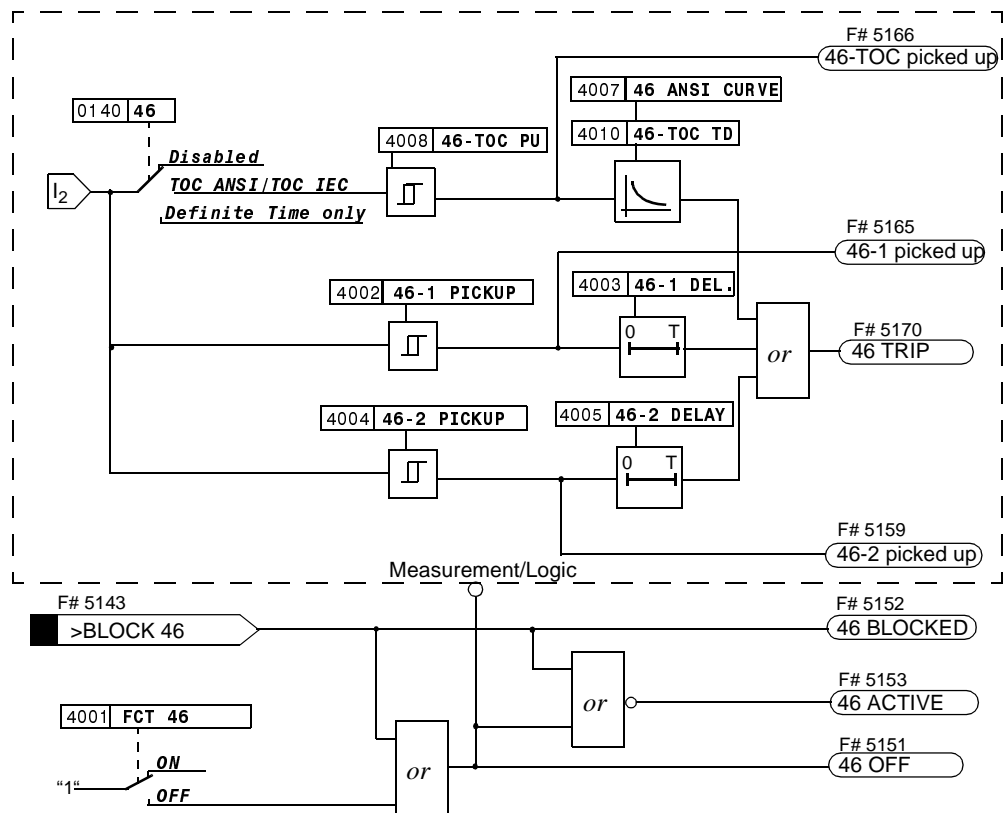
Figure 6-27   Logic Diagram for Negative Sequence Protection

Disk emulation offers advantages when the negative sequence protection must be coordinated with conventional source side relays.

Logic

Figure 6-27 shows the logic diagram for negative sequence protection. The protection may be blocked via a binary input.

When the negative sequence protection criteria are no longer satisfied (i.e. all phase currents drop below 10 % of the nominal relay current or at least one phase current is greater than four (4) times the nominal device current, the tripping time delay is immediately reset.

6.6.2 Programming Settings

General

Negative sequence protection is configured at address 0140 **46**. If only the definite time elements are desired, address 0140 should be set to **Definite Time only**. If both definite time and inverse time elements are to be used, address 0140 should be set to **Time Overcurrent Curve ANSI**, and if negative sequence protection is not needed, address 0140 should be set to **Disabled**.

Negative sequence protection is switched **ON** or **OFF** at address 4001 **FCT 46**.

Refer to phase rotation via binary input section 6.1.1.1 and 6.12.

The default pickup settings and delay settings of the negative sequence time-overcurrent relay elements are generally sufficient for most applications. If the device is used to protect a motor, and data is available from the manufacturer regarding the allowable long-term load imbalance and the allowable load imbalance per unit of time, this data should be used as the basis for selecting the pickup and delay settings. In this situation, it is important to ensure that the values given by the manufacturer represent the primary values for the motor. For example, if the long-term allowable thermal inverse current (with respect to the nominal motor current) is given, this value is used to calculate the settings for the negative sequence time-overcurrent element. For this situation:

$$\text{Pickup Setting} \qquad I_2 = \left(\frac{I_{2\text{perm prim}}}{I_{\text{NMotor}}} \right) \cdot I_{\text{NMotor}} \cdot \frac{I_{\text{CT sec}}}{I_{\text{CT prim}}}$$

where $I_{2\text{ perm prim}}$ Permissible Thermal Inverse Current of the Motor

   $I_{\text{N Motor}}$ Nominal Motor Current

   $I_{\text{CT sec}}$ Secondary Nominal Current of the Current Transformer

   $I_{\text{CT prim}}$ Primary Nominal Current of the Current Transformer

Definite Time Elements

The pickup and delay settings associated with the 46-1 element are set at addresses 4002 **46-1 PICKUP** and 4003 **46-1 DELAY** respectively while the pickup and delay settings for the 46-2 element are set at address 4004 **46-2 PICKUP** and 4005 **46-2 DELAY** respectively. Typically the 46-1 element is set with a lower pickup value and higher time delay than the 46-2 element. This allows the 46-1 element to act as an alarm while the 46-2 element will initiate fast tripping for severe imbalances.

If the 46-2 element is used for fast tripping against severe imbalances, the pickup value should be set at 60 % of the nominal phase current. This will ensure pickup for the complete loss of one phase. On the other hand, because the loss of a phase could be

interpreted as a phase-to-phase fault, the time delay of this element should be coordinated with fault protection relays. The magnitude of the negative sequence current with respect to the phase current when one phase is out of service is given as follows:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

<u>Examples:</u>

<u>Motor:</u>

	$I_{N\ Motor}$	= 545 A
	$I_{2\ long\text{-}term\ prim} / I_{N\ Motor}$	= 0.11 long-term
	$I_{2\ short\text{-}term\ prim} / I_{N\ Motor}$	= 0.55 for T_{max} = 1 s

Current Transformers	CT	= 600 A/1 A

Set Value 46-1	Address 4002	= 0.11 · 545 A · (1/600 A) = 0.10 A
Set Value 46-2	Address 4004	= 0.55 · 545 A · (1/600 A) = 0.50 A

This ensures

When protecting a <u>feeder</u>, negative sequence protection may serve to identify low magnitude unsymmetrical faults below the pickup values of the directional and non-directional overcurrent elements. To detect load magnitude faults, the pickup value of the negative sequence time-overcurrent elements must be set below the following:

– a phase-to-phase fault (I) results in the following negative sequence current:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

– a phase-to-ground fault (I) corresponds to the following negative sequence current:

$$I_2 = \frac{1}{3} \cdot I = 0.33 \cdot I$$

To prevent false operations for fault in other zones of protection, the time delay should be coordinated with other fault protection relays in the system.

For a <u>transformer</u>, negative sequence protection may be used as sensitive protection for low magnitude phase-to-ground and phase-to-phase faults. In particular, this application is well suited for delta-wye transformers where low side phase-to-ground faults do not generate high side zero sequence currents.

The relationship between negative sequence currents and total fault current for phase-to-phase faults and phase-to-ground faults are valid for the transformer as long as the turns ratio is taken into consideration.

Consider a transformer with the following data:

Transformer Base Rating	16 MVA
Nominal High Side Voltage	V_{HS} = 110 kV
Nominal Low Side Voltage	V_{LS} = 20 kV
Transformer Connection	Delta-Grounded Wye
High Side CT Ratio	CTR = 100 A / 1 A

The following faults may be detected at the lower-voltage side:

If the pickup setting (PU) of the device on the high side is set to 0.1 A, then a phase-to-ground fault current of

$I = (1/0.33) * CTR * PU * V_{HS} / V_{LS} =$

$\quad 3 * 100 * 0.1 \text{ A} * 110 \text{ kV} / 20 \text{ kV} = 165 \text{ A}$

and a phase-to-phase fault current of

$I = (1/0.58) * CTR * PU * V_{HS} / V_{LS} =$

$\quad 1.732 * 100 * 0.1 \text{ A} * 110 \text{ kV} / 20 \text{ kV} = 95 \text{ A}$

can be detected at the low side. These faults correspond to 36 % and 20 % of the base transformer rating respectively. It is important to note that load current is not taken into account in this simplified example. To prevent false operation for faults in other zones of protection, the delay time must be coordinated with other relays in the system.

Inverse Time Element with IEC Curves

If the 46-TOC element is employed, a characteristic tripping curve should be selected to coordinate with the thermal overload curve representing the protected equipment (e.g. induction motor, etc.). The curve should be selected at address 4006 **46 IEC CURVE**. The characteristic tripping curves, and the formulas on which they are based, are given in the Technical Specifications, Section 10.8.

The 46-TOC element picks up when the negative sequence input current exceeds 110% of the pickup settings and drops out when he negative sequence current decreases to 95 % of the pickup setting. The pickup settings is entered at address 4008 **46-TOC PICKUP**.

The associated time multiplier is entered at address 4010 **46-TOC TIMEDIAL**.

The time multiplier may also be set to ∞ thus allowing the element to pickup and generate a message, but never to trip. If the inverse time element is not required at all, address 0140 should be set to ***independent*** during configuration of protective functions (Section 5.1).

Inverse Time Element with ANSI Curves

If the 46-TOC element is employed, a characteristic tripping curve should be selected to coordinate with the thermal overload curve representing the protected equipment (e.g. induction motor, etc.). The curve should be selected at address 4007 **46 ANSI CURVE**. The characteristic tripping curves, and the formulas on which they are based, are given in the Technical Specifications, Section 10.8.

The 46-TOC element picks up when the negative sequence input current exceeds 110 % of the pickup settings and drops out when the negative sequence current decreases to 95 % of the pickup setting. The pickup settings is entered at address 4008 **46-TOC PICKUP**. If ***Disk Emulation*** was selected at address 4011 **46-TOC RE-SET**, reset will occur in accordance with the reset curve as described in Subsection 6.6.1.3. The associated time dial is entered at address 4009 **46-TOC TIMEDIAL**.

The time may also be set to ∞ thus allowing the element to pickup and generate a message, but never to trip. If the inverse time element is not required at all, address 0140 should be set to ***Definite Time only*** during configuration of protective functions (Section 5.1).

6.6.2.1 Settings for Negative Sequence (Phase Balance) Current Protection

In the list below, the setting ranges and default setting values for the pickup currents are for a device with a nominal current rating I_N = 5 A. For a nominal current rating I_N

= 1 A, divide the Setting Options values and Default Setting values by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	LCD-Text	Setting Options	Default Setting	Comments	Definite Time only	ANSI Curve	IEC Curve
4001	FCT 46	ON OFF	OFF	Negative sequence current protection	X	X	X
4002	46-1 PICKUP	0.50 ~ 15.00 A	0.50 A	Pickup current 46-1	X	X	X
4003	46-1 DELAY	0.00 ~ 60.00 sec	1.50 sec	Definite delay time 46-1	X	X	X
4004	46-2 PICKUP	0.50 ~ 15.00 A	2.50 A	Pickup current 46-2	X	X	X
4005	46-2 DELAY	0.00 ~ 60.00 sec	1.50 sec	Definite delay time 46-2	X	X	X
4006	46 IEC CURVE	Normal Inverse Very Inverse Extremely Inverse	Extremely Inv.	Current-time IEC characteristic curve 46-TOC			X X X
4007	46 ANSI CURVE	Extremely Inverse Inverse Moderately Inverse Very Inverse	Extremely Inv.	Current-time ANSI characteristic curve 46-TOC		X X X X	
4008	46-TOC PICKUP	0.50 ~ 10.00 A	4.50 A	Pickup current 46-TOC		X	X
4009	46-TOC TIMEDIAL	0.50 ~ 15.00 sec	5.00 sec	Time dial, ANSI characteristics, 46-TOC		X	
4010	46-TOC TIMEDIAL	0.05 ~ 3.20 sec	0.50 sec	Time multiplier, IEC characteristics, 46-TOC			X
4011	46-TOC RESET	Instantaneous Disk Emulation	Instantaneous	Reset characteristic for 46-TOC, ANSI current-time characteristics		X	

6.6.2.2 Information List for Negative Sequence Current Protection

F#	LCD-Text	Comment
5151	46 OFF	46 switched OFF
5152	46 BLOCKED	46 is BLOCKED
5153	46 ACTIVE	46 is ACTIVE
5159	46-2 picked up	46-2 picked up
5165	46-1 picked up	46-1 picked up
5166	46-TOC pickedup	46-TOC picked up
5170	46 TRIP	46 TRIP
5171	46 Dsk pickedup	46 Disk emulation picked up
5143	>BLOCK 46	>BLOCK 46

6.7   Motor Starting Protection (48)

6.7.1   Description of Motor Starting Protection

General

When the 7SJ61 relay is used to protect a motor, the starting time monitoring feature supplements the overload protection described in Section 6.8 by protecting the motor against the potential damage that might result from frequent starting or extended starting durations. In particular, rotor-critical high-voltage motors can quickly be heated above their thermal limits when multiple starting attempts occur in a short period of time. If the durations of these starting attempts are lengthened by excessive voltage surges during motor starting, by excessive load moments, or by blocked rotor conditions, a tripping signal will be initiated by the device.

Motor starting protection consists of two time-overcurrent tripping characteristics initiated by the motor starting recognition setting entered at address 1107 **I MOTOR START**. One characteristic is definite time while the other one is inverse time. When the motor phase currents exceed the setting entered at address 1107, time delayed tripping will be initiated. To gain a better understanding of how to set the motor starting recognition setting at address 1107, refer to Subsection 6.1.3.

Inverse Time Time-Overcurrent Tripping Characteristic

The inverse time time-overcurrent characteristic is designed to operate only when the rotor is not blocked. When the phase currents exceed the motor starting recognition setting entered at address 1107, time delayed tripping via the inverse time characteristic is initiated. The inverse time characteristic allows motor starting protection to adjust for those situations where high starting voltages result in decreased starting currents. The tripping time is calculated based on the following formula:

$$t_{TRIP} = \left| \frac{I_A}{I} \right|^2 \cdot t_{Amax} \qquad \text{where } I > I_{MOT\ START}$$

where
t_{TRIP} — Actual tripping time for flowing current I

$t_{A\ max}$ — Tripping time for nominal start-up current I_A (set at address 4103)

I — Current actually flowing (measurement value)

I_A — Nominal starting current of the motor (set at address 4102)

$I_{MOT\ START}$ — Pickup value for recognition of motor starting (set at address 1107)
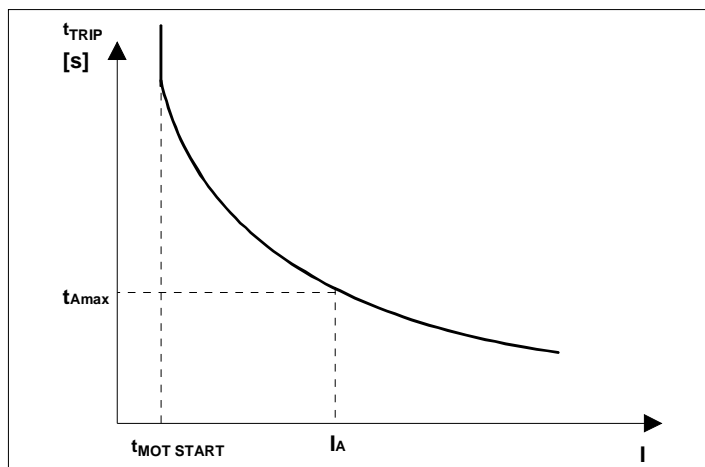
Figure 6-28   Inverse Time Characteristic Tripping Curve for Motor Starting Current

Therefore, if the starting current I actually measured is smaller (or larger) than the nominal starting current I_A entered at address 4102 **STARTUP CURRENT**, the actual tripping time t_{trip} is lengthened (or shortened) accordingly. See Figure 6-28.

Definite Time Time-Overcurrent Tripping Characteristic (Blocked Rotor Time)

During motor starting, the definite time characteristic is designed to initiate a trip if the motor starting time exceeds the maximum allowable blocked rotor time. The device can detect a blocked rotor condition via a binary input from an external rpm-counter. If the current in any of the phases exceeds the motor starting recognition setting entered at address 1107, and if a blocked rotor conditions is detected via a binary input, a motor starting condition is assumed, and time delayed tripping via the definite time characteristic will be initiated (based on the maximum allowable blocked rotor time).

It is important to note that message generation does not occur unless a trip is initiated. Furthermore, when a blocked rotor condition is detected via a binary input, and the definite time characteristic times out, immediate tripping will take place regardless of whether the blocked rotor condition was detected before or after the definite time characteristic timed out.

Motor starting protection may be switched on or off at address 4101 **FCT 48/66**. In addition, motor starting protection may be blocked via a binary input, at which time pickup messages and time delays will be reset. Figure 6-29 illustrates the logic for motor starting protection.
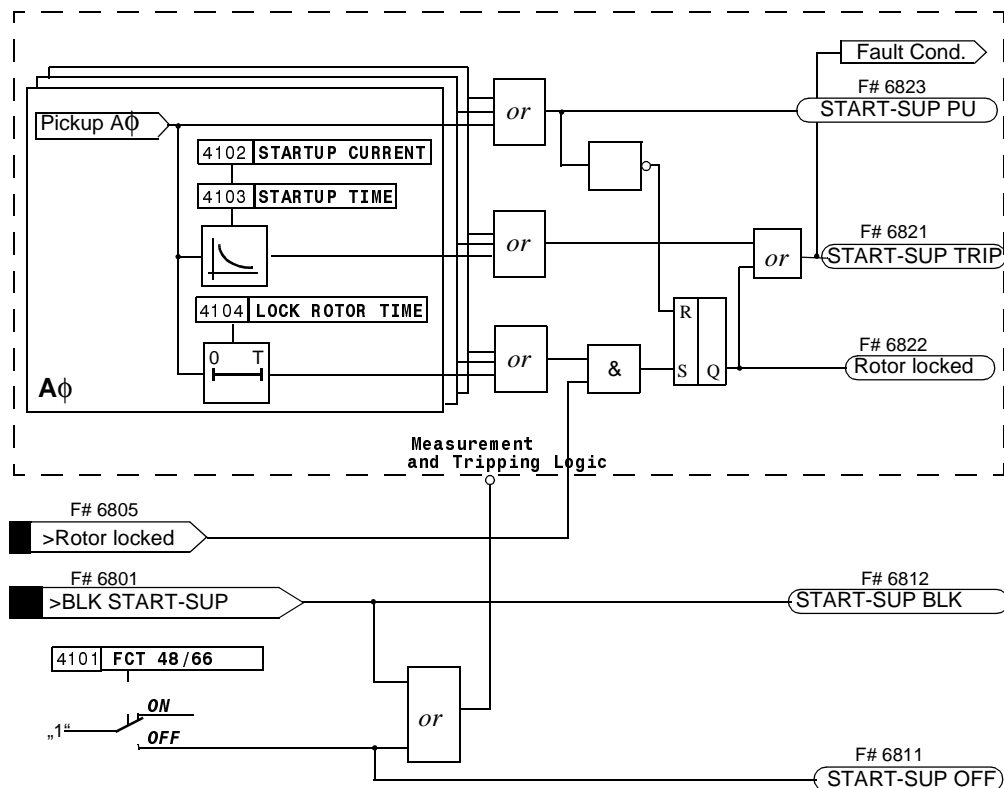
Figure 6-29   Logic Diagram for Motor Starting Protection

6.7.2   Programming Settings

General

Motor starting protection is only effective and accessible if address 0141 **48** was set to Enabled during configuration of protective function. If the motor starting protection feature is not required, address 0141 should be set to Disabled. The function may switched **ON** or **OFF** at address 4101 **FCT 48/66**.

Setting Values

<u>Example:</u> Motor with the following data:

Nominal Voltage	V_N = 6600 V
Nominal Current	I_G = 126 A
Start-Up Current	$I_{STARTUP}$ = 624 A
Long-Term Current Rating	I_{MAX} = 135 A
Start-Up Duration for $I_{STARTUP}$	$T_{STA\ MAX}$ = 8.5 sec
CT Ratio $I_{N\ CT\ prim}$ / $I_{N\ CT\ sec}$	200 A / 1 A

The setting for Address 4102 **STARTUP CURRENT** is calculated as follows:

$$I_{STARTUP\text{-}sec} = \frac{I_{STARTUP}}{I_{N\ CT\ prim}} \cdot I_{N\ CT\ sec} = \frac{624\ A}{200\ A} \cdot I_A = 3.12\ A$$

For reduced voltage, the start-up current is also reduced almost linearly. At 80% nominal voltage, the start-up current in this example is reduced to

$0.8 * I_{STARTUP} = 2.5\ A.$

The setting at address 1107 **I MOTOR START** must lie above the maximum load current and below the minimum start-up current. If no other influencing factors are present (peak loads), the value set at address 1107 may be a median value:

Based on the Long-Term Current Rating: $\dfrac{135\ A}{200\ A} = 0{,}68 \cdot I_{N\ CT\ sec}$

$$I_{STARTUP\text{-}SEC} = \frac{2.5\ I_N + 0.68\ I_N}{2} \approx 1{,}6 \cdot I_{NCT\ sec}$$

For ratios deviating from nominal conditions, the motor tripping time changes:,

$$T_{TRIP} = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$$

At 80 % of nominal voltage (which corresponds to 80 % of nominal starting current), the tripping time is:

$$T_{TRIP} = \left(\frac{624\ A}{0.8 \cdot 624\ A}\right)^2 \cdot 8.5\ s = 13.3\ s$$

After the definite time characteristic times out, the blocked rotor binary input becomes effective and initiates a tripping signal.If the time delay associated with the definite time characteristic is set such that a trip signal is initiated for blocked rotor conditions within the duration of a normal motor start, faster tripping will be available during motor starting under blocked rotor conditions.

Note:

Overload protection characteristic curves are effective during motor starting conditions, however, thermal dissipation during motor starting is constant. The setting at address 1107 limits the working range of the overload protection to larger current values.

6.7.2.1 Settings for Motor Starting Time Monitoring

In the list below, the setting range and default setting value for the current-based setting are for a device with a nominal current rating $I_N = 5$ A. For a nominal current rating $I_N = 1$ A, divide the Setting Options values and Default Setting value by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	LCD-Text	Setting options	Default Setting	Comment
1107	I MOTOR START	3.00 ~ 50.00 A	12.50 A	Motor Start Current (Block 49, Start 48)
4101	FCT 48/66	ON OFF	OFF	48 / 66 Motor (Startup Monitor/Counter)
4102	STARTUP CURRENT	5.00 ~ 80.00 A	25.00 A	Maximum start-up current
4103	STARTUP TIME	1.0 ~ 180.0 sec	10.0 sec	Maximum start-up time
4104	LOCK ROTOR TIME	0.5 ~ 120.0 sec	2.0 sec	Fixed brake time

6.7.2.2 Information List for Motor Starting Time Monitoring

F#	LCD-Text	Comment
6811	START-SUP OFF	Startup supervision OFF
6812	START-SUP BLK	Startup supervision is BLOCKED
6813	START-SUP ACT	Startup supervision is ACTIVE
6821	START-SUP TRIP	Startup supervision TRIP
6822	Rotor locked	Rotor locked
6823	START-SUP pu	Startup supervision Pickup
6801	>BLK START-SUP	>BLOCK Startup Supervision
6805	>Rotor locked	>Rotor locked

6.8 Thermal Overload Protection (49)

6.8.1 Description of Thermal Overload Protection

General

The thermal overload protection feature of the 7SJ61 is designed to prevent overloads from damaging the protected equipment.

The device is capable of projecting excessive operating temperatures for the protected equipment in accordance with a single-body thermal model, based on the following differential equation:

$$\frac{d\Theta}{dt} + \frac{1}{\tau} \cdot \Theta = \frac{1}{\tau} \cdot I^2$$

where Θ – Actual operating temperature expressed as a percent of the operating temperature corresponding to the maximum permissible operating current ($k*I_N$)

τ – Thermal time constant for the heating of the equipment being protected

I – Operating current expressed as a percentage of the maximum permissible operating current ($k*I_N$)

The thermal overload protection feature models a heat image of the equipment being protected. Both the previous history of an overload and the heat loss to the environment are taken into account.

Thermal overload protection calculates the operating temperature of the protected equipment as a percent of the maximum allowable operating temperature. When the calculated operating temperature reaches a settable percentage of the maximum allowable operating temperature, a warning message is issued to allow time for the load reduction measures to take place. When the calculated operating temperature reaches 100 % of the maximum allowable operating temperature, a trip signal is initiated to de-energize the overloaded equipment. Initiation of a trip signal is based on the phase with the highest calculated temperature.

The maximum thermally-permissible continuous current I_{max} is described as a multiple of the nominal current I_N:

$I_{max} = k \times I_N$

For thermal overload protection to calculate operating temperature as a percent of maximum allowable operating temperature, it is necessary to enter the k factor setting, the time constant setting τ and the warning temperature level Θ.

Thermal overload protection also features a current warning element in addition to the temperature warning stage. The current warning element may report an overload current prematurely, even if the calculated operating temperature has not yet attained the warning or tripping levels.

Extension of Time Constants

When using the device to protect motors, the varying thermal behaviors associated with cycling the motor on and off may be correctly evaluated. Under a cycling condition, a motor without external cooling losses heat more slowly, and a longer thermal time constant must be used. For a motor that is cycled on and off, the 7SJ61 increases the time constant τ by a programmable factor ($k\tau$ factor). The motor is considered off

the motor currents drop below a programmable minimum current setting (refer to "Current Flow Monitoring" in Subsection 6.1.1). For externally-cooled motors, cables, and transformers, the **k**τ **FACTOR** = *1*.

Blocking

The thermal overload protection feature may be blocked via a binary input. When blocking occurs, the thermal image is simultaneously reset.

When motors must be started for emergency reasons, operating temperatures above the maximum permissible operating temperatures can be allowed by blocking the tripping signal via a binary input. Since the calculated operating temperature may be higher than the maximum allowable operating temperature after drop out of the binary input has taken place, the thermal overload protection function features a programmable run-on time interval which is started when the binary input drops out. Tripping will be defeated until this time interval elapses. On a final note, the binary input used for emergency starting affects only the tripping signal. There is no effect on the fault condition protocol nor does the thermal image reset.

Figure 6-30 shows the logic diagram for thermal overload protection.
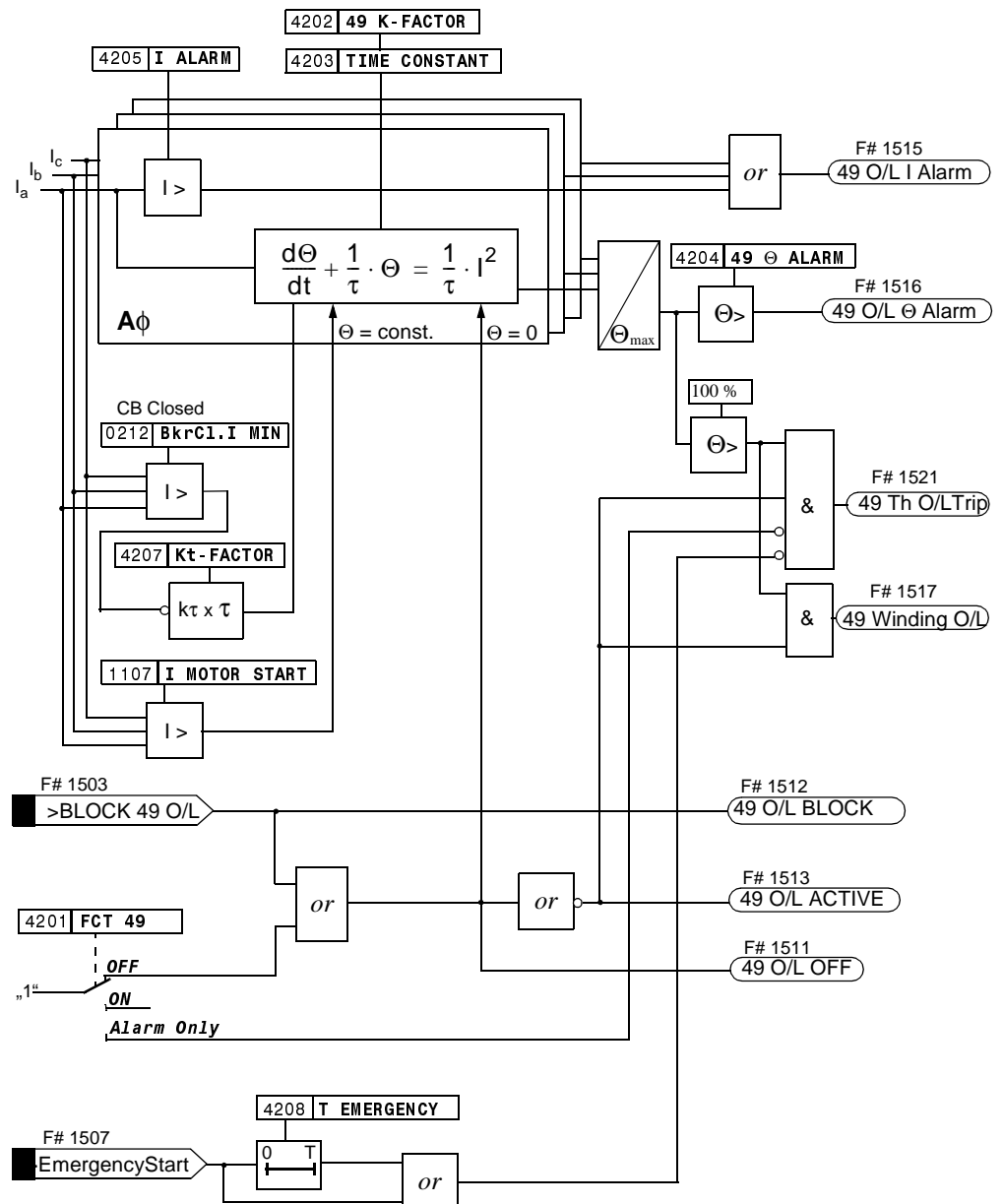
Figure 6-30   Logic Diagram for Thermal Overload Protection

6.8.2   Programming Settings

General

Thermal overload protection is only effective and accessible if address 0142 was set to *Enabled* during configuration of protective functions. If the thermal overload protection is not required, address 0142 **49** should be set to *Disabled*.

Transformers and cable are prone to damage by overloads which last for an extended period of time. For this reason, fault protection elements such as the directional and non-directional overcurrent elements should not be used to protect against overload.

The short time delays associated with fault protection elements do not allow sufficient time for the orderly curtailment of load by operating personnel. In addition, fault protection elements set to trip for overload will not allow short-duration, non-damaging overloads – a practice which is often required in real operating situations.

The 7SJ61 protective relay features an thermal overload protective function with a thermal tripping characteristic curve which may be adapted to the overload tolerance of the equipment being protected.

Thermal overload protection may be switched *ON* or *OFF* or `Alarm Only` at address 4201 `FCT 49`. If switched *ON*, tripping is also possible.

k–Factor

The nominal device current is used as a basis for overload detection. The programmable **K–FACTOR** (set at address 4202) is calculated as the ratio of the thermally-permissible continuous current I_{max} to the nominal device current I_N:

$$k = \frac{I_{max}}{I_N}$$

The thermally-permissible continuous current for the equipment being protected is known from manufacturer's specifications. The thermal overload function is normally not applicable to aerial lines since the actual current capability of aerial lines is dependent on factors that are generally unknown (e.g. wind speed, ambient temperature, etc.). For cables, the permissible continuous current is dependent on the cross-section, insulating material, design, and the cable routing, among other things. It may be taken from pertinent tables, or is specified by the cable manufacturer. If no specifications are available, a value of 1.1 times the nominal current rating is assumed.

When determining the nominal current rating of the protected equipment, it is important to relate this current to the nominal current rating of the device. For example, the maximum permissible continuous current for a motor and the nominal current rating of the motor are given in primary amperes.

For the k factor to be set based on the nominal device current, the following equation must be used:

Set the **K–FACTOR** $$k = \frac{I_{max\ prim}}{I_{NMotor}} \cdot \frac{I_{NMotor}}{I_{N\ CT\ prim}}$$

where $I_{max\ prim}$ Maximum permissible continuous motor current in primary amperes

$I_{N\ Motor}$ Nominal motor current in primary amperes

$I_{N\ CT\ prim}$ Current transformer primary nominal current

Example: Motor and current transformer with the following data:

Permissible Continuous Current: $I_{max\ prim} = 1.2 \cdot I_N$

Motor Nominal Current $I_{N\ Motor} = 1100\ A$

Current Transformer Ratio   1200 A/1 A

$$\text{Set Value K-FACTOR} = 1.2 \cdot \frac{1100\ A}{1200\ A} = 1.1$$

Time Constant τ

The thermal overload protection element tracks excessive temperature progression, employing a thermal differential equation whose solution is an exponential function. The **TIME CONSTANT** τ (set at address 4203) is used in the calculation to determine the operating temperature. This is expressed as a maximum allowable operating temperature.

For cable protection, the heat-gain time constant τ is determined by cable specifications and by the cable environment. If no time-constant specification is available, it may be determined from the short-term load capability of the cable. The 1-sec current (i.e. the maximum current permissible for a one-second period of time), is often known or available from tables. Then, the time constant may be calculated from the formula:

$$\text{Set Value } \tau \text{ (min)} = \frac{1}{60} \times \left| \frac{I_{1 \text{ sec}}}{I_{\text{max Prim}}} \right|^2$$

If the short-term load capability is given for an interval other than one sec, the corresponding short-term current is used in the above formula instead of the 1-sec current, and the result is multiplied times the given duration. For example, if the 0.5-second current rating is known,

$$\text{Set Value } \tau \text{ (min)} = \frac{0.5}{60} \times \left| \frac{I_{0.5 \text{ sec}}}{I_{\text{max Prim}}} \right|^2$$

It is important to note, however, that the longer the effective duration, the less accurate the result.

<u>Example:</u>

Cable and current transformer with the following data:

Continuous permissible current	$I_{\text{max}} = 500$ A @ 40 °C
Maximum current for 1 sec	I1s = 45 * Imax = 22.5 kA
Current transformer	600 A / 1 A

The k factor and time constant are calculated as follows:

$$k = \frac{I_{\text{max}}}{I_N} = \frac{500 \text{ A}}{600 \text{ A}} = 0.833$$

$$\tau_{\text{min}} = \frac{1}{60} \cdot \left(\frac{I_{1s}}{I_{\text{max}}} \right) = \frac{1}{60} \cdot 45^2 = 33.75 \text{ min}$$

The settings are: **K-FACTOR** (Address 4202)   = **0.83**
                        TIME CONSTANT   = **33.7** min

Warning Temperature Level

By setting the thermal warning level **49** Θ **ALARM** at address 4204, a warning message can be issued prior to tripping, thus allowing time for load curtailment procedures to be implemented. This warning level simultaneously represents the dropout level for the tripping signal. In other words, the tripping signal is interrupted only when the cal-

culated operating temperature falls below the warning level, thus allowing the protected equipment to be placed back into service.

The thermal warning level is given in % of the tripping temperature level (maximum allowable operating temperature).

A current warning level is also available (**I ALARM** 4205). The setting at address 4205 corresponds to secondary amperes, of course, and should be set equal to, or slightly less than, permissible continuous current (k * I_{Nsec}). The current warning level may be used in lieu of the thermal warning level by setting the thermal warning level to 100 %.

Extension of Time Constants

The time constant programmed at address 4203 is valid for a running motor. For cycling motors without external cooling, the motor loses heat more slowly. For a cycling motor, the 7SJ61 takes the reduced heat loss into account by increasing the time constant τ by a programmable factor kτ (set at address 4207). If no distinguishing of the time constants is necessary (e.g. externally-cooled motors, cables, transformers, etc.) the **Kτ FACTOR** is set at *1* (Default Setting value).

Emergency Starting

The drop-out time to be entered at address 4208 must be sufficient to allow the calculated operating temperature to decrease below the drop out level.

Motor Starting Recognition

To ascertain whether or not a motor is starting, the motor currents are compared with the setting at address 1107. If the motor currents exceed the setting at address 1107, a motor starting condition is assumed. Information on how to set address 1107 is given in Subsections 6.1.3 and 6.7.2.

6.8.2.1 Settings for Thermal Overload Protection

In the list below, the setting range and default setting value for I ALARM is for a device with a nominal current rating I_N = 5 A. For a nominal current rating I_N = 1 A, divide the Setting Options values and Default Setting value by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	LCD-Text	Setting options	Default Setting	Comment
4201	FCT 49	OFF ON Alarm only	OFF	49 Thermal overload protection
4202	49 K-FACTOR	0.10 ~ 4.00	1.10	49 (Service Factor k)
4203	TIME CONSTANT	1.0 ~ 999.9 min	100.0 min	Time Constant
4204	49 Θ ALARM	50 ~ 100%	90%	49 Thermal warning stage
4205	I ALARM	0.50 ~ 20.00 A	5.00 A	Current warning stage
4207	Kτ-FACTOR when motor stops	1.0 ~ 10.0	1.0	Kτ time factor for non-running motor
4208	T EMERGENCY	10 ~ 15000 sec	100 sec	Dropout time after emergency start-up

6.8.2.2 Information List for Thermal Overload Protection

F#	LCD-Text	Comment
1511	49 O / L OFF	49 Overload Protection is OFF
1512	49 O/L BLOCK	49 Overload Protection is BLOCKED
1513	49 O/L ACTIVE	49 Overload Protection is ACTIVE
1515	49 O/L I Alarm	49 Overload Current Alarm (I alarm)
1516	49 O/L Θ Alarm	49 Overload Alarm! Near Thermal Trip
1517	49 Winding O/L	49 Winding Overload
1521	49 Th O/L TRIP	49 Thermal Overload TRIP
806	Θ Stator	Temperature of Stator (calculated by 49)
1503	>BLOCK 49 O/L	>BLOCK 49 Overload Protection
1507	>EmergencyStart	>Emergency start of motors

6.9 Start Inhibit for Motors (66/68)

General

The rotor temperature of a motor generally remains well below its maximum allowable temperature during normal operation and even during severe loading conditions. However, during motor starting, the rotor can heat up quickly. If multiple starting attempts are made in a short duration of time, the rotor could suffer thermal damage. Therefore, the 7SJ61 motor start blocking feature is available. A motor start blocking signal is initiated when the relay projects rotor temperature will exceed the maximum allowable rotor temperature, and blocking continues until the calculated rotor temperature decreases below the reset level. To block starting, the blocking signal must be connected to a binary output whose contact is inserted in the motor starting circuit.

6.9.1 Description of Start Inhibit for Motors

Determining Excessive Rotor Temperature

Because the rotor current cannot be measured directly, the stator current must be used to generate a thermal profile of the rotor. The excessive rotor temperature is calculated using the highest of the three phase currents. The thermal limit values for the rotor winding are based on manufacturer's data regarding the nominal starting current, maximum permissible starting time, and the number of starts permitted from cold and warm conditions. From this data, the device performs the necessary calculations to establish the thermal rotor profile and issues a blocking signal until the thermal rotor profile decreases below the restarting limit.

Although the heat distribution at the rotor brushes can range widely during motor starting, the different maximum temperatures in the rotor do not necessarily affect motor start blocking (see Figure 6-31). It is much more important to establish a thermal profile, after a complete motor start, that is appropriate for the protection of the motor's thermal condition. Figure 6-31 shows, as an example, the heating processes during repeated motor starts (three starts from cold operating condition), as well as the thermal reproduction by the protective relay.
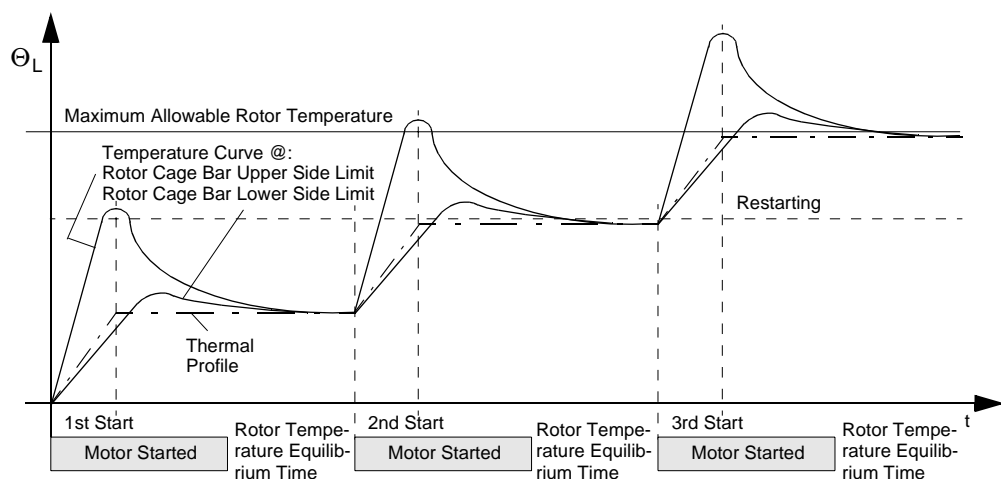
Figure 6-31 Temperature Curve at the Rotor and the Thermal Profile during Repeated Starting Attempt

Restarting Limit

If the rotor temperature has exceeded the restarting limit, the motor cannot be restarted. When the rotor temperature goes below the restarting limit, that is, when exactly

one start becomes possible without exceeding the excessive rotor temperature limit, the blocking signal is terminated.

Therefore the restarting temperature related to trip temperature is expressed as:

$$\frac{\Theta_{Restart}}{\Theta_{Trip}} = \frac{n_{cold} - 1}{n_{cold}}$$

Restarting Times

When giving the maximum allowable cold and warm starting attempts , the motor manufacturer assumes the motor is not restarted immediately after motor shutdown. This is assumption is made because the distribution of heat in the rotor, is very different immediately after motor shutdown. Only after a certain heat equilibrium time has passed can a new starting attempt be made. The device can allow for the equilibrium time via a programmable time interval entered at address 4304 **T Equal**. Each time the motor is shutdown, the timer starts, and the calculated thermal profile of the rotor does not change until this timer elapses. Once the time interval entered at address 4304 elapses, the device assumes equilibrium has taken place in the rotor, and the thermal profile begins to update. A time of zero can be entered at address 4304 at the option of the user. The entire time that must elapse be fore motor starting can resume is equal to the equilibrium time entered at address 4304 and the amount of time, calculated via the thermal model, that it takes for the rotor temperature to decrease to the reset temperature level.

Extending the Time Constants

In order to properly account for the reduced heat exchange when a self-ventilated motor is stopped, the cooling time constants can be increased relative to the time constants for a running machine. A stopped motor is defined by current below an adjustable current flow monitoring threshold, assuming that the motor idle current is greater than this threshold.

Logic

If, under emergency conditions, motor starting in excess of the maximum allowable rotor temperature must take place, the motor start blocking signal can be terminated via a binary input, thus allowing a new starting attempt. The thermal rotor profile continues to function, however, the maximum allowable rotor temperature will be exceeded. No motor shutdown will be initiated by motor start blocking, but the calculated excessive temperature of the rotor can be observed for risk assessment.

If the motor start blocking function is blocked or switched off, the thermal profile of the excessive rotor temperature and the equilibrium time are reset, and any existing motor start blocking signal is terminated.

Figure 6-32 shows the logic diagram of the start inhibit for motors function.
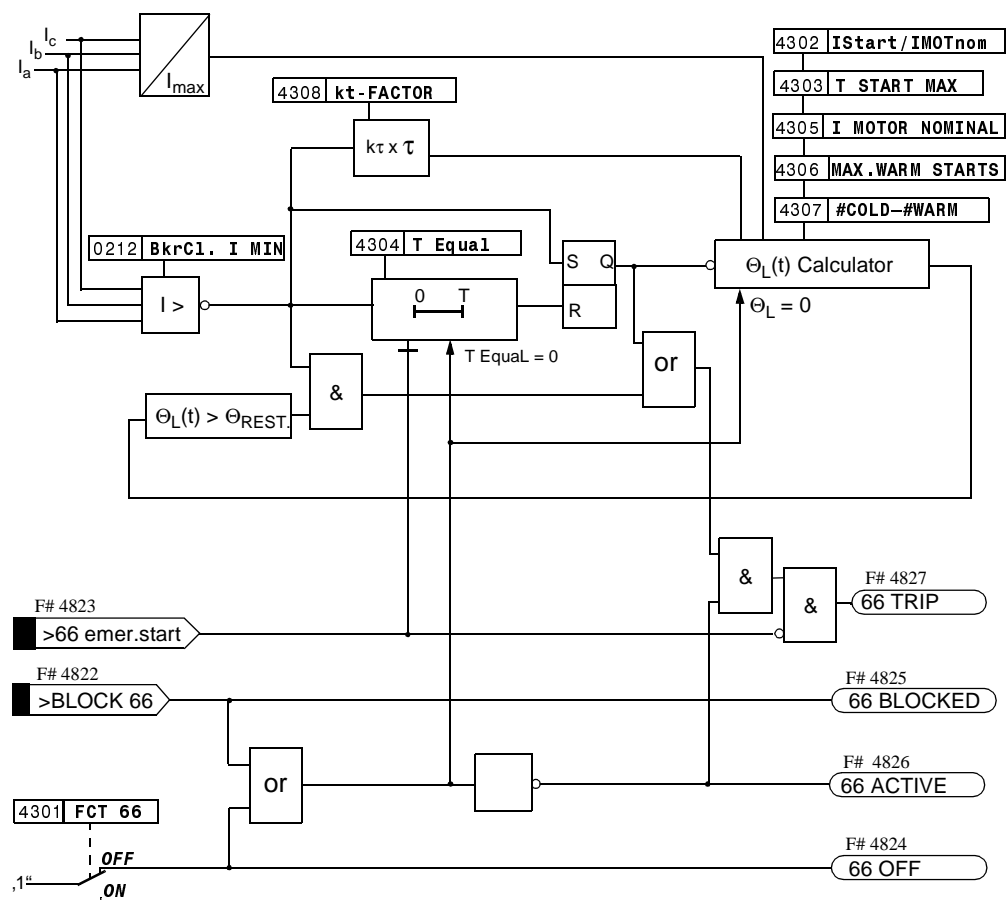
Figure 6-32   Logic Diagram of the Start Inhibit for Motors Function

6.9.2   Programming Settings

General

The motor start blocking function is only in effect and accessible if address 0143 **66 #of Starts** is set to *Enabled* during configuration of protective functions. If the function is not needed, then *Disabled* is set. The function can be turned on or off under address 4301 **FCT 66**.

Required Data

Many of the variables needed to calculate the rotor temperature are supplied by the motor manufacturer. Among these variables are the starting current, the nominal motor current, the maximum allowable starting time **T START MAX** (address 4303), the number of allowable starts from cold conditions, and the number of allowable starts from warm conditions.

The starting current is entered at address 4302 **IStart/IMOTnom**, expressed as a multiple of nominal motor current. In contrast, the nominal motor current is entered as a secondary value, directly in amperes, at address 4305 **I MOTOR NOMINAL**. The number of warm starts allowed is entered at address 4306 **MAX.WARM STARTS** and

the difference between the number of allowable cold and warm starts is entered at address 4307 **#COLD–#WARM**.

For motors without separate ventilation, the reduced cooling at motor stop can be accounted for by entering the **kτ–FACTOR** at address 4308. As soon as the current no longer exceeds the current flow monitoring setting entered at address 0212, the time constant is increased by the kτ factor.

If no difference between the time constants is to be used (e.g. externally-ventilated motors), then the **kτ–FACTOR** should be set to *1*.

Example: Motor with the following data:

Nominal Voltage	V_N = 6600 V
Nominal Current	I_N = 126 A
Starting Current	I_{Start} = 624 A
Starting Duration @ I_{Start}	$T_{ANL\ max}$ = 8.5 s
Allowable Starts with Cold Motor	n_{cold} = 3
Allowable Starts with Warm Motor	n_{warm} = 2
Current Transformer Ratio	200 A/1 A

The following settings are derived from these data:

$$I_{START}/I_N = \frac{624\ A}{126\ A} = 4.95$$

$$I_N = \frac{126\ A}{200\ A} = 0.62 \cdot I_{NCTsec}$$

The following settings are made:

I_{Start}/I_N = *4.9*
I_N = *0.6 A*
Warm Starts = *2*
Cold Starts – Warm Starts = *1*

6.9.2.1 Settings for Start Inhibit of Motors

In the list below, the setting range and default setting value for Address 4305 are for a device with a nominal current rating I_N = 5 A. For a nominal current rating I_N = 1 A, divide the Setting Options values and Default Setting value by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	LCD-Text	Setting Options	Default Setting	Comments
4301	FCT 66	OFF ON	OFF	66 Startup Counter for Motors
4302	IStart/IMOTnom	3.0 ~ 10.0	4.5	I Start / I Motor nominal
4303	T START MAX.	3 ~ 120 sec	10 sec	Maximum Permissible Starting Time
4304	T Equal	0.0 ~ 60.0 min	1.0 min	Rotor Temperature Equilibrium Time

Addr.	LCD-Text	Setting Options	Default Setting	Comments
4305	I MOTOR NOMINAL	1.0 ~ 6.0 A	5.0 A	Rated Motor Current
4306	MAX.WARM STARTS	1 ~ 4	2	Maximum Number of Warm Starts
4307	#COLD–#WARM	1 ~ 2	1	Number of Cold Starts – Warm Starts
4308	Kτ-FACTOR	1 ~ 10	2	Kt-Factor at Stop

6.9.2.2 Information List for Start Inhibit of Motors

F#	LCD-Text	Comments
4824	66 OFF	66 Motor start protection OFF
4825	66 BLOCKED	66 Motor start protection BLOCKED
4826	66 ACTIVE	66 Motor start protection ACTIVE
4827	66 TRIP	66 Motor start protection TRIP
805	Θ Rotor	Temperature of Rotor (calculated by 66)
4822	>BLOCK 66	>BLOCK Motor Startup counter

6.10 Breaker Failure Protection (50BF)

6.10.1 Description of Breaker Failure Protection

General

The breaker failure protection function monitors the reaction of a circuit breaker to a trip signal. If after a programmable time delay, the circuit breaker has not opened, a breaker failure trip signal issued, and all adjacent circuit breakers that represent sources to the fault can be tripped (see Figure 6-33). To determine if the circuit breaker has properly opened in response to a trip signal, one of the following methods is used to ascertain the status of the circuit breaker:

- The current flow through the circuit breaker.

- The position of a circuit breaker auxiliary contact.
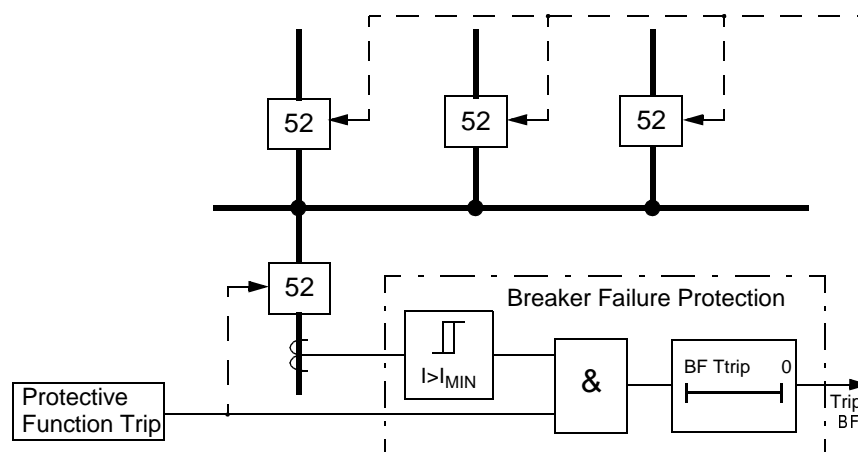
Figure 6-33   Functional Principle of the Breaker Failure Protection Function

Initiation

The breaker failure protection function can be initiated by two different sources:

- Internal protective function of the 7SJ61,

- External trip signals via binary inputs.

For each of the two sources, a unique pickup message is generated, a unique time delay is initiated, and a unique tripping signal is generated. The setting values for breaker failure pickup and delay apply to both sources.

Criteria

The criteria used to determine if the circuit breaker has operated is selectable and should depend on the protective function that initiated the breaker failure function. For protective functions that operate in response to currents (e.g. overcurrent protection, etc.), both the current flow through the circuit breaker and the position of the circuit breaker auxiliary contact can be used to determine if the circuit breaker properly operated. However, operation of a circuit breaker auxiliary contact does not always mean that the circuit breaker successfully cleared the fault current, therefore, the device can be programmed such that only the current flow criterion is used to determine breaker status.

The current criterion is met if at least one of the three phase currents exceeds the current flow monitoring setting entered at address 0212 (see Subsection 6.1.1). Evalua-

tion of the circuit breaker auxiliary contact depends on the type of contact(s), and how they are connected to the binary inputs:

- Both "a" and "b" type auxiliary contacts are connected.

- Only an "a" type auxiliary contact is connected.

- Only a "b" type auxiliary contact is connected.

- No auxiliary contact is connected.

The circuit breaker condition can be detected prior to the initiation of a trip signal, depending on the configuration of binary inputs and auxiliary contacts. This information can be used to properly operate the breaker failure function.

Logic

If breaker failure is initiated, an alarm message is generated (50 BF Pickup), and the breaker failure timer is started. Once the time delay elapses, a breaker failure trip signal is issued (50 BF Trip). Figure 6-34 shows the logic diagram for the breaker failure protection scheme. It is possible to turn the entire breaker failure protection function on or off, or it can be blocked dynamically via binary inputs.

For utilities requiring a **50BF Retrip** function, the 50BF Pickup element (internally and/ or externally initiated pickup) can be configured to the circuit breaker trip output contact.

If one of the criteria (current value, breaker auxiliary contacts) that led to pickup of the breaker failure scheme is no longer met during the time delay elapses, then breaker failure timer drops out and no trip signals are issued.

To protect against nuisance tripping due to excessive contact bounce, a stabilization of the binary inputs for external trip signals takes place. This external signal must be present during the entire period of the delay time, otherwise the timer is reset and no tripping signal is issued.
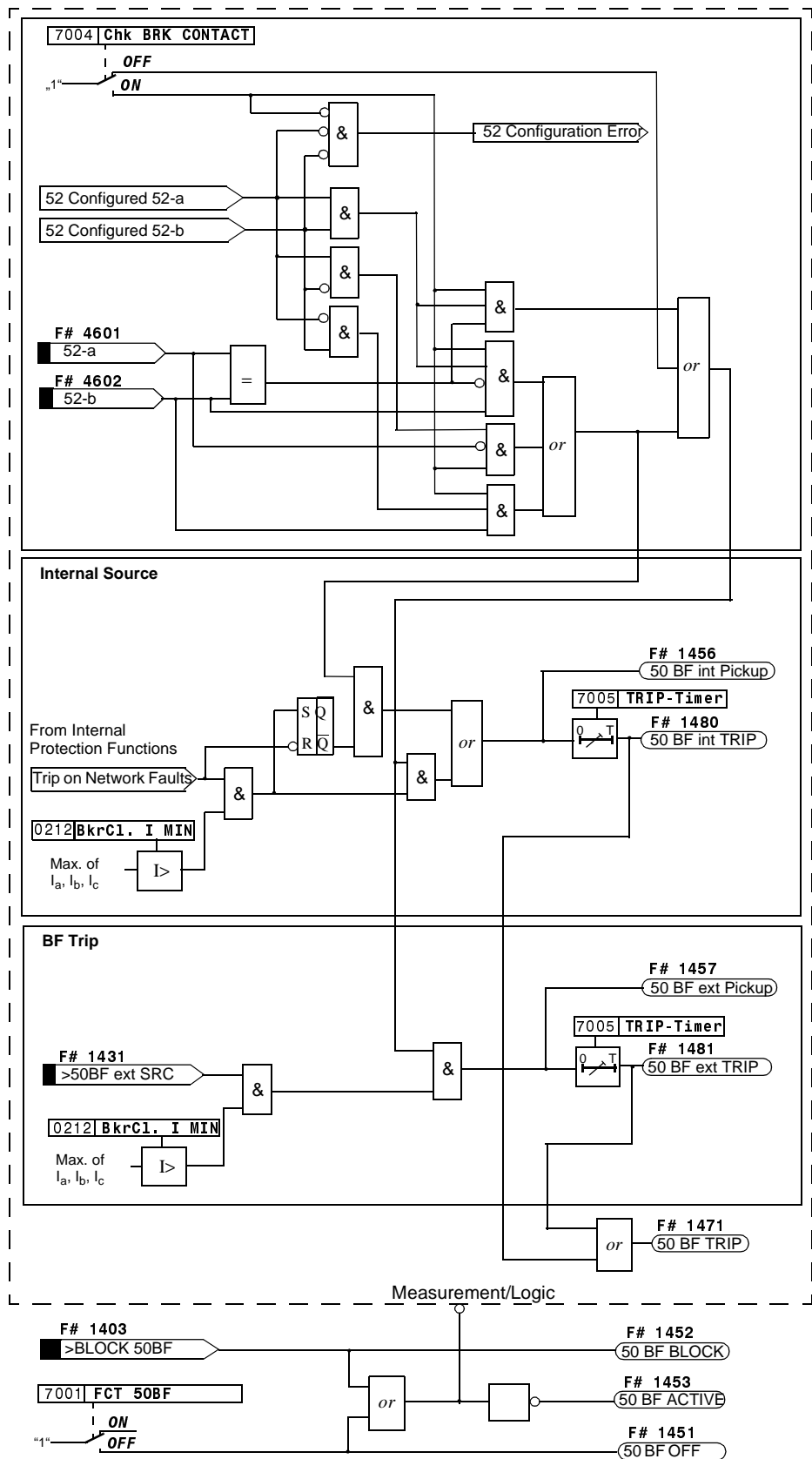
Figure 6-34   Logic Diagram for the Breaker Failure Protection

6.10.2 Programming Settings

General

The breaker failure protection function is only effective and available if address 0170 **BREAKER FAILURE** is set to *Enabled*. If the breaker failure function is not required, then address 0170 should be set to *Disabled*.

Criteria

Address 7004 **Chk BRK CONTACT** establishes whether or not a breaker auxiliary contact is used, via a binary input, to detect the position of a circuit breaker. If address 7004 is set to *ON*, then both the current flow through the circuit breaker and the position of the circuit breaker auxiliary contact are used to ascertain the position of the circuit breaker. If address 7004 is set to *OFF*, only the current flow through the circuit breaker is used to indicate the position of the circuit breaker.

The current flow monitoring setting programmed at address 0212 applies to all three phases, and should be selected such that it is at least 10 % below the smallest fault current the circuit breaker would interrupt when responding to trip signals initiated by protective relays. The setting at address 0212 should not be set too low, otherwise, the danger exists that equalization processes in the current transformer secondary circuit could lead to extended drop out times under conditions of extremely high current. In addition, it should be noted that other protection functions depend on the current flow monitoring settings as well (e.g. overload protection, and restarting block for motors).

Time Delay

The breaker failure time delay setting is entered at address 7005 **TRIP-Timer**. This setting should be based on the circuit breaker interrupting time plus the dropout time of the current flow monitoring element plus a safety margin. Figure 6-35 illustrates the timing of a typical breaker failure scenario.
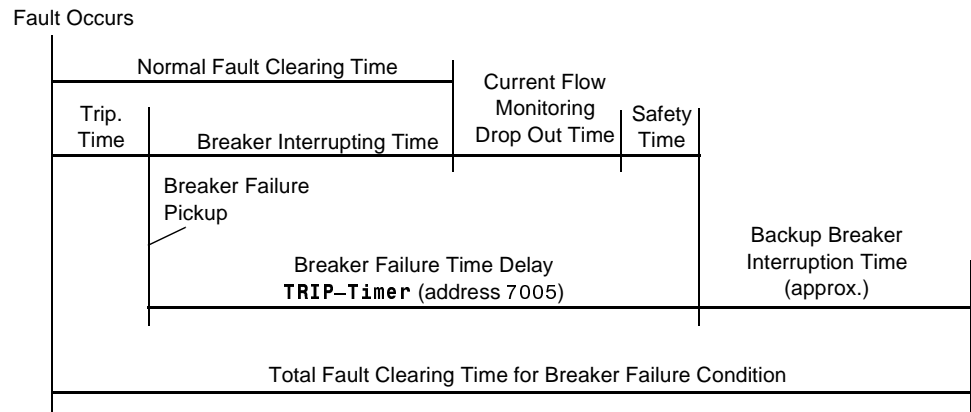
Figure 6-35   Time Chart for Typical Breaker Failure Operation

6.10.2.1 Settings for Breaker Failure Protection

Addr.	LCD-Text	Setting Options	Default Setting	Comments
7001	FCT 50BF	OFF ON	OFF	50BF Breaker failure protection
7004	Chk BRK CONTACT	OFF ON	OFF	Evaluation of breaker auxiliary contacts (52/a or 52/b) via binary inputs
7005	TRIP–Timer	0.06 ~ 60.00 sec	0.25 sec	Timer to indicate failure

6.10.2.2 Information List for Breaker Failure Protection

F#	LCD-Text	Comments
1451	50BF OFF	50BF Breaker failure protection switched OFF
1452	50BF BLOCK	50BF Breaker failure protection is BLOCKED
1453	50BF ACTIVE	50BF Breaker failure protection is ACTIVE
1456	50BF int Pickup	50BF (internal) PICKUP - after internal BFI
1457	50BF ext Pickup	50BF (external) PICKUP - after external BFI
1471	50BF TRIP	50BF Breaker failure TRIP
1480	50BF int TRIP	50BF Breaker failure (internal) TRIP, int. BFI
1481	50BF ext TRIP	50BF Breaker failure (external) TRIP, ext. BFI
1403	>BLOCK 50BF	>BLOCK 50BF Breaker failure protection
1431	>50BF ext SRC	>50BF initiated externally
4601	>52-a	>52-a contact (OPEN, if breaker is open)
4602	>52-b	>52-b contact (OPEN, if breaker is closed)

6.11 Automatic Reclosing System (79M)

6.11.1 Description of Automatic Reclosing System

General From experience, the majority of faults associated with overhead distribution feeders are temporary in nature. Therefore, to maximize service availability, it is desirable to employ a system that will close the circuit breaker shortly after it is tripped. This is accomplished in the 7SJ61 relay via the automatic reclosing system.

When using the automatic reclosing system, if the fault still exists after the circuit breaker has been reclosed, then the protective elements will re-trip the circuit breaker. Depending on the number of reclosing attempts programmed for the automatic reclosing system (up to nine are possible), the circuit breaker will either be reclosed again, or will remain open.

The automatic reclosing function is typically utilized only in situations where the occurrence of temporary faults is anticipated. Therefore, the automatic reclosing system is not applied when the 7SJ61 relay is used to protect generators, motors, transformers, and cables.

The automatic reclosing function can also be initiated by an external protection relay. For this application, an output contact from the tripping relay must be wired to a binary input of the 7SJ61 relay. It is also possible to allow the 7SJ61 relay to work in conjunction with an external reclosing device.

Figure 6-36 shows an example of a timing diagram for a successful second reclosure. Figure 6-37 shows an example of a timing diagram for two unsuccessful reclosing shots, with no additional reclosing of the circuit breaker.
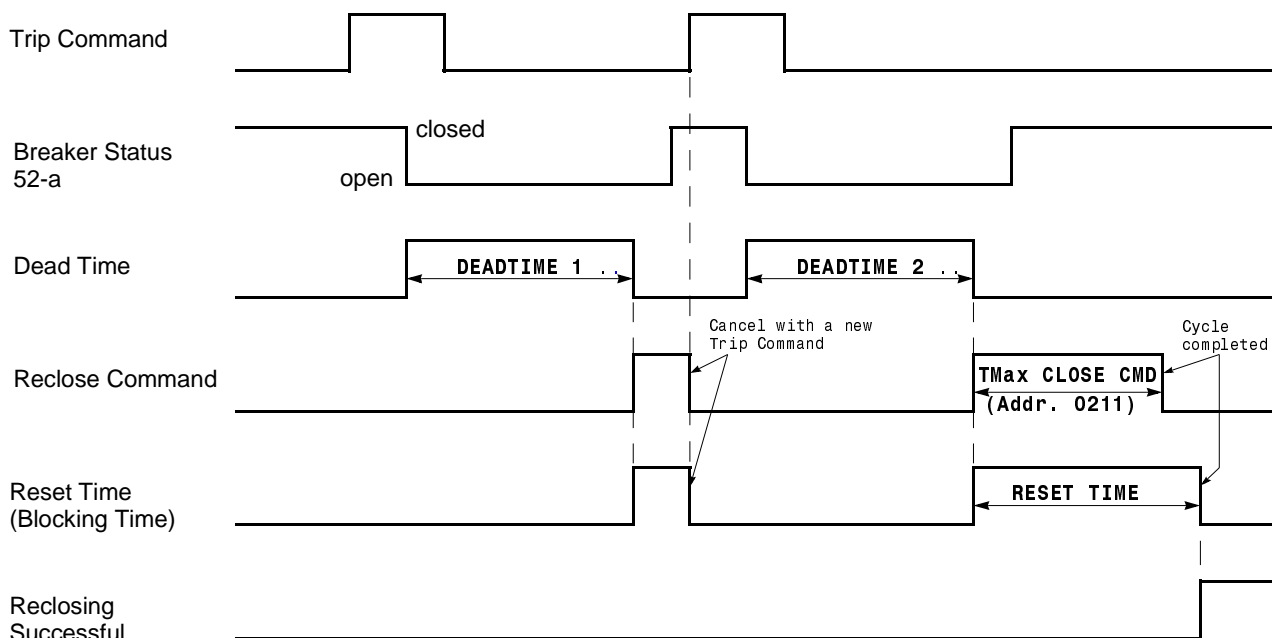
Figure 6-36   Timing Diagram for a Second Successful Reclosure
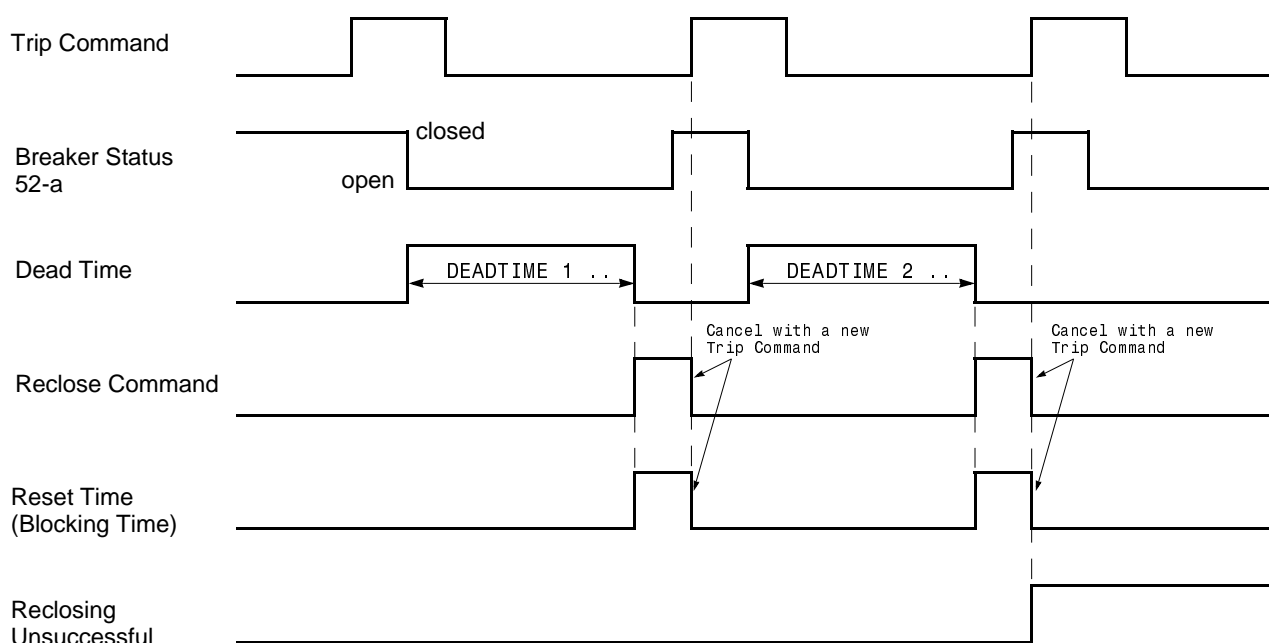
Figure 6-37   Timing Diagram showing Two Unsuccessful Reclosing Shots (no additional reclosing of the circuit breaker)

Initiation

Initiation of the automatic reclosing function can be caused by internal protective functions or externally using a binary input. Each of the following elements may initiate the automatic reclosing function:

50-2, 50N-2
50-1, 50N-1
51, 51N
Sensitive Ground Fault Protection 50Ns, 51Ns
Negative Sequence Protection 46
Binary Inputs

The automatic reclosing system can be programmed such that any of the elements above can initiate, not initiate, or block reclosing. If an element initiates reclosing, the appropriate reclosing program is executed.

Reclosing Programs

Depending on the type of fault, two different reclosing programs can be used. The following applies:

• The single phase fault (ground fault) reclosing program applies if a phase-to-ground fault is detected. Therefore, the ground fault reclosing program is executed only when the elements associated with a specific phase and/or ground pick up. This program can also be started via a binary input.

• The multiple phase fault (phase fault program) reclosing program applies to all other cases. That is, when elements associated with two or more phases pickup, with or without the pickup of ground elements, the phase reclosing program is executed. In addition, when automatic reclosing is initiated by other functions, such as negative sequence elements, the program is started. Like the ground fault reclosing program, this program can be started via a binary input as well.

Determination of which program will be executed is based solely on which elements pick up prior to the first reclosing attempt. Once a program is started, it will be used to control reclosing until the last allowable reclosing signal is initiated.

For each of the programs, up to 9 reclosing attempts can be separately programmed. The open breaker times preceding the first four reclosing attempts can be independently set, however, the open breaker times preceding the fifth through the ninth reclosing attempts will correspond to the open breaker time that precedes the fourth reclosing attempt.

Selectivity Before Reclosing

For the automatic reclosure sequence to be successful, faults on any part of the line must be cleared from the feeding line end(s) within the same – shortest possible – time. Usually, therefore, an instantaneous protection element is set to operate before an automatic reclosure. In addition, when two or more reclosing attempts are anticipated, high speed tripping should be allowed. To begin with, high speed tripping minimizes the impact fault current might have on the system. Second, high speed tripping prevents the operation of load side fuses for temporary faults. Prior to the final reclosing attempt, however, high speed tripping should be defeated to prevent a feeder lockout from occurring due to faults beyond load side protective devices.

Single-Shot Reclosing

When a trip signal is programmed to initiate the automatic reclosing system, the appropriate automatic reclosing program will be executed. Once the circuit breaker has opened, the programmable dead time interval is started. Once the dead time interval has elapsed, a closing signal is issued to reclose the circuit breaker. A blocking time interval is started at the same time.

The dead time can be set individually for each of the two reclosing programs.

If the fault is cleared (successful reclosing attempt), the blocking time expires and automatic reclosing is reset in anticipation of a future fault.

If the fault is not cleared (unsuccessful reclosing attempt), then a final tripping signal is initiated by one or more protective elements. In addition, if a new fault occurs before the blocking time elapses, no reclosing will be initiated. After the unsuccessful reclosing attempt, the automatic reclosing system is dynamically blocked (see below).

Multi-Shot Reclosing

The 7SJ61 relay can be programmed to initiate up to nine (9) reclosing attempts. The number of reclosing attempts can be set differently for the phase fault reclosing program and the ground fault reclosing program. The first dead time interval precedes, in principle, the first reclosing attempt. If the first reclosing attempt is unsuccessful, the blocking time interval is reset and the second dead time interval begins. At the end of the second open breaker interval, a second reclosing attempt is initiated. This cycle can be repeated until the allowable number of reclosing attempts programmed have been made.

The dead time intervals preceding the first four (4) reclosing attempts can be set differently for each of the two reclosing programs. The dead time intervals preceding the fifth (5) through the ninth (9) reclosing attempts will be equal to the dead time interval that precedes the fourth (4) reclosing attempt.

If one of the reclosing attempts is successful, the blocking time expires and the automatic reclosing system is reset.

If none of the reclosing attempts is successful, then a final circuit breaker trip will take place after the last allowable reclosing attempt has been made.

After the final circuit breaker trip, the automatic reclosing system is dynamically blocked (see below).

Blocking Time   The blocking time (reset time) is started each time a reclosing attempt is initiated. If the reclosing attempt is successful, then the automatic reclosing system will reset once the blocking time has elapsed. Occurrence of a fault after the blocking time is considered a new fault, and the initiation of trip signals by protective elements for this fault will initiate a new automatic reclosing sequence (and possibly execute a different reclosing program, depending on the type of fault). When no additional reclosing attempts are permitted, the last reclosing attempt will be considered unsuccessful, and upon final tripping of the circuit breaker by the protective element(s), the automatic reclosing system will be dynamically blocked (see below).

Static Blocking   The automatic reclosing system is statically blocked for one or more of the following:

– A blocking signal (FNo. 2703 "`>BLOCK 79`") is present at a binary input, if the automatic reclosing system is not initiated.

– A signal (FNo. 2730 "`>CB Ready`") indicating the circuit breaker is ready disappears from a binary input, if the automatic reclosing system is not initiated.

– The number of allowable reclosing attempts set for both reclosing programs is zero.

– No protective functions or binary inputs are set to initiate the automatic reclosing system.

Static blocking means that the automatic reclosing system is not ready to initiate reclosing, and cannot initiate reclosing as long as the blocking signal is present. When static blocking takes place, a corresponding message is generated. The static blocking signal is also used internally to block the protection elements that are only supposed to work when reclosing is enabled.

Dynamic Blocking   Dynamic blocking defeats the possibility of a reclosing attempt when certain events occur. Dynamic blocking is initiated if:

– The final reclosing attempt was <u>unsuccessful</u>.

– The protection function has detected a three-phase fault and the device is programmed not to reclose into three-phase faults.

– The circuit breaker is tripped without initiation of the automatic reclosing system.

– A reclosing signal fails to close a circuit breaker.

– A protective element picks up that is set to block automatic reclosing (regardless of whether one or more other protective functions set to initiate automatic reclosing also pickup).

– The circuit breaker failure function is initiated.

– The reclosing program executed is programmed to initiate zero reclosing attempts.

– A static block occurs after initiation of the automatic reclosing function.

– **Not applicable for version 7SJ61**–**C**– and 7SJ61**–**P**–**: The circuit breaker is not ready for operation after the circuit breaker monitoring time (set at address 7113 **CHECK CB?**) has elapsed, provided that the circuit breaker monitor function is set to be in effect.

– **Not applicable for version 7SJ61**–**A**– and 7SJ61**–**M**–**: If the circuit breaker is not ready for operation after the reclosing delay time (triggered by binary input with Function No: 2705 "`>79 T WAIT`" and specific setting of delayed AR command at address 7116 **MAX.InhibitTIME**) has elapsed.

– Manual closing was detected (externally).

– Through an binary input (FNo. 2703 "`>BLOCK 79`") configured with functions of dynamic blocking.

Upon initiation of dynamic blocking, automatic reclosing is disabled. Automatic reclosing will resume only when the circuit breaker is closed again and the dynamic blocking time has elapsed. The dynamic blocking time also blocks reclosing when a circuit breaker is operated manually.

Circuit breaker status

The detection of the actual circuit breaker position is necessary for the correct functionality of the auto reclose function. The breaker position can be detected via the breaker contact or the current criteria. (address 0212 **`BkrClosed I MIN`**). The method to be used depends on the masking of the binary inputs: "`>52-a`" (FNo. 4601) and "`>52-b`" (FNo. 4602). The following applies:

- Masking of "`>52-a`": The breaker contact will be used. The current criteria is not used.

- Masking of "`>52-b`": The breaker contact will be used. The current criteria is not used.

- Masking of "`>52-a`" and "`>52-b`": Breaker contacts will be used, if an intermediate postion is not detected. As soon as an intermediate position is detected (both binary inputs are low or both are high) the current criteria will be used. If the primary current is higher then the setting under address 0212 **`BkrClosed I MIN`** the breaker is considered as closed.

- No masking of binary inputs: If the primary current is higher then the setting under address 0212 **`BkrClosed I MIN`** the breaker is considered as closed.

Circuit Breaker Monitoring

The ability of a circuit breaker to reclose and re-trip if necessary can be monitored by the 7SJ61 relay. There are two methods to achieve this:

1st Method: Not applicable for version 7SJ61**–**C**– and 7SJ61**–**P**

A precondition for a reclosing attempt, following a trip command initiated by a protective relay element and subsequent initiation of the automatic reclosing function, is that the circuit breaker is ready for at least one TRIP-CLOSE-TRIP cycle. The readiness of the circuit breaker is monitored by the device using a binary input (FNo. 2730 "`>CB Ready`"). In the case where this signal from the breaker mechanism is not available, the circuit breaker monitoring feature should be disabled, otherwise reclosing attempts will remain blocked.

For a situation where only one reclosing attempt will be made, monitoring of the circuit breaker when automatic reclosing is initiated should be sufficient. However, when multiple reclosing attempts are programmed, it is a good idea to monitor the circuit breaker condition prior to each reclosing attempt as well, since operation of, for example, pneumatically controlled circuit breakers will result in reduced air pressure. A reclosing attempt will be blocked until the binary input, configured with the function 2730, indicates that the circuit breaker is ready to complete another CLOSE-TRIP cycle. When the 2730 binary input drops out i.e. during the dead time of the reclose cycle, indicating that the circuit breaker is not ready, a programmable monitoring delay time (Address 7115 **`CB TIME OUT`**) is initiated.

If the circuit breaker is not ready for operation when the dead time elapses, the dead time can be extended (see setting of dress 7115). If during this extended dead time period the circuit breaker mechanism indicates, via the 2730 binary input, that it is ready for another operation, a reclose command is initiated. However, if after the dead time the additional monitoring delay time elapses before the 2730 binary input picks

up, dynamic blocking is initiated and any further operation of the circuit breaker from the automatic reclosing system is prohibited.

2nd Method: Not applicable for version 7SJ61**–A**– and 7SJ61**–M**

An alternative circuit breaker monitoring method involves a separate time delay interval and binary input (FNo. 2705 "**>79 T WAIT**"). This binary input indicates that the circuit breaker is **not** ready for operation, as opposed to indicating that the circuit breaker is ready. At the end of the dead time interval, if the 2705 binary input is picked up, a closing command time delay is initiated (see setting dress 7116 **MAX.Inhibit TIME**). If the 2705 binary input drops out prior to the elapse of the closing command time delay, reclosing is performed. However, if the closing command delay time elapses before the 2705 binary input drops out, dynamic blocking is initiated and further operation of the circuit breaker by the automatic reclosing system is blocked.

Load Side Fuse Protection and Zone Sequence Coordination	**Not applicable for version 7SJ61**–**A**– and 7SJ61**–**M**:** Figure 6-38 shows an example of how zone sequencing and protection of load side fuses is possible in a radial distribution system. Consider the relays protecting Feeder #3 and the busbar. Assume that the relay protecting Feeder #3 is programmed for one reclosing attempt and that the busbar relay does not utilize reclosing.

For fault F1 at Tap Line #2, the 50-2 elements associated with both the Feeder #3 relay and the busbar relay pickup. The time delay of the 50-2 element protecting Feeder #3 is set so that the Feeder #3 circuit breaker will clear the fault before the fuse at Tap Line #2 is damaged. After the first reclosing attempt, if the fault was cleared, normal service is restored to all customers (including the customers served by Tap Line #2). If after the first reclosing attempt, the fault continues to exist, the 50-2 element at Feeder #3 is blocked, and the fuse operates to clear the fault. If the fuse fails to clear the fault, then the 50-1 element protecting Feeder #3 will initiate a delayed trip signal (0.4 seconds), thus serving as backup protection for the fuse.

Assume protection requirement require that the 50-2 element at the busbar relay be set with a delay of 0.4 seconds as well. When the fault first appears at F1, the 50-2 element at the bus relay picks up, but drops out when the 50-2 element at Feeder #3 trips the circuit breaker. Upon reclosing, if the fault still remains, the 50-2 element associated with the bus relay picks up again, however, the fuse operates to clear the fault, thus resulting in a drop out of the 50-2 element at the busbar relay. Had the fault been on Feeder #3, however, the 50-2 element associated with the busbar relay would have initiated a trip (simultaneously with the trip initiated by the Feeder #3 50-1 element) after reclosing had occurred. All three feeders supplied by the bus would have been cut off from the incoming supply for a fault that should have locked out Feeder #3 only.

To prevent this from happening, zone sequencing is switched on at the bus relay (See AR setting dress 7140). With zone sequencing in operation, the bus relay counts the number of times a fault is interrupted. For the first fault, the 50-2 element at the bus is allowed to trip. If the fault is at F1 or on Feeder #3, the 50-2 element protecting Feeder #3 will initiate a high speed trip, thus causing the 50-2 element at the bus relay to drop out.

For the second fault, the 50-2 element at the bus relay must be blocked because the 50-2 element at Feeder #3 is blocked, and a permanent fault on Feeder #3 could result in an inadvertent trip by the 50-2 element protecting the bus. Because zone sequencing is switched on at the bus relay, the bus relay counts the number of faults, and after the first fault, blocks the 50-2 element from tripping. Therefore, for a permanent fault on Feeder #3, the 50-2 element at the bus would have been blocked after the reclosing attempt, and the 50-1 element at Feeder #3 would have tripped the circuit breaker in

0.4 seconds. Had the 50-1 element failed to clear the fault, the 50-1 element at the bus relay, which is set for 0.9 seconds, would serve as backup protection.

For the bus fault F2, the 50-2 element at the bus would have cleared the fault in 0.4 seconds. The 50-1 element at the bus serves to backup the 50-2 element. Had zone sequencing not been available, the 50-2 element at the bus relay could not have been set to clear the bus fault in 0.4 seconds without causing coordination problems between the bus relay and the Feeder #3 relay. On a final note, zone sequencing is only effective at the bus relay when all three feeders utilize high speed tripping prior to the first reclosing attempt.
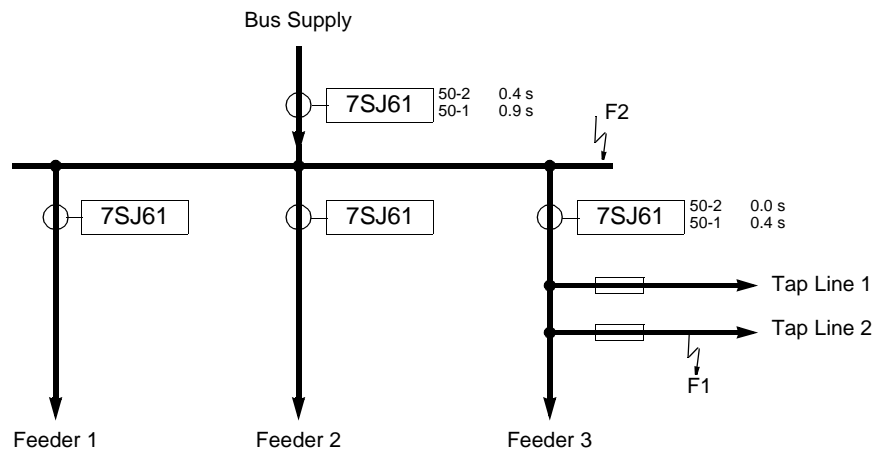
Figure 6-38   Illustration of Zone Sequencing and the Protection of Load Side Fuses

6.11.2 Programming Settings

General Settings

The internal automatic reclosing system will only be effective and accessible if address 0171 is to *Enabled* during configuration or protective functions. If the automatic reclosing function is not required, then address 0171 should be set to *Disabled*. The function can be turned *ON* or *OFF* at address 7101 **FCT 79**.

When a circuit breaker is manually closed into a fault, it is often desirable for the circuit breaker to be immediately tripped and locked out. If a contact from an external control switch is connected to a binary input and address 7103 **BLK MAN. CLOSE** is set to *YES*, then closing the circuit breaker via the external control switch will prohibit reclosing from taking place.

Blocking Time and Dynamic Blocking

The blocking time set at address 7105 **79 TIME RESTRAINT** defines the time that must elapse, after a successful reclosing attempt, before the automatic reclosing function is reset, in preparation of a new fault. If a protective element picks up before the blocking time elapses, the reclosing cycle is continues. If a protective trip occurred after the last allowable reclosing attempt was made, then together with the trip command the feeder is locked out. If a protective element picks up after the blocking time has elapsed, then a new reclosing cycle is initiated. In general, address 7105 should be set for only a few seconds. In areas with frequent thunderstorms, a shorter blocking time may be necessary to avoid feeder lockout due to sequential lightning strikes. A longer blocking time should be chosen if there is no possibility to monitor the circuit breaker ready status (see below) during multiple reclosing. In this case, the blocking

time should be longer than the time required for the circuit breaker mechanism to be ready.

If a dynamic blocking of the automatic reclosing system was initiated, then reclosing functions remain blocked until the circuit breaker is closed manually again (not from a protective function). The setting at address 7108 **SAFETY 79 ready** establishes how long automatic reclosing blocking is extended, after the dynamic blocking is reset. In this way the delay set at address 7108 also establishes how long automatic reclosing is blocked after manual closing of the circuit breaker. Address 7108 should be set to ensure a safe close and trip of the circuit breaker (0.5 to 1.0 seconds).

Circuit Breaker Monitoring

1. Not applicable for version 7SJ61–**C**– and 7SJ61**–**P****

If circuit breaker monitoring is desired, address 7113 **CHECK CB?** should be set to monitor before each reclosing attempt (*Chk each cycle*), otherwise address 7113 should be set not to monitor (*No check*). If monitoring is not possible, address 7113 should be set not to monitor.

If circuit breaker monitoring is accomplished via a binary input that detects a circuit breaker ready condition, then the device must detect a ready condition prior to the elapse of the time delay set at address 7115 **CB TIME OUT** or further reclosing will be suspended.

2. Not applicable for version 7SJ61–**A**– and 7SJ61**–**M****

If circuit breaker monitoring is accomplished via a binary input that picks up when the breaker is not ready (FNo. 2705 **>79 T WAIT**), then a time delay set at address 7116 **MAX.InhibitTIME** is started when the dead time has elapsed, and the binary input must drop out before the time delay elapses, otherwise further reclosing will be suspended.

Open Breaker Times

The dead time preceding the first reclosing attempt is set at address 7127 **DEADTIME 1: PH** for the multiple phase fault reclosing program and at address 7128 **DEADTIME 1:G** for the single phase fault reclosing program. The dead time should be set long enough to allow a temporary fault to clear (0.9 to 1.5 seconds) unless stability is a concern, in which case faster times may be required (typically 0.3 to 0.6 seconds). The dead times for the second (2nd) through fourth (4th) reclosing attempts are set at addresses 7129, 7131, and 7133 respectively for the multiple phase reclosing program and at addresses 7130, 7132, and 7134 respectively for the single phase reclosing program. As was stated earlier, the dead times preceding the fifth (5th) through the ninth (9th) reclosing attempts are equal to the open breaker time which precedes the fourth (4th) reclosing attempt.

The number of reclosing attempts is set at address 7136 **# OF RECL. PH** for the multiple phase reclosing program and at address 7135 **# OF RECL. GND** for the single phase reclosing program.

Blocking Three-Phase Faults

Regardless of which reclosing program is executed, automatic reclosing can be blocked for three-phase faults at address 7159 **3Pol.PICKUP BLK**. The pickup of all three phases for a specific phase element is the criterion required for three-phase fault blocking.

Blocking of auto re-close via internal control

The auto reclose function can be blocked, if control commands are issued. The control information must be routed via CFC (interlocking task-level) using the CMD_Information block (see Figure 6-39).
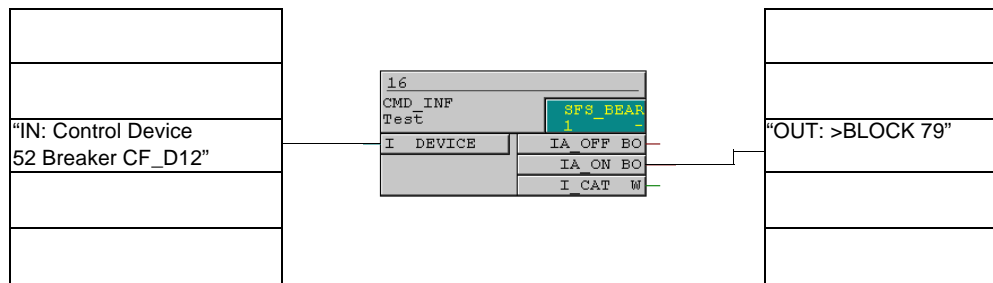
Figure 6-39   Blocking of the auto reclose function using the internal control function

Zone Sequencing

Not applicable for version 7SJ61**–**A**– and 7SJ61**–**M**

At address 7140 **ZONE SEQ.COORD.**, the zone sequencing feature can be turned **ON** or **OFF**. If zone sequencing is turned on, then the device counts the number of reclosing attempts made by sequenced devices via flow measurement so that tripping can be blocked for based on the reclosing attempt of another device.

Initiation and Blocking of Reclosing by Protective Functions

At addresses 7150 to 7158, reclosing can be initiated or blocked for various types of protective elements.

Blocking of Protective Functions by the Automatic Reclosing System

At addresses 7170 to 7185, it is possible to block tripping by various types of protective elements subsequent to any of the first four reclosing attempts. The settings in these addresses are used when zone sequencing is turned on and if the protection of load side fuses against temporary fault is desired. Zone sequencing is enabled in address 7140.

6.11.2.1 Settings for Automatic Reclosing

Addr.	LCD-Text	Setting Options	Default Setting	Comments	Ordering Code 7SJ61**–		
					A–I **M**–I	**B**–I **N**–I	**C**–I **P**–I
7101	FCT 79	OFF ON	OFF	Automatic reclosing	X	X	X
7103	BLK MAN. CLOSE	NO YES	NO	Block automatic reclosing during manual closing of breaker (01 - BI)	X	X	X
7105	TIME RESTRAINT	0.50 ~ 320.00 sec.	3.00 sec.	Reset time of automatic reclosing	X	X	X
7108	SAFETY 79 ready	0.01 ~ 300.00 sec.	15.00 sec.	Safety time until automatic reclosing is ready	X	X	X

Addr.	LCD-Text	Setting Options	Default Setting	Comments	Ordering Code 7SJ61**–		
					A–| **M**–|	**B**–| **N**–|	**C**–| **P**–|
7113	CHECK CB?	No check Chk each cycle	No check	Check breaker position indication before attempting a reclosing shot	X	X	-
7115	CB TIME OUT	0.10 ~ 320.00 sec.	3.00 sec.	Breaker ready monitoring time	X	X	-
7116	MAX.InhibitTIME	0.01 ~ 320.00 sec.	15.00 sec.	Maximum inhibit time of auto reclosing allowed for external binary input	-	X	X
7127	DEADTIME 1: PH	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 1, Phase Fault	X	X	X
7128	DEADTIME 1: G	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 1, Ground Fault	X	X	X
7129	DEADTIME 2: PH	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 2, Phase Fault	X	X	X
7130	DEADTIME 2: G	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 2, Ground Fault	X	X	X
7131	DEADTIME 3: PH	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 3, Phase Fault	X	X	X
7132	DEADTIME 3: G	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 3, Ground Fault	X	X	X
7133	DEADTIME 4: PH	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 4-9, Phase Fault	X	X	X
7134	DEADTIME 4: G	0.01 ~ 320.00 sec.	0.50 sec.	Dead Time 4-9, Ground Fault	X	X	X
7135	# OF RECL. GND	0 ~ 9	1	Number of reclosing attempts for ground faults	X	X	X
7136	# OF RECL. PH	0 ~ 9	1	Number of reclosing attempts for phase faults	X	X	X
7140	ZONE SEQ.CO-ORD.	OFF ON	OFF	Zone sequence coordination	-	X	X
7150	50–1/50N–1	No influence Starts 79 Stops 79	No influence	50–1 and 50N–1 supervision of automatic reclosing	X	X	X
7151	50–2/50N–2	No influence Starts 79 Stops 79	No influence	50–2 and 50N–2 supervision of automatic reclosing	X	X	X
7152	51/51N	No influence Starts 79 Stops 79	No influence	51 and 51N supervision of automatic reclosing	X	X	X
7156	sens Ground Flt	No influence Starts 79 Stops 79	No influence	Sensitive ground fault detection supervision of automatic reclosing	X	X	X
7157	46	No influence Starts 79 Stops 79	No influence	46–1, 46–2, and 46N–TOC supervision of automatic reclosing (one setting)	X	X	X
7158	BINARY INPUT	No influence Starts 79 Stops 79	No influence	Binary input supervision of automatic reclosing (phase and ground)	X	X	X
7159	3Pol.PICKUP BLK	YES NO	NO	3 pole trips block automatic reclosing	X	X	X

Addr.	LCD-Text	Setting Options	Default Setting	Comments	Ordering Code 7SJ61**–		
					A**–I **M**–I	**B****–I **N**–I	**C****–I **P**–I
7170	1.Cy: 50(N)–1	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–1 and 50N–1 during first shot	X	X	X
7171	1.Cy: 50(N)–2	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–2 and 50N–2 during first shot	X	X	X
7174	2.Cy: 50(N)–1	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–1 and 50N–1 during second shot	X	X	X
7175	2.Cy: 50(N)–2	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–2 and 50N–2 during second shot	X	X	X
7176	2.Cy: 67(N)–1	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 67–1 and 67N–1 during second shot	X	X	X
7177	2.Cy: 67(N)–2	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 67–2 and 67N–2 during second shot	X	X	X
7178	3.Cy: 50(N)–1	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–1 and 50N–1 during third shot	X	X	X
7179	3.Cy: 50(N)–2	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–2 and 50N–2 during third shot	X	X	X
7182	4.Cy: 50(N)–1	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–1 and 50N–1 during 4th to 9th shot	X	X	X
7183	4.Cy: 50(N)–2	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 50–2 and 50N–2 during 4th to 9th shot	X	X	X
7184	4.Cy: 67(N)–1	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 67–1 and 67N–1 during 4th to 9th shot	X	X	X
7185	4.Cy: 67(N)–2	Not Blocked Blocked Via 79	Not Blocked	Automatic reclosing control of 67–2 and 67N–2 during 4th to 9th shot	X	X	X

6.11.2.2 Information List for Automatic Reclosing

F#	LCD-Text	Explanation	Ordering Code 7SJ61**–		
			A– **M**–	**B**– **N**–	**C**– **P**–
2781	79 OFF	79 Auto recloser is switched OFF	X	X	X
2782	79 ON	79 Auto recloser is switched ON	X	X	X
2784	CB is NOT ready	Circuit breaker is NOT ready	X	X	X
2785	79 Dyn Block	79 – Auto-reclose is dynamically BLOCKED	X	X	X
2801	79 in progress	79 Reclosing is in progress	X	X	X
2851	79 Close	79 – Close command	X	X	X
2862	79 Successful	79 – cycle successful	X	X	X
2863	79 Lockout	79 – Lockout	X	X	X
2869	TRIP Gnd Fault	TRIP Ground fault	X	X	X
2870	TRIP Ph Fault	TRIP Phase fault	X	X	X
2876	79 STEP	79–A/R attempt step	X	X	X
2878	79 L–N Sequence	79–A/R single phase reclosing sequence	X	X	X
2879	79 L–L Sequence	79–A/R multi-phase reclosing sequence	X	X	X
2883	ZSC active	Zone sequencing is active	-	X	X
2884	ZSC ON	Zone sequencing coordination is switched ON	-	X	X
2885	ZSC OFF	Zone sequencing coordination is switched OFF	-	X	X
0127	79 ON/OFF	79 ON/OFF (via system port)	X	X	X
2701	>79 ON	>79 ON	X	X	X
2702	>79 OFF	>79 OFF	X	X	X
2703	>BLOCK 79	>BLOCK 79 Auto recloser	X	X	X
2705	>79 T WAIT	>79 T wait (coordination control)	-	X	X
2730	>CB ready	>Circuit breaker ready	X	X	-
2715	>79 TRIP 1p	>79 Ext. 1pole TRIP for internal A/R	X	X	X
2716	>79 TRIP 3p	>79 Ext. 3pole TRIP for internal A/R	X	X	X
2722	>ZSC ON	>Switch zone sequence coordination ON	-	X	X
2723	>ZSC OFF	>Switch zone sequence coordination OFF	-	X	X
4601	>52-a	>52-a contact (OPEN, if breaker is open)	X	X	X
4602	>52-b	>52-b contact (OPEN, if breaker is closed)	X	X	X
356	>Manual Close	>Manual close signal	X	X	X

6.12   Phase Rotation

6.12.1   Description of Phase Rotation

General

Various functions of the 7SJ61 only function correctly if the phase rotation of the currents is known. Among these functions are negative sequence protection and measurement quantity monitors. A phase rotation is implemented in the 7SJ61 device using binary inputs and settings, thus making it possible for all protective and monitoring functions to operate correctly when the phase rotation is reversed.

If an "acb" phase rotationphase rotation is normal, the appropriate setting should be entered at address 0209. (See Subsection 6.1.1).

If the phase rotation can change during operation (e.g. the direction of a motor must be routinely changed), then a changeover signal at the input masked for this purpose is sufficient to inform the protective relay of the phase rotation changeover.

Logic

As stated before, the phase rotation is always established at address 0209. The binary input (FNo. 5145) sets the phase rotation for the opposite of the setting at 0209, via the exclusive-OR function (see Figure 6-40).
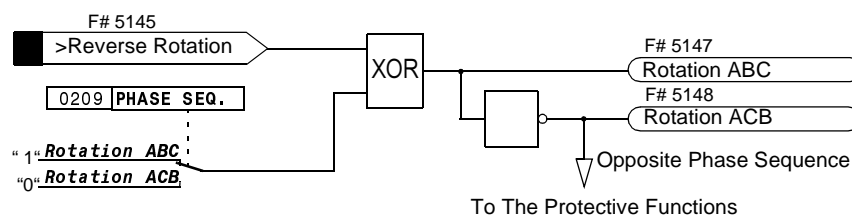
Figure 6-40   Message Logic for the phase rotation Changeover

Influence on Protective Functions

The swapping of phases directly impacts the calculation of positive and negative sequence quantities. Therefore, this function is vital so that phase detection messages, fault values, and operating measurement values are not falsified. As stated before, this function influences the negative sequence protection function and some of the monitoring functions (see Subsection 6.13.1.3) that issue messages if the required and calculated phase rotations do not match.

6.12.2   Programming Settings

The normal phase sequence is set at 0209 **PHASE SEQ.** (see Subsection 6.1.1). If, on the system side, phase rotation are made temporarily, then these are communicated to the protective device using the binary input 5145.

6.13 Monitoring Functions

The device is equipped with extensive monitoring capabilities - both for hardware and software. In addition, the measured values are also constantly monitored for plausibility, therefore, the current transformer circuits are largely integrated into the monitoring. It is also possible to implement trip and closing circuit monitoring, using appropriate binary inputs as available.

6.13.1 Description of Measured Values Monitoring

6.13.1.1 Hardware Monitoring

The device is monitored from the measurement inputs to the binary outputs. Monitoring checks the hardware for malfunctions and disallowed conditions.

Auxiliary and Reference Voltages

The processor voltage of 5 V DC is monitored, and if the voltage decreases below the minimum value, the device is removed from operation. When the normal voltage returns, the processor system is restarted.

Removal of or switching off the supply voltage removes the device from operation and a message is immediately generated by a dead contact. Brief voltage interruptions of less than 50 ms do not disturb the readiness of the device (for nominal auxiliary voltage $\geq$ 110 V DC).

The processor monitors the offset and reference voltage of the AD (analog-digital) converter. The protection is suspended if the voltages deviate outside an allowable range, and lengthy deviations are reported.

Buffer Battery

The buffer battery, which ensures the operation of the internal clock and the storage of counters and messages if the auxiliary voltage fails, is periodically checked for charge status. If it is less than an allowed minimum voltage, then the "`battery empty`" message is issued.

Memory Components

The working memory (RAM) is tested when the system is started up. If a malfunction occurs then, the starting sequence is interrupted and an LED blinks. During operation, the memory is checked using its checksum.

For the program memory, the cross sum is formed periodically and compared to the stored program cross sum.

For the settings memory, the cross sum is formed periodically and compared to the cross sum that is freshly generated each time the setting process takes place.

If a malfunction occurs, the processor system is restarted.

Probing

Probing and the synchronization between the internal buffer components are constantly monitored. If any deviations cannot be removed by renewed synchronization, then the processor system is restarted.

Measurement Value Collection – Currents

Up to four input currents are measured by the device. Three of the currents correspond to phase currents and the fourth current corresponds to the neutral or ground

current measured from a separate current transformer. If all four currents inputs are connected, their digitized sum must be zero.

Faults in the current circuit are recognized if

$$I_F = |i_a + i_b + i_c + (k_N \cdot i_g)| > \Sigma \text{ I THRESHOLD} \cdot I_N + \Sigma \text{ I FACTOR} \cdot I_{max}$$

The factor k_N (= address 0207 **CT N/CT Ph**) takes into account a possible difference in the neutral current transformer ratio. Σ **I THRESHOLD** and Σ **I FACTOR** are programmable settings. The component Σ **I FACTOR** $\cdot$ I_{max} takes into account the allowable error of the input transformer, which can be especially large when high fault current levels are present (Figure 6-41). The dropout ratio is about 97%. This malfunction is reported as "Failure ΣI".

Note:

Current sum monitoring is only in effect if the ground current for the line to be protected is connected.
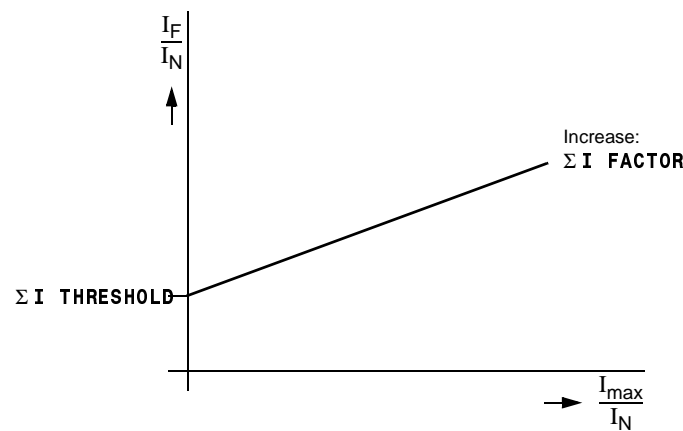
Figure 6-41   Current Sum Monitoring

6.13.1.2 Software Monitoring

Watchdog

For continuous monitoring of the program sequences, a time monitor is provided in the hardware (hardware watchdog) that runs upon failure of the processor or an internal program, and causes a complete restart of the processor system.

An additional software watchdog ensures that malfunctions during the processing of programs are discovered. This also initiates a restart of the processor system.

To the extent such a malfunction is not cleared by the restart, an additional restart attempt is begun. After three unsuccessful restarts within a 30 second window of time, the device automatically removes itself from service and the red "Error" LED lights up. The readiness relay opens and indicates "device malfunction" with its normal contact.

6.13.1.3 Monitoring of External Current Transformer Circuits

Interruptions or short circuits in the secondary circuits of the current transformers, as well as faults in the connections (important for start-up!), are detected and reported by the device. The measured quantities are periodically checked in the background for this purpose, as long as no system fault is present.

Current Symmetry   During normal system operation (i.e. the absence of a short-circuit fault), symmetry among the input currents is expected. This symmetry is checked by the device, using a quantity monitor. The smallest phase current is compared to the largest phase current, and asymmetry is recognized if:

$|I_{min}|/|I_{max}| <$ **BAL. FACTOR I**, as long as $I_{max}/I_N >$ **BALANCE I LIMIT** $/ I_N$

where I_{max} is the largest of the three phase currents and I_{min} is the smallest. The symmetry factor **BAL. FACTOR I** represents the allowable asymmetry of the phase currents while the limit value **BALANCE I LIMIT** is the lower limit of the operating range of this monitoring (see Figure 6-42). Both settings are adjustable, and the dropout ratio is about 97 %.

This malfunction is reported as "`Malfunction Isymm`".
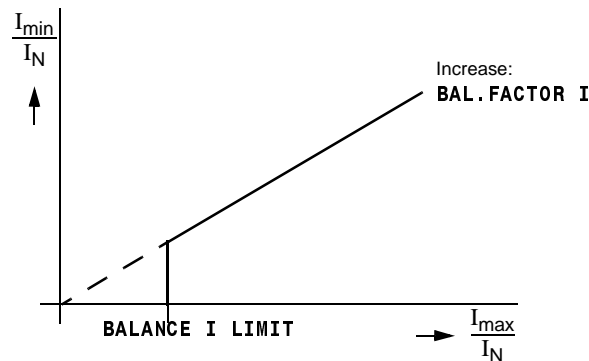
Figure 6-42   current Symmetry Monitoring

Current Rotation   To detect swapped phase connections in the current input circuits, the phase currents are checked by the monitoring.

The phase sequence of the phase currents is verified by ensuring the following

I_a leads I_b leads I_c leads I_a

Verification of the current rotation occurs when each measured current is at least

$|I_a|, |I_b|, |I_c| > 0.5\ I_N$.

For abnormal phase sequences, the messages "`Fail Ph. Seq. I`" are issued, along with the switching of this message "`Fail Ph. Seq.`" to the substation control system (SCADA).

For applications in which an opposite phase sequence is expected, the protective relay should be adjusted via a binary input or a programmable setting. If the phase sequence is changed in the relay, phases 'b' and 'c' internal to the relay are reversed, and the positive and negative sequence currents are thereby exchanged (see also Section 6.12). The phase- related messages, malfunction values, and measured values are not affected by this.

6.13.2 Programming Settings for Measured Values Monitoring

Measured value monitoring can be turned on or off at address 8101 **MEASURE. SU-PERV**. In addition, the sensitivity of measured value monitor can be modified. Default values are set at the factory, which are sufficient in most cases. If especially high operating asymmetry in the currents and/or voltages is to be expected for the application, or if it becomes apparent during operation that certain monitoring functions activate sporadically, then the setting should be less sensitive.

Address 8104 **BALANCE I LIMIT** determines the limit current, above which the current symmetry monitor is effective (see also Figure 6-42). Address 8105 **BAL. FACTOR I** is the associated symmetry factor; that is, the slope of the symmetry characteristic curve (Figure 6-42).

Address 8106 Σ **I THRESHOLD** determines the limit current, above which the current sum monitor (see Figure 6-41) is activated (absolute portion, only relative to I_N). The relative portion (relative to the maximum conductor current) for activating the current sum monitor (Figure 6-41) is set at address 8107 Σ **I FACTOR**.

Note:

Current sum monitoring is only in effect if the ground current for the line to be protected is connected.

6.13.2.1 Settings for Measured Values Monitoring

In the list below, the setting ranges and default setting values for current-based settings are for a device with a nominal current rating I_N = 5 A. For a nominal current rating I_N = 1 A, divide the Setting Options values and Default Setting values by 5. Consider the current transformer ratios when setting the device with primary values.

Addr.	LCD-Text	Setting Options	Default Setting	Comments
8101	MEASURE. SUPERV	OFF ON	ON	Measured Value Monitor
8104	BALANCE I LIMIT	0.50 ~ 5.00 A	2.50 A	Symmetry Iph: Threshold Value
8105	BAL. FACTOR I	0.10 ~ 0.90	0.50	Symmetry Iph: Characteristic
8106	Σ I THRESHOLD	0.25 ~ 10.00 A	0.50 A	Sum I: Threshold Value
8107	Σ I FACTOR	0.00 ~ 0.95	0.10	Sum I: Characteristic

6.13.2.2 Information

F#	LCD-Text	Comments
0162	Failure Σ I	Failure: Current Summation
0163	Fail I balance	Failure: Current Balance
0171	Fail Ph. Seq.	Failure: Phase Sequence
0175	Fail Ph. Seq. I	Failure: Phase Sequence Current
0161	Fail I Superv.	Failure: general Current Supervision
0197	MeasSup OFF	Measurement Supervision is switched OFF

6.13.3 Description of Trip Circuit Monitor (74TC)

The 7SJ61 is equipped with an integrated trip circuit monitor. Depending on the number of available binary inputs, monitoring with one or two binary inputs can be selected. If the configuration of the binary inputs needed for this does not match the selected monitoring type, then a message to this effect is sent. When using two binary inputs, malfunctions in the trip circuit can be detected under all circuit breaker conditions. When only one binary input is used, malfunctions in the circuit breaker itself cannot be detected.

Monitoring with Two Binary Inputs

When using two binary inputs, these are connected according to Figure 6-43, parallel to the associated trip contact on one side, and parallel to the circuit breaker auxiliary contacts on the other.

A condition for the use of trip circuit monitoring is that the control voltage for the circuit breaker is greater than the sum of the minimum voltage drops of both binary inputs ($V_{St} > 2 \cdot V_{BImin}$). Since at least 17 V are needed for each binary input, the monitor can only be used with a system control voltage of over 35 V.
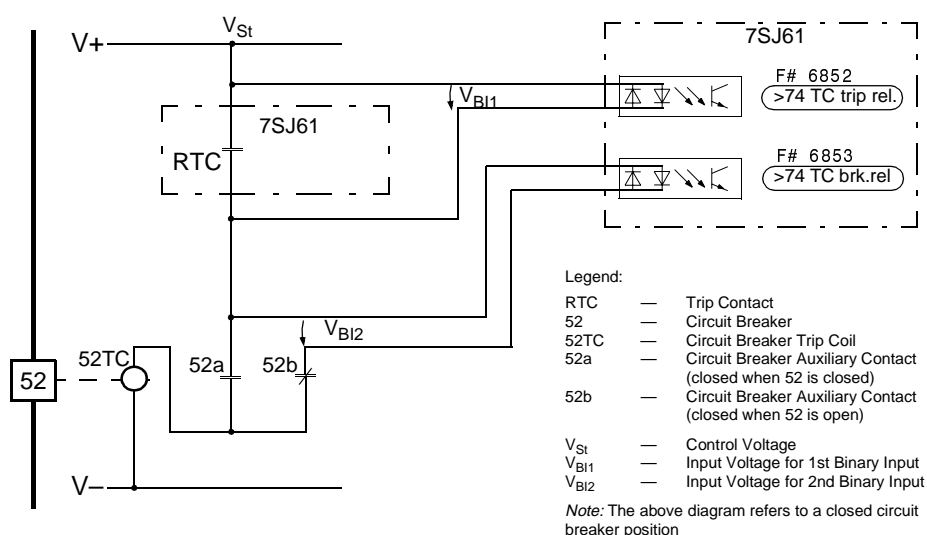
Figure 6-43   Principle of Trip Circuit Monitor with Two Binary Inputs

Monitoring with binary inputs not only detects interruptions in the trip circuit and loss of control voltage, it also monitors the response of the circuit breaker using the position of the circuit breaker auxiliary contacts.

Depending on the conditions of the trip contact and the circuit breaker, the binary inputs are activated (logical condition "H" in Table 6-2), or not activated (logical condition "L").

Even for healthy trip circuits the condition that both binary inputs are not actuated ("L") is possible during a short transition period (trip contact is closed, but the circuit breaker has not yet opened.) A continuous state of this condition is only possible when the trip circuit has been interrupted, a short-circuit exists in the trip circuit, a loss of battery voltage occurs, or malfunctions occur with the circuit breaker mechanism.

Table 6-2   Condition Table for Binary Inputs, Depending on RTC and CB Position

No.	Relay Trip Contact	Circuit Breaker	52a Contact	52b Contact	BI 1	BI2
1	Open	Closed	Closed	Open	H	L
2	Open	Open	Open	Closed	H	H
3 [1]	Closed	Closed	Closed	Open	L	L
4 [1]	Closed	Open	Open	Closed	L	H

[1] Trip Circuit is faulty

The conditions of the two binary inputs are checked periodically. A check takes place about every 600 ms. If three consecutive conditional checks detect an abnormality (after 1.8 s), an annunciation is reported (see Figure 6-44). This is used to avoid the annunciation for brief transition periods. When the fault in the trip circuit has been cleared, the annunciation is automatically reset.
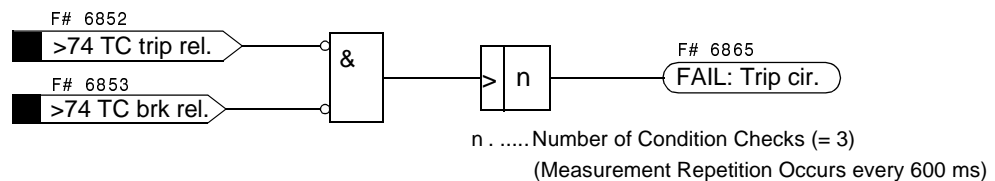
Figure 6-44   Logic Diagram for Trip Circuit Monitoring with Two Binary Inputs

Monitoring with One Binary Input

The binary input is connected according to figure 6-45 in parallel with the associated trip contact. The circuit breaker auxiliary contact 52-b is connected in series with a high-ohm resistor R.

The control voltage for the circuit breaker should be about two times the value of the minimum voltage drop at the binary input ($V_{St} > 2 \cdot V_{BImin}$). Since the minimum voltage to activate a binary input is 17 V, a DC voltage supply of 35 V or higher is required.
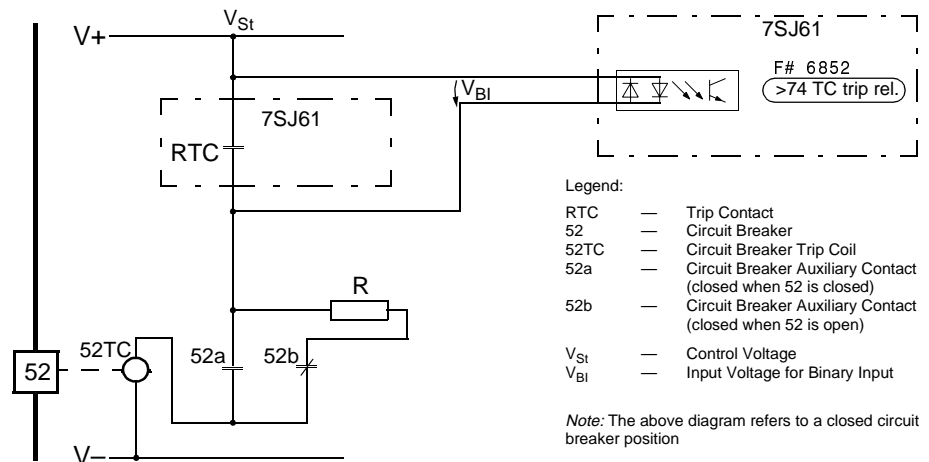
Figure 6-45　Principle of Trip Circuit Monitoring with One Binary Input

During normal operation, the binary input is activated (logical condition "H") when the trip contact is open and the trip circuit is intact, because the monitoring circuit is closed by either the 52a circuit breaker auxiliary contact (if the circuit breaker is closed) or through the replacement resistor R by the 52b circuit breaker auxiliary contact. Only as long as the trip contact is closed, the binary input is short circuited and thereby de-activated (logical condition "L").

If the binary input is continuously de-activated during operation, this leads to the conclusion, there is an interruption in the trip circuit or loss of control voltage.

The trip circuit monitor does not operate during system faults. A momentary closed tripping contact does not lead to a failure message. If, however, tripping contacts from other devices operate in parallel with the trip circuit, then the failure annunciation must be delayed (see also Figure 6-46). The conditions of the binary input are, therefore, checked 500 times before an annunciation is sent. A condition check takes place about every 600 ms, so trip circuit monitoring is only activated during an actual malfunction of the trip circuit (after 300 s). After the malfunction in the trip circuit is cleared, the failure annunciation is reset automatically.
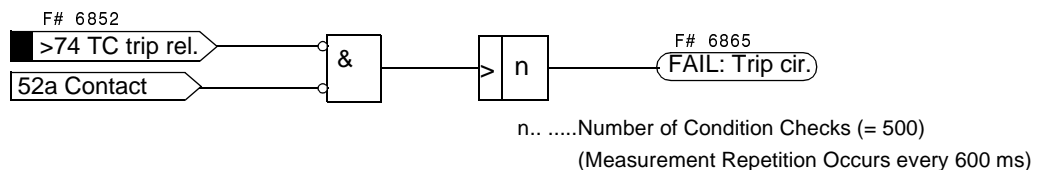
Figure 6-46　Logic Diagram for Trip Circuit Monitoring with One Binary Input

Figure 6-47 shows the logic diagram for the message that can be generated by the trip circuit monitor, depending on the control settings and binary inputs.
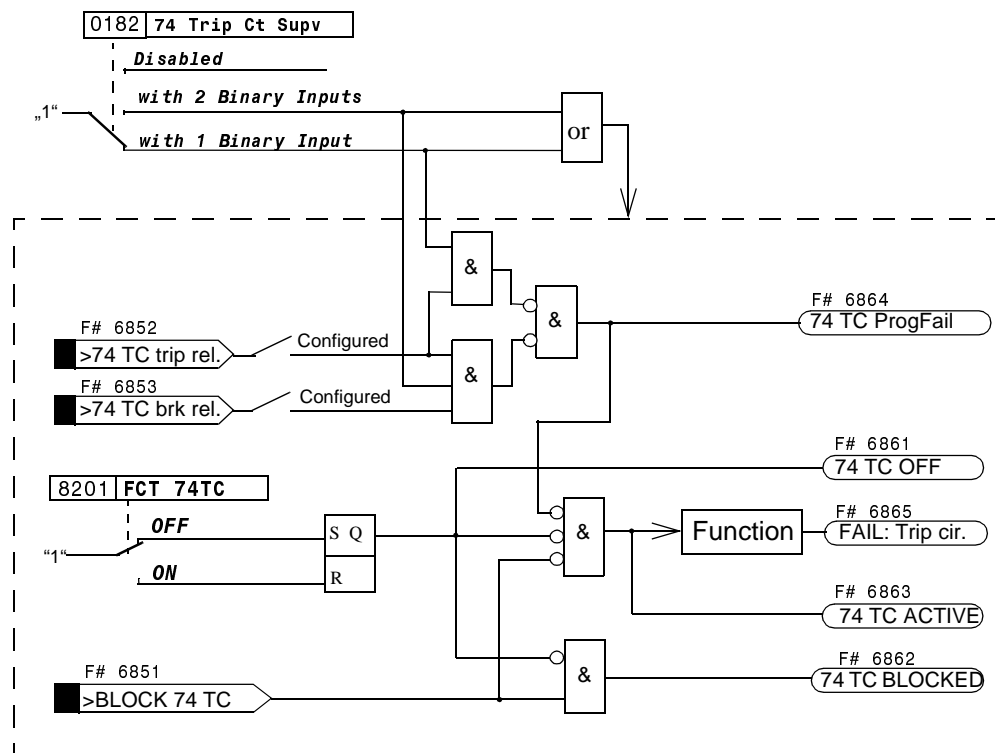
Figure 6-47   Message Logic for the Trip Circuit Monitor

6.13.4 Programming Settings for Trip Circuit Monitor

Trip circuit monitoring is only in effect and accessible if address 0182 was set to either *2 Binary Inputs* or to *1 Binary Input*, and the appropriate number of binary inputs have been masked for this purpose. Trip circuit monitoring can be turned *ON* and *OFF* at address 8201 **FCT 74TC**. If the masking of the required binary inputs does not match the selected monitoring type, then a message to this effect is generated. If the trip circuit monitor is not to be used at all, then address 0182 should be set to *Disabled*. Further settings are not needed. The message of a trip circuit interruption is delayed by a fixed amount of time. For two binary inputs, the delay is about 2 seconds, and for one binary input, the delay is about 300 ms. This ensures that, for the longest possible duration of a trip signal, a false malfunction message will not be generated.

Monitoring with One Binary Input

NOTE: When using only one binary input (BI) for the trip circuit monitor, some malfunctions, such as interruption of the trip circuit or loss of battery voltage, can indeed be detected, but malfunctions with closed trip contacts cannot. Therefore, the measurement must take place over a period of time that bridges the longest possible duration of a closed trip contact. This is ensured by the fixed number of measurement repetitions and the time between the condition checks.

When using only one binary input, a resistor R is inserted into the circuit on the system side, instead of the missing second binary input. Through appropriate sizing of the resistor and depending on the system relationship, a lower control voltage can often be sufficient. The resistor R is inserted into the circuit of the 52b circuit breaker auxiliary contact, to facilitate the detection of a malfunction when the 52a circuit breaker auxiliary contact open and the trip contact has dropped out (see Figure 6-45). This resistor

must be sized such that the circuit breaker trip coil is no longer energized when the circuit breaker is open (which means 52a is open and 52b is closed). The binary input should still be picked up when the trip contact is simultaneously opened.

This results in an upper limit for the resistance dimension, R_{max}, and a lower limit R_{min}, from which the optimal value of the arithmetic mean should be selected:

$$R = \frac{R_{max} + R_{min}}{2}$$

In order that the minimum voltage for controlling the binary input is ensured, R_{max} is derived as:

$$R_{max} = \left(\frac{V_{St} - V_{BI\,min}}{I_{BI\,(High)}}\right) - R_{CBTC}$$

So the circuit breaker trip coil does not remain energized in the above case, R_{min} is derived as:

$$R_{min} = R_{CBTC} \cdot \left(\frac{V_{St} - V_{CBTC\,(LOW)}}{V_{CBTC\,(LOW)}}\right)$$

$I_{BI\,(HIGH)}$	Constant Current with BI on
$V_{BI\,min}$	Minimum Control Voltage for BI (=19 V for delivery setting for nominal voltage of 24/48/60 V;
	=88 V for delivery setting for nominal voltage of 110/125/220/250 V)
V_{ST}	Control Voltage for Trip Circuit
R_{CBTC}	DC Resistance of Circuit Breaker Trip Coil
$V_{CBTC\,(LOW)}$	Maximum Voltage on the Circuit Breaker Trip Coil that does not lead to Tripping

If the calculation results that $R_{max} < R_{min}$, then the calculation must be repeated, with the next lowest pickup threshold $V_{BI\,min}$, and this threshold must be implemented in the device using plug-in bridges (see Subsection 8.1.3).

For the power consumption of the resistance:

$$P_R = I^2 \cdot R = \left(\frac{V_{St}}{R + R_{CBTC}}\right)^2 \cdot R$$

Example:

$I_{BI\,(HIGH)}$	1.8 mA (from SIPROTEC[®] 7SJ61)
$U_{BI\,min}$	19 V for delivery setting for nominal voltage 24/48/60 V (from SIPROTEC[®]7SJ61)
	88 V or delivery setting for nominal voltage 110/125/220/250 V) (from SIPROTEC[®] 7SJ61)
V_{ST}	110 V (from system / release circuit)
R_{CBTC}	500 Ω (from system / release circuit)
$V_{CBTC\,(LOW)}$	2 V (from system / release circuit)

$$R_{max} = \left(\frac{110\,V - 19\,V}{1.8\,mA}\right) - 500\,\Omega = 50.1\,k\Omega$$

$$R_{min} = 500\,\Omega \cdot \left(\frac{110\,V - 2\,V}{2\,V}\right) = 27\,k\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 38.6 \text{ k}\Omega$$

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110 \text{ V}}{39 \text{ k}\Omega + 0.5 \text{ k}\Omega}\right)^2 \cdot 39 \text{ k}\Omega$$

$$P_R \geq 0.3 \text{ W}$$

6.13.4.1 Setting for Trip Circuit Monitor

Addr.	LCD-Text	Setting Options	Default Setting	Comments
8201	FCT 74TC	ON OFF	ON	Status of Trip Circuit Monitoring

6.13.4.2 Information

F#	LCD-Text	Comments
6861	74TC OFF	74TC Trip circuit supervision OFF
6862	74TC BLOCKED	74TC Trip circuit supervision is BLOCKED
6863	74TC ACTIVE	74TC Trip circuit supervision ACTIVE
6864	74TC ProgFail	74TC blocked Bin. input is not set
6865	FAIL: Trip cir.	74TC Failure Trip Circuit
6851	>BLOCK 74TC	>BLOCK 74TC
6852	>74TC trip rel.	>74TC Trip circuit superv.: trip contact
6853	>74TC brk rel.	>74TC Trip circuit superv.: breaker aux. contact

6.13.5 Malfunction Responses of the Monitoring Functions

Depending on the type of malfunction discovered, an annunciation is sent, a restart of the processor system is initiated, or the device is taken out of service. after three unsuccessful restart attempts. The live status contact operates to indicate the device is malfunctioning. Also, the red LED "ERROR" lights up on the front cover, if the internal auxiliary voltage is present, and the green "RUN" LED goes out. If the internal power supply fails, then all LEDs are dark. Table 6-3 shows a summary of the monitoring functions and the malfunction responses of the relay.

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Table 6-3   Summary of the Device Malfunction Responses

Monitoring	Possible Cause	Malfunction Response	Message	Output
AC/DC Supply Voltage Loss	External (aux. Voltage) Internal (power supply)	Device shutdown	All LEDs dark	Live status contact de-energized
Internal Supply Voltages	Internal (power supply) Ribbon cable disconnected	Device shutdown	LED "ERROR"	Live status contact de-energized[2]
Battery	Internal battery discharged	Annunciation	"Fail Battery" (FNo. 177)	
Hardware Watchdog	Internal (processor failure)	Restart attempt [1]	LED "ERROR"	Live status contact de-energized[2]
Software Watchdog	Internal (program sequence)	Restart attempt [1]	LED "ERROR"	Live status contact de-energized[2]
ROM	Internal (Hardware)	Restart attempt [1]	LED "ERROR"	Live status contact de-energized[2]
RAM	Internal (Hardware)	Detection during boot sequence	LED blinks	Live status contact de-energized[2]
		Detection during operation: Restart attempt [1]	LED "ERROR	
Settings	Internal (Hardware)	Restart attempt [1]	LED "ERROR"	Live status contact de-energized[2]
Analogue data acquisition	Internal (Hardware)	Device shutdown	LED "ERROR"	Live status contact de-energized[2]
Current Summation	CT Error)	Message	„Failure ΣI" (FNo. 162)	as masked

Table 6-3   Summary of the Device Malfunction Responses

Monitoring	Possible Cause	Malfunction Response	Message	Output
Current Symmetry	CT Error	Message	„Fail I balance" (FNo. 163)	as masked
Current Phase Sequence	External (connections or power system)	Message	„Fail Ph. Seq. I" (FNo. 175)	as masked
Trip Circuit Monitoring	External (open trip coil or blown fuses)	Message	„Fail: Trip cir." (FNo. 6865)	as masked

[1]) After three unsuccessful restart attempts, the device will go out of service.
[2]) Protection and control function are blocked, HMI might be still accessible.

6.14 Protection Function Logic

The function logic is the heart of the device. It coordinates the sequence of both the protective and auxiliary functions, processes functional decisions, and processes data received from the system. In particular, the function logic is responsible for the following:

- Processing Measurement and Detection Logic
- Processing Tripping Logic

6.14.1 Pickup Logic for the Entire Device

6.14.1.1 Description

General Device Pickup and Dropout

The pickup signals for all protective functions in the device are connected via an "OR" function, and lead to the general device pickup. General device pickup is initiated by the first function to pickup, and general device drop out occurs when the last function drops out. A corresponding message indicating that general device pickup has occurred is reported.

General device pickup is a precondition for a series of internal and external functions that occur subsequently. The following are among the internal functions controlled by general device pickup:

- Start of Trip Log: From general device pickup to general device drop out, all fault messages are entered in the trip log.

- Initialization of Oscillographic Records: The storage and maintenance of oscillographic values can also be made dependent on the general device pickup.

- Generation of Spontaneous Messages: Certain fault messages are displayed in the device display as so-called spontaneous messages (see below). This display can also be made dependent on the general device pickup.

External functions can be controlled by general device pickup, using an output contact. Examples are:

- Restarting devices
- Starting of additional devices, or similar

Spontaneous Messages

Spontaneous messages are fault messages that appear in the display automatically when general device pickup has occurred. For the 7SJ61 relay, these messages include:

- A message indicating the protective function that last picked up.

- A message indicating the protection function that last initiated a trip signal.

- The running time from general device pickup to general device dropout, with time indicated in ms.

- The running time from general device pickup to initiation of the first trip signal by the device, with time indicated in ms.

Please note, the overload protection does not have a pickup comparable to the other protective functions. The general relay pickup time is first started with the trip signal, and an abnormal occurrence is opened. The dropout of the thermal image of the overload protection ends the fault message and, thereby, the running time from general relay pickup to general device dropout.

6.14.2 Tripping Logic of the Entire Device

6.14.2.1 Description

General Trip

The tripping signals for all protective functions are connected by "OR" and generate a message indicating that the device has initiated a trip signal.

This message can be configured to an LED or binary output, just as the individual tripping messages can.

Terminating the Tripping Signal

- All trip signals from a protection function hold the 0511 Relay TRIP function, and start the minimum trip signal duration timer (set at address 0210 **Tmin TRIP CMD**, see Figure 6-48). This trip signal duration timer ensures the trip signal is transmitted to the circuit breaker for a sufficient amount of time, even if the function which issued the trip signal drops out quickly. The trip signal is only terminated after all protection functions drop out AND the minimum trip signal duration expires.

- A further condition for terminating the trip signal is the opening of the circuit breaker. This is monitored, using the status feedback indications from the circuit breaker and current flow monitoring.

- Finally, it is possible to latch the trip signal until it is manually reset (lockout function). The reset takes place either by pressing the LED reset key or by activating an appropriately masked binary input. A precondition, of course, is that the circuit breaker trip coil – as usual – remains energized at the circuit breaker as long as the trip signal is present, and that the trip coil current is interrupted by the auxiliary contacts of the circuit breaker.
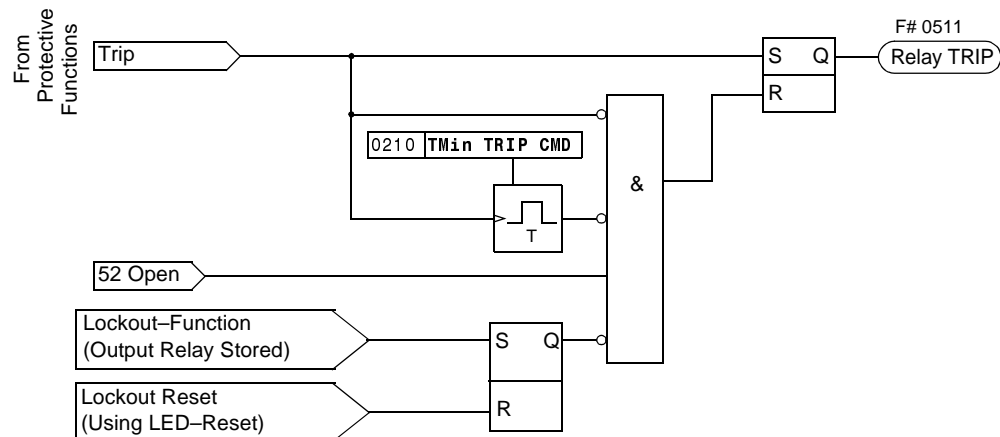
Figure 6-48   Terminating the Trip Signal

6.14.2.2 Programming Settings for Tripping Logic

Trip Signal Duration The setting of the minimum trip signal duration at address 0210 **Tmin TRIP CMD** was already discussed in Subsection 6.1.1. This time is valid for all protective functions that can initiate trip signals, as well as for trip signals that are initiated using the device function controller.

Addr.	Setting	Setting Options	Default Setting	Comment
210	TMin TRIP CMD	0.01 ~ 32.00 s	0.15 s	Minimum Trip Command Duration

6.14.3 Fault Display on the LEDs/LCD

6.14.3.1 Description of "No Trip – No Flag" Option

The indication of messages masked to local LEDs, and the maintenance of spontaneous messages, can be made dependent on whether the device has issued a trip signal. In this situation, messages are not reported, if one or more protective functions have picked up on a fault, but a trip signal has not been issued yet by the device because the fault was cleared by another device (for instance, in another line). These messages are then limited to faults in the line to be protected.

Figure shows the logic diagram for this function.
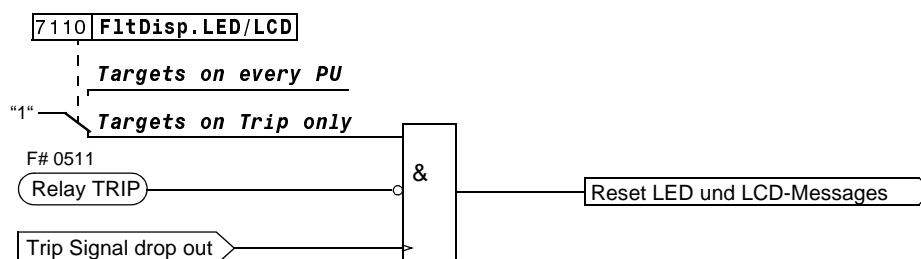
Figure 6-49   Logic Diagram for the Trip Dependent Messages

6.14.3.2 Programming Settings

Pickup of a new protective function generally turns off any previously set light displays, so that only the latest fault is displayed at any time. It can be selected whether the stored LED displays and the spontaneous messages on the display appear upon renewed pickup, or only after a renewed trip signal is issued. In order to enter the desired type of display, select the sub-menu **Device** in the **SETTINGS** menu. The two alternatives are selected at address 7110 **FltDisp.LED/LCD**.

Addr.	LCD-Text	Setting Options	Default Setting	Comments
7110	FltDisp.LED/LCD	Targets on every PU Targets on TRIP only	Target on every PU	Initiation of fault messages on LCD and LEDs

6.14.4 Statistical Counters

6.14.4.1 Description

Number of Trips   The number of trips initiated by the 7SJ61 is counted, as long as the position of the circuit breaker is monitored via breaker auxiliary contacts and binary inputs.

Fault Current   Furthermore, the fault current in each pole of the circuit breaker is determined for each trip signal. The fault current is indicated in the fault messages and is added to previously stored fault current values in the statistic-counters to maintain an accumulation of fault currents, per pole, experienced by the breaker over time.

Operating hours   The operating hours under load are also stored (the current value in at least one phase is larger than the limit value set under address 0212 **BkrClosed I MIN**). The counter and memory levels are secured against loss of auxiliary voltage.

6.14.4.2 Setting/Resetting

Setting or resetting of the statistical counters listed above takes place under the menu item **ANNUNCIATION** → **STATISTIC** by overwriting the counter values shown.

6.14.4.3 Information List for the Device

F#	LCD-Text	Explanation
0051	Device OK	Device is Operational and Protecting
0052	ProtActive	At Least 1 Protection Funct. is Active
0055	Reset Device	Reset Device
0056	Initial Start	Initial Start of Device
0067	Resume	Resume
0060	Reset LED	Reset LED
0110	Event Lost	Event lost
0113	Flag Lost	Flag Lost
0140	Error Sum Alarm	Error with a summary alarm
0160	Alarm Sum Event	Alarm Summary Event
0178	I/O-Board error	I/O-Board Error
0144	Error 5V	Error 5V (power supply)
0145	Error 0V	Error 0V (offset monitoring)
0146	Error -5V	Error -5V (power supply)
0147	Error PwrSupply	Error Power Supply
0177	Fail Battery	Battery empty
0070	Settings Calc.	Setting calculation is running

F#	LCD-Text	Explanation
0071	Settings Check	Settings Check
0072	Level-2 change	Level-2 Change
0068	Clock SyncError	Clock Synchronization Error
0069	DayLightSavTime	Daylight Savings Time (clock)
0183	Error Board 1	Error Board 1
0184	Error Board 2	Error Board 2
0185	Error Board 3	Error Board 3
0186	Error Board 4	Error Board 4
0187	Error Board 5	Error Board 5
0188	Error Board 6	Error Board 6
0189	Error Board 7	Error Board 7
0301	Pow.Sys.Flt.	Power System fault
0302	Fault Event	Fault Event
0125	Chatter ON	Chatter ON
0001	Not configured	Not set-up
0003	>Time Synch	>Synchronize Internal Real Time Clock
0005	>Reset LED	>Reset LED
0016	>DataStop	>Stop data transmission
0015	>Test mode	>Test mode
-----	>Light on	>Back Light on (LCD)

6.15 Auxiliary Functions

The auxiliary functions of the 7SJ61 relay include:

❑ Message Processing

❑ Measurements

❑ Waveform Capture

6.15.1 Message Processing

After the occurrence of a system fault, data regarding the response of the protective relay and the measured quantities should be saved for future analysis. For this reason message processing is done in three ways:

- LED Display and Binary Outputs (Output Relays)

- Information via Display Field or Personal Computer

- Information to a Control Center

LED Display and Binary Outputs (Output Relays)

Important events and conditions are displayed, using LEDs on the front panel of the relay. The relay also contains output relays for remote signaling. All LEDs and binary outputs indicating specific messages can be freely configured . The relay is delivered with a default setting. The default settings and configuration possibilities are described in detail in Section 5.2.

The output relays and the LEDs can be operated in a latched or unlatched mode (individually settable for each one).

The latched conditions are protected against loss of the auxiliary voltage. They are re-established after restart of the device. However they can be reset as follows:

− On site by pressing the LED key on the relay.

− Remotely using a binary input.

− Using one of the serial interfaces.

− Automatically at the beginning of a new pickup.

Condition messages should not be stored. Also, they cannot be reset until the criterion to be reported is cleared. This applies to messages from monitoring functions, or similar.

A green LED displays operational readiness of the relay, and cannot be reset. It goes out if the self-check feature of the microprocessor recognizes an abnormal occurrence, or if the auxiliary voltage is lost.

When auxiliary voltage is present, but the relay has an internal malfunction, then the red LED (ERROR) lights up and the processor blocks the relay.

Fault Information Display or Personal Computer

Events and conditions can be read out on the display on the front cover of the relay. Using the front PC interface or the rear service interface, for instance, a personal computer can be connected, to which the information can be sent.

In the idle condition, as long as no system fault is present, the display field can display selected operating information (overview of operating measurement values).

In the case of a system fault, information about the system fault appears instead (spontaneous messages). After the fault related annunciations have been cleared (acknowledged), the initial display is shown again. Acknowledgment can be perfomed by pressing the LED button on the front panel.

The relay is also equipped with several event buffers, for operational messages, circuit breaker statistics, etc., which are protected against loss of the auxiliary voltage by a buffer battery. These messages can be retrieved, at any time, using the operating keypad in the display field, or transferred to a personal computer, using the serial operating interface. Readout of messages during operation is described in detail in Subsection 7.1.1.

After a short-circuit fault on the system, for example, important information about the progression of the fault can be retrieved, such as the pickup of a protective element or the initiation of a trip signal. The time the initial occurrence of the short-circuit fault occurred is accurately provided via the system clock. Time progression of the short-circuit fault is reported based on the moment of pickup, so that the duration, until the trip signal is issued and interrupted, is available. The time resolution used for reporting is 1 ms.

With a personal computer and the protection data processing program DIGSI$^®$ 4, event information can also be retrieved, with the comfort of visualization on the screen and menu-driven processing. The data can be documented on a connected printer, or stored and evaluated at another location, if desired.

The protective relay stores the messages from the last eight system faults. Upon the occurrence of a ninth system fault, the oldest event is erased from the abnormal occurrence memory.

A system fault begins with the recognition of the fault by pickup of the protective function, and ends with the dropout of the last fault or with the expiration of the reclosing blocking time, so several unsuccessful interruption cycles are also stored in combination. Therefore, a system fault may include several abnormal occurrences.

Information to a Control Center

Stored information can also be transferred to a central control system (SCADA), using the system interface. The transfer can take place using various transfer protocols.

6.15.2 Measurements

Display of Measured Values

A series of measured values and the values derived from them are constantly available for call up on site, or for data transfer (See table 6-4, as well as the following list).

A precondition for correctly displaying the primary and percentage values is complete and correct entry of the nominal values for the current transformers, and protected equipment, in accordance with Subsections 6.1.1 and 6.1.3.

Depending on the type of device ordered and the device connections, some of the operating measured values listed below may not be available.

The ground current I_G is either measured directly or calculated from the conductor currents:

$$I_G = 3 \cdot I_0 / (I_G/I_{phTRA})$$

with:

$$3I_0 = (I_a + I_b + I_c)$$

I_G/I_{phTRA} = Transformation adjustment for ground input current (setting 0207)

Table 6-4   Operating Measured Values

Measured Values		Primary	Secondary	% of
I_a, I_b, I_c	Phase Currents	A	A	Nominal Operating Current[1]
I_G	Ground Current	A	A	Nominal Operating Current[1]
$3I_0$	Ground Current	A	A	Nominal Operating Current[1]
I_1, I_2	Positive and Negative Sequence Components of Current	A	A	Nominal Operating Current[1]
I_{Ns}	Sensitive Ground Current	A	mA	-----
[1]) per address 1102 (see Subsection 6.1.3)				

In addition, the following may be available:

− Minimum and maximum values for the three phase currents I_x; the positive sequence component I_1; in primary values. Included are the date and time they were last updated.

− The long-term averages of the three phase currents I_x; the positive sequence components I_1 for the three phase currents; in primary values. The period of time for averaging is selectable.

− Minimum and maximum values for the above mentioned long-term averages, including the date and time they were last updated, in primary values.

− Θ/Θ_{out} overload protection values for stator and rotor in % of the trip initiating excessive temperature,

The measured values are updated at a period of ≥ 0.3 s and ≤ 1 s.

The minimum and maximum values are listed with the date and time of the latest update. Using binary inputs or a SCADA interface, the maximum and minimum values can be reset. In addition, the reset can also take place cyclically, beginning with a preselected point in time.

For the long-term averages mentioned above, the length of the time window for averaging and the frequency with which it is updated can be set. The associated minimum and maximum values can be reset, using binary inputs or by using the integrated control panel in the DIGSI® 4 operating program.

Transfer of Measured Values

Measured values can be retrieved by SCADA, or through DIGSI® 4.

Set points

To recognize extraordinary operational conditions, warning levels can be programmed. When a programmed limit value is exceeded (or fallen below), a message is generated that can be masked to both output relays and LEDs. In contrast to the actual protective functions, such as time-overcurrent protection or overload protection, this monitoring program may becomes lower.

The following individual limit value levels are configured, when delivered from factory:

− Falling below a preset current in any phase

− Exceeding a preset maximum average current in Phase A

− Exceeding a preset maximum average current in Phase B

− Exceeding a preset maximum average current in Phase C

− Exceeding a preset maximum average positive sequence current

6.15.3 Waveform Capture

The 7SJ61 relay is equipped with an oscillographic data saving feature. The momentary values for the measurement quantities

I_a, I_b, I_c, I_G, and I_{Ns}

are scanned at intervals of 1.04 ms for 60 Hz (1.25 ms for 50 Hz) and stored in a revolving buffer (16 samples per cycle). For a fault, the data are stored for an adjustable period of time, but not more than 5 seconds. Up to 8 fault records can be recorded in this buffer. The memory is automatically updated with every new fault, so no acknowledgment for previously recorded faults is required. Waveform capture can also be started with protection pickup, via binary input, via PC- interface, or SCADA.

Using the PC-interface or the rear service port, data can be retrieved by a personal computer and processed, using the protective data processing program DIGSI$^®$ 4, and the graphics program DIGRA$^®$ 4. DIGRA$^®$ 4 graphically prepares the data generated during the fault, and calculates additional quantities, such as rms values, from the delivered measured values. The currents can be represented as primary or secondary quantities. In addition, relay sequence of events signals are recorded as well.

Fault data may be retrieved via the serial interface of a PC. Data evaluation is performed by the PC using the respective programs. For this, the currents are related to their maximum values, are standardized to the nominal value, and prepared for graphical display. Additionally, events such as the pickup of a relay element or the initiation of a trip signal can be displayed as well.

If configured in SCADA, data are transferred automatically to the SCADA computer.

6.15.4 Programming Settings

Average Calculation

The selection of the time period for measured value averaging is set at address 8301 **DMD Interval**. The first number specifies the averaging time window in minutes while the second number gives the frequency of updates within the time window. A setting of *15 Min., 3 Subs*, for example, means that time average generation occurs for all measured values that arrive within 15 minutes, and that output is updated three times during the 15 minute window, or every 15/3 = 5 minutes.

The point in time where averaging begins (on the hour, on the half hour, etc.) is set at address 8302 **DMD Sync.Time**. If the settings for averaging are changed, then the measured values stored in the buffer are deleted, and new results for the average calculation are only available after the set time period has passed.

Minimum and Maximum Values	The tracking of minimum and maximum values can be reset automatically at a programmable point in time. To select this feature, address 8311 **MinMax cycRESET** should be set to *Yes*. The point in time when reset is to take place (the minute of the day in which reset will take place) is set at address 8312 **MiMa RESET TIME**. The reset cycle in days is entered at address 8313 **MiMa RESETCYCLE**, and the beginning date of the cyclical process, from the time of the setting procedure (in days), is entered at address 8314 **MinMaxRES.START**.
Limit Values	Phase currents and the averages of the currents can be monitored. These are stationary monitors that cannot be used as pre-warning levels by time-overcurrent protection, for example. The percentages are relative to the nominal device quantities.
	The settings are entered under **MEASUREMENT** in the sub-menu **SET POINTS(MV)** by overwriting the existing values.
Waveform Capture	Waveform capture of faults is executed only when Address 0104 **OSC. FAULT REC.** is set for *Enabled.* Other settings pertaining to waveform capture are found under the **OSC.FAULT REC.** sub-menu of the **SETTINGS** menu.
	The trigger for an oscillographic record and the criterion to save the record are determined with the setting of Address 0401 **WAVEFORMTRIGGER**. With the setting *Save w. Pickup*, the trigger and the criterion for saving are the same – the pickup of a protective element. Another option for Address 0401 is **Start w. TRIP.** A trip command issued by the device is both the trigger and the criterion to save the record with this setting. The final — and more commonly used — option for Address 0401 is **Save w. TRIP.** The trigger under this setting is the pickup of a protective element (first element to pick up) and saving of the waveforms occurs only if the device issues a trip command. Each setting for Address 0401 has specific advantages. The choice depends primarily on the expected duration of faults, the time period of a complete fault duration that is of most interest (e.g. inception or clearing), and the frequency of waveform capturing that is to be expected.
	There are two options available for the coverage of oscillographic recording. The selection is made under Address 0402 **WAVEFORM DATA** and is based on the user's preference for recording events that occur while automatic reclosing is performed by the device. With the setting *Fault event,* waveform capturing occurs each time the recording trigger and save criterion are established. If automatic reclosing in the device is employed, the second option *Pow.Sys.Flt.* can be selected if desired. With this setting, the entire course of a fault - from inception, through reclosing, to clearing - is captured. This option provides detailed data for analysis of the entire fault history; however, the option also requires considerable memory for recording during dead times.
	An oscillographic record includes data recorded prior to the time of trigger, and data after the dropout of the recording criterion. The user determines the length of pre-trigger time and post-dropout time to be included in the fault record with the settings in Address 0404 **PRE. TRIG. TIME** and Address 0405 **POST REC. TIME.** The settings depend on Address 0401 and the information desired. For example, consider the trigger being a pickup of a protective element and the save criterion being a trip. The pre-trigger time is set based on the amount of pre-fault information that is desired. The post-dropout time is set based on the amount of information desired after clearing (e.g. checking for restrikes).
	The maximum length of time of a record is entered in Address 0403 **MAX. LENGTH.** The largest value here is 5 seconds. A total of 8 records can be saved. However the total length of time of all fault records in the buffer may not exceed 5 seconds. Once

the capacity of the buffer is exceeded the oldest fault is deleted , whereas the new fault is saved in the buffer.

An oscillographic record can be triggered and saved by a change in status of a binary input or via the operating interface connected to a PC. The trigger is dynamic. The length of a record for these special triggers is set in Address 0406 **BinIn CAPT. TIME** (upper bound is Address 0403). Pre-trigger and post-dropout settings in Addresses 0404 and 0405 do not apply. If Address 0406 is set for "∞," then the length of the record equals the time that the binary input is activated (static), or the **MAX. LENGTH.** setting in Address 0403, whichever is shorter.

6.15.4.1 Settings for Auxiliary Functions

Demand and Min/ Max Measurement Setup

Addr.	LCD-Text	Setting Options	Default Setting	Comments
8301	DMD Interval	15 Min., 1 Sub 15 Min., 3 Subs 15 Min., 15 Subs 30 Min., 1 Sub 60 Min., 1 Sub	60 Min., 1 Sub	Interval for Averaging
8302	DMD Sync. Time	On The Hour 15 After Hour 30 After Hour 45 After Hour	On The Hour	Synchronization time to form average values
8311	MinMax cycRESET	NO YES	YES	Automatic cyclic reset function
8312	MiMa RESET TIME	0 ~ 1439 min	0 min	Min/Max reset timer (time of day)
8313	MiMa RESET CYCLE	1 ~ 365 Days	7 Days	Min/Max reset cycle period
8314	MinMaxRES.START	1 ~ 365 Days	1 Days	Min/Max, Start reset cycle in ...

Oscillographic Fault Recording

Addr.	LCD-Text	Setting Options	Default Setting	Comments
0401	WAVEFORMTRIGGER	Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Trigger and Save Criterion for Oscillographic Records
0402	WAVEFORM DATA	Fault event Pow.Sys.Flt.	Fault event	Recording scope (for automatic reclosing)
0403	MAX . LENGTH	0.30 ~ 5.00 sec.	1.00 sec.	Maximum length of a record
0404	PRE. TRIG. TIME	0.05 ~ 0.50 sec.	0.10 sec.	Pre-trigger time included in records
0405	POST REC. TIME	0.05 ~ 0.50 sec.	0.10 sec.	Time after dropout of save criterion included in records
0406	BinIn CAPT.TIME	0.10 ~ 5.00 sec.	0.50 sec.	Record length for external trigger

6.15.4.2 Information List for Auxiliary Functions

F#	LCD-Text	Explanation
0395	>I MinMax Reset	>I MIN/MAX Buffer Reset
0396	>I1 MiMaReset	>I1 MIN/MAX Buffer Reset
0403	>Idmd MiMaReset	>Idmd MIN/MAX Buffer Reset

F#	LCD-Text	Explanation
0203	Wave. deleted	Waveform data deleted
0004	>Trig.Wave.Cap	>Trigger Waveform Capture

6.16 Breaker Control

General

In addition to the protective functions described thus far, a Control command process is integrated in the SIPROTEC® 7SJ61 to coordinate the operation of circuit breakers and other equipment in the power system. Control commands can originate from four command sources:

– Local operation using the keypad on the local user interface of the device

– Local or remote operation using DIGSI® 4

– Remote operation using the SCADA Interface (via IEC, Profibus)

– Automatic functions (e.g., using a binary input)

The device supports the operation of circuit breakers/switchgear. The number of switchgear devices to be controlled is, basically, limited by the number of binary inputs and outputs present. High security against inadvertent device operations can be ensured if interlocking checks are enabled. A standard set of optional interlocking checks is provided for each command issued to circuit breakers/switchgear.

Operation Using the keypad on the local user interface

Control ommands can be initiated using the keypad on the local user interface of the relay (see also Section 7.3 - System Control). Using the navigation keys ▲, ▼, ◄, ►, the **CONTROL** menu can be accessed and the circuit breaker/switchgear to be operated can be selected. After entering a password, a new window is displayed in which multiple control actions (close, open, cancel) are available and can be selected using the ▲ and ▼ keys. Next a security check takes place. After the security check is completed, the ENTER key must be pressed again to carry out the command. If the ENTER key is not pressed within one minute, the selection is cancelled. Cancellation via the ESC key is possible at any time before the control command is issued.

If the attempted command fails, because an interlocking condition is not met, then an error message appears in the display. The message indicates why the control command was not accepted (see also Subsection 7.3.7). This message must be acknowledged with ENTER before any further control commands can be issued.

Operation using DIGSI® 4

The procedure for issuing control commands using the DIGSI® 4 program is described in Section 7.3 (Control of Switchgear).

Operation using the SCADA Interface

Commands can be issued remotely via the SCADA interface as well. Please check MLFB order number to ensure that your individual relay has a SCADA interface module that supports this. Please refer to specific protocol documents for a complete list of supported commands (see Section 5.6).

6.16.1 Types of Commands

Two (2) types of commands can be processed within the device:

– Control commands

– Internal / pseudo commands

Control Commands Control commands operate (OPEN/CLOSE) binary outputs. Examples are:

- Commands (e.g. operation of circuit breakers, etc.)

- Step Commands (e.g. raising and lowering transformer LTCs)

- Set-point Commands with configurable time settings (Petersen coils)

Internal / pseudo Commands These commands do not directly operate binary outputs. They serve to initiate internal functions, simulate changes of state, or to acknowledge changes of state.

- Marking/Tagging commands are used to manually overwrite or set status functions normally controlled by binary inputs.

- Additionally, Tagging commands are issued to establish internal settings, such as switching authority (remote vs. local), parameter set changeover, data transmission block to the SCADA interface, and measured value set-points.

- Acknowledgment and resetting commands for setting and resetting internal buffers.

- Status Information commands:

  - Controlling activation of binary input status

  - Binary Output Blocking

6.16.2 Steps in the Command Sequence

Safety mechanisms in the command sequence ensure that a command can only be released after a thorough check of preset criteria has been successfully concluded. Standard Interlocking checks are provided for each individual control command. Additionally, user-defined interlocking conditions can be programmed separately for each command. The actual execution of the command is also monitored afterwards. The entire sequence of a command is described briefly in the following:

Check Sequence

- Command Entry (e.g. using the keypad on the local user interface of the device)

  – Check Password → Access Rights

  – Check Switching Mode (interlocking activated/deactivated) → Selection of Deactivated Interlocking Recognition

- User configurable Interlocking checks that can be selected for each command

  – Switching Authority (local, remote)

  – Device Position (scheduled vs. actual comparison)

  – Zone Controlled/Field Interlocking/ (logic using CFC)

  – System Interlocking (centrally, using SCADA system or substation controller)

  – Double Operation (interlocking against parallel switching operation)

  – Protection Blocking (blocking of switching operations by protective functions)

- Fixed Command Checks

  – Internal process time (software watch dog which checks the time for processing the control action between initiation of the control and final close of the relay contact. After 1 second the control action will be aborted).

  – Setting Modification in Process (if setting modification is in process, commands are denied or delayed)

  – Equipment not Present at Output (If a circuit breaker or other operable equipment is not configured to a binary output, then the command is denied)

  – Output Block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is denied)

  – Component Hardware Malfunction

  – Command in Progress (only one command can be processed at a time for one circuit breaker or switch)

  – 1-of-n-check (for schemes with multiple assignments, such as common ground, whether a command has already been initiated for the affected output relay is checked).

Monitoring the Command Execution

  – Interruption of a Command because of a Cancel Command

  – Running Time Monitor (feedback message monitoring time)

6.16.3 Interlocking
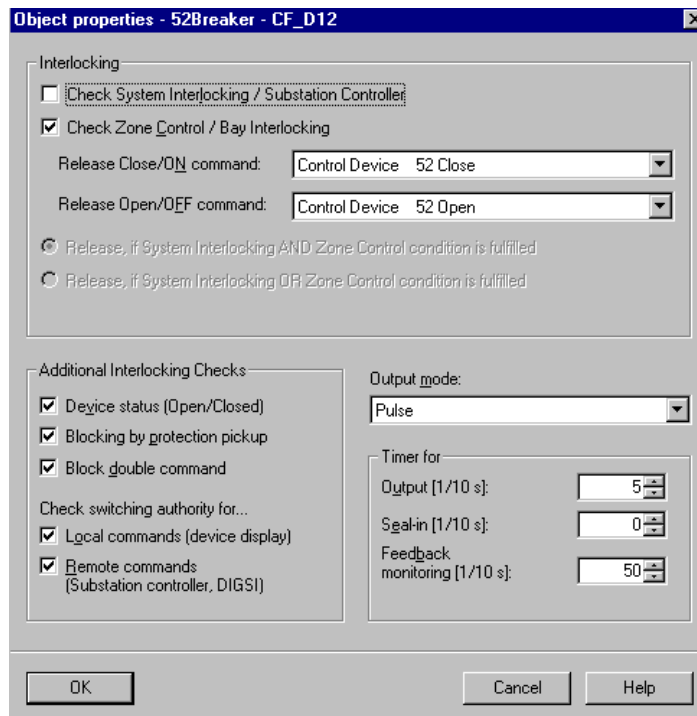
Figure 6-50   DIGSI® 4 Dialogue Box for Object Properties – for Setting the Interlocking Conditions.

The interlocking checks are divided into:

- System Interlocking (checked by a central control system such as SCADA or substation controller), to be implemented with Version 4.2
- Zone Controlled/Bay Interlocking (checked in the device)

System interlocking relies on the system data base in the substation or central control system. Circuit breakers (or other equipment) that require system interlocking in a central control system (Substation Controller) must be configured in their specific commands object properties box for the specific control device. Interlocking conditions can be selected.

Zone Controlled/Bay Interlocking relies on the status of the circuit breaker and other switches that are connected to the relay. The extent of the interlocking checks is determined by the configuration of the relay.

For all commands, operation with interlocking (normal mode) or without interlocking (test mode) can be selected:

– for Local commands, by reprogramming the settings (using the local user interface) with password check,

– for automatic commands, via command processing by CFC,

– for local / remote commands, using an additional interlocking disable command, via Profibus. (Other Protocols may support these feature in the future).

6.16.3.1 Interlocked/Non-Interlocked Switching

The command checks that can be selected for the 7SJ61 relay are also referred to as "standard interlocking". These checks can be activated (interlocked) or deactivated (non interlocked).

Deactivated interlock switching means the configured interlocking conditions are not checked in the relay.

Interlocked switching means that all configured interlocking conditions are checked within the command processing.

Interlocking conditions (e.g. device Position Check, Blocked by Protection etc.) for each control device are individually selectable in the Command Output-object properties box.

Internal control actions are always executed regardless of any interlocking.

Standard Interlocking Defaults

The following is a list of Standard Interlocking Conditions that can be selected for each controllable device. All of these are enabled as a default.

- System Interlocking/Substation Controlled: in preparation, to be implemented with Version 4.2.

- Zone Controlled/Bay Interlocking: All devices controlled by this relay can be interlocked by the CFC logic.

- Device Status Check (scheduled = actual): the switching command is rejected, and an error message is displayed, if the circuit breaker is already in the scheduled (desired) position. (If this check is enabled, then it works whether interlocking, e.g. zone controlled, is activated or deactivated.) This condition is checked in both interlocked and non-interlocked status modes.

- Blocked by protection: A CLOSE-command is rejected as soon as one of the protective elements in the relay picks up. The OPEN-command, in contrast, can always be executed. Please be aware, activation of thermal overload protection elements or sensitive ground fault detection can create and maintain a fault condition status, and can therefore block CLOSE commands. If the interlocking "Blocking by protection" is removed, consider that the restart blocking for motors will also be disabled, and a CLOSE command to the motor would be possible. Restarting would then have to be interlocked some other way. One method would be to use a specific interlocking in the CFC logic.

- Double Operation Block: parallel switching operations are interlocked against one another; while one command is processed, a second cannot be carried out.

- Switch Authority LOCAL: When this interlocking check is enabled in the Object Properties dialog box, the status of Switching authority is checked prior to issuing a control command. If this particular setting is selected, a control command from the user interface of the device is only allowed if switching authority is set to LOCAL.

- Switch Authority DIGSI: Switching commands can be issued locally or remotely via DIGSI. As part of the safety features, the device will check the DIGSI configuration file in regard to the virtual device number to ensure that the correct configuration file is used. DIGSI must have the same virtual device number. It is important that one file can not be reused with multiple relays. But it is possible to copy the file and use the new file with another relay.

- Switch Authority REMOTE: When this interlocking check is enabled in the Object Properties dialog box, the status of Switching authority is checked prior to issuing a control command. If this particular setting is selected a control command from a re-

mote DIGSI connection or via the SCADA interface is only allowed if switching authority is set to REMOTE.

An overview for processing the interlocking conditions in the relay is shown by Figure 6-51.
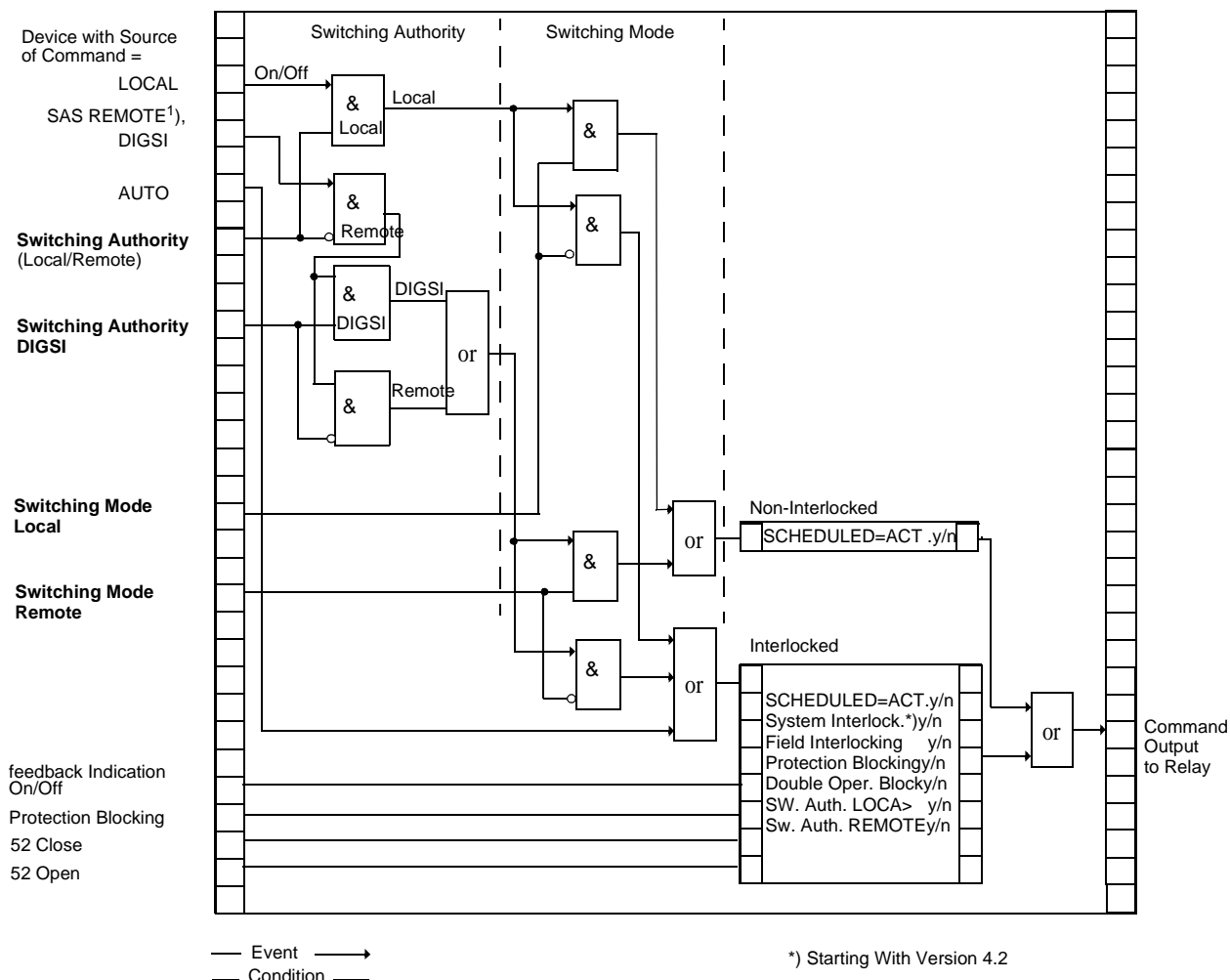
Figure 6-51   Standard Interlocking Arrangements

Control Logic using CFC

For Zone Controlled (field interlocking), control logic can be developed, using the CFC.

Switching Authority

Switching authority configures the relay to perform Local/Remote Supervisory functions. Note, that only *one* source can have authority at a time. The following switching authority ranges are defined in the following priority sequence:

− LOCAL (commands are issued from the relay keyboard)

– DIGSI® 4

– REMOTE (commands are issued from SCADA)

The switching authority condition **LOCAL** allows commands from the user interface of the relay, but not remote or DIGSI commands.

The selection between local and remote is made using the local user interface. A password is required, to make this selection.

The switching authority condition **DIGSI** allows commands to be initiated using DIGSI® 4. Commands are allowed for both a remote and a local DIGSI® 4 connection.

Configuration Programming:

1. Specific Device (e.g., switching device): Switching authority LOCAL (check for commands initiated Locally via keypad): y/n

2. Specific Device (e.g., switching device): Switching authority REMOTE (check for SAS, REMOTE, or DIGSI commands: y/n

In detail, the following interlocking logic is derived when using default configuration settings:

Current Switching Authority Status	Switching Authority DIGSI	Command issued Locally	Command issued from SAS or SCADA	Command issued from DIGSI
LOCAL	Not checked	Allowed	Interlocked - switching authority LOCAL [*2]	Interlocked - DIGSI not checked
LOCAL	checked	Allowed	Interlocked - switching authority LOCAL [*2]	Interlocked - switching authority LOCAL [*2]
REMOTE	Not checked	Interlocked - switching authority REMOTE [*1]	Allowed	Interlocked - DIGSI not checked
REMOTE	checked	Interlocked - switching authority DIGSI [*1]	Interlocked - switching authority DIGSI [*2]	Allowed

[*1]) By-passes Interlock if Configuration for: "switching authority LOCAL (check for Local status): is not marked.
[*2]) By-passes Interlock if Configuration for: "switch authority REMOTE (check for CLOSE, REMOTE, or DIGSI status): is not marked

SC = source of command

SC = AUTO: Commands that are initiated internally (command processing in the CFC) are not subject to switching authority and are therefore always allowed.

Switching Mode   There are three modes:

– Local

– Remote

– Auto

The switching mode determines whether selected interlocking conditions will be activated or deactivated at the time of the switching operation.

The following switching modes are defined:

- **Local** commands (SC = LOCAL)

    - interlocked, or

    - non-interlocked switching.

  For devices without key-switches, the switching mode can be changed between "interlocked" and "non-interlocked" using the front PC port, after password entry.

- **Remote or DIGSI**® **4** commands (SC = SAS, REMOTE, or DIGSI)

    - interlocked, or

    - non-interlocked switching. Here, deactivation of interlocking is accomplished via a separate command. The position of the key-switch is irrelevant.

- **Auto**: For commands from CFC (SC = AUTO), the notes in the CFC handbook should be referred to (e.g. component: BOOL to command)

Zone Controlled/ Field Interlocking

Zone Controlled (field interlocking) includes the verification that predetermined switchgear position conditions are satisfied to prevent switching errors as well as verification of the state of other mechanical interlocking such as High Voltage compartment doors etc.

Interlocking conditions can be programmed separately, for each switching device, for device control CLOSE and/or OPEN. Processing of the status of the release condition for an operation switching device can be based on information acquired:

- directly, using a single point or double point indication (binary inputs), key-switch, or internal indication (marking), or

- with logic using CFC.

When a switching command is initiated, the actual status of all relevant switching devices is scanned cyclically.

Substation Controller (System Interlocking)

Substation Controller (System interlocking) involves switchgear conditions of **other** bays evaluated by a central control system. This functionality will be available with the release of SW version 4.2.

Double Operation

Parallel switching operations are interlocked. When this function is enabled only one control can be issued at a time. All control objects are checked prior to issuing a command.

Blocked by Protection

When configured, the pickup of Protective elements blocks switching operations, configurable separately for both closing and tripping commands. Operations in progress will also be aborted by the pickup of a protective element.

Device Position (Scheduled = Actual)

For switching commands, a check takes place whether the selected switching device is already in the scheduled/desired position (Open/Closed; scheduled/actual comparison). This means, if a circuit breaker is already in the CLOSED position and an attempt is made to issue a closing command, the command will be refused, with the operating message "scheduled condition equals actual condition". If the circuit breaker/switchgear device is in the intermediate position, then this check is not performed.

▮■

Operators Tools

<div style="text-align: right; font-size: 2em;">**7**</div>

This chapter describes interaction possibilities with the SIPROTEC® 7SJ61 device during operation. The information that can be obtained and the procedure for retrieving the data are discussed. Methods of influencing the device functions during operation and controlling the system using the device are covered.

Detailed knowledge about the device functions is not required at this point; however, the configuration of the device covered in Chapter 5 — especially configuration (masking) of the input and output functions — is assumed to have already taken place.

Please note that the examples shown are general and may differ in wording or details from the device at hand. Also, depending on the model variant, all of the functions discussed below may not be available.

7.1 Retrieval of Information

General

The device provides information that can be obtained locally or remotely:

- Messages,
- Operating measurement and metered values,
- Waveform data in oscillographic records.

This information is individually discussed below. Methods for viewing, retrieving, acknowledging, and storing this information on a PC are also explained.

7.1.1 Messages

7.1.1.1 Output of Messages

Messages provide operating information about the power system, the device, and the measurements. Other messages give an overview of important events such a network fault and the operation of device functions. The information provided is useful in checking overall operation of the device during testing and commissioning.

Password entry is not required to read messages.

The messages generated in the device can be presented in various ways:

- Display using light-emitting diodes (LEDs) on the front of the device,
- Operation of binary outputs connected to external signaling equipment,
- Display in the LCD on the front of the device,
- Displayed in DIGSI$^®$ 4 program, connected to the front or rear DIGSI serial interface port on the device,
- Transfer to a SCADA via SCADA port.

Light-Emitting Diodes

The green light-emitting diode with the label "RUN" lights continuously during normal operation.

The red LED with the label "ERROR" indicates that the processor system has recognized an internal problem. If this LED is on, then the device is not in operation. Chapter 9 discusses steps to take if a failure occurs in the device.

The other LEDs on the front of the device display the messages in accordance with the masking, as discussed in Chapter 5. The description of each LED illumination should then be indicated on the label strips.

Latched LEDs can be reset by the LED key `LED`. This key simultaneously serves as a functional check for all of the LEDs except the "RUN" and "ERROR" LEDs. While the key is pressed, all of these LEDs must light.

LEDs that display a condition light for as long as the condition is maintained if not latched. The LED action is therefore generally not stored, but erased as soon as the condition vanishes. Of course, these LEDs are also included in the function check with the LED key `LED`.

Binary Outputs Indications can be configured to binary outputs for external indication (e.g. annunciator, sequence-of-events recorder, RTU, etc), and operate exactly like LEDs. See also Chapter 5 for details.

Front Panel Display To retrieve messages using the front panel display on a device that is ready for operation:

First press the **MENU** key MENU. The **MAIN MENU** appears. The first menu item **(*Annunciation*)** is marked.

All menus and message lists begin with a title. The number in the upper right hand corner of the display indicates the presently selected menu entry or message, and the total number of menu entries or messages (see Figure 7-1, each first line).

Press the ▶ key to go to the **ANNUNCIATION** sub-menu, as shown in Figure 7-1. In this menu the messages can be reached by entering the associated selection number, or by selecting the desired entry using the ▼ and ▲ keys and moving further with the ▶ key. This procedure is described in more detail below.

```
            MAIN MENU       01/05
            --------------------
  ▼        >Annunciation   ->  1
            Measurement    ->  2        ▶        ANNUNCIATION    01/05
                                                 --------------------
                                                >Event Log       ->  1
                                                 Trip Log        ->  2
```
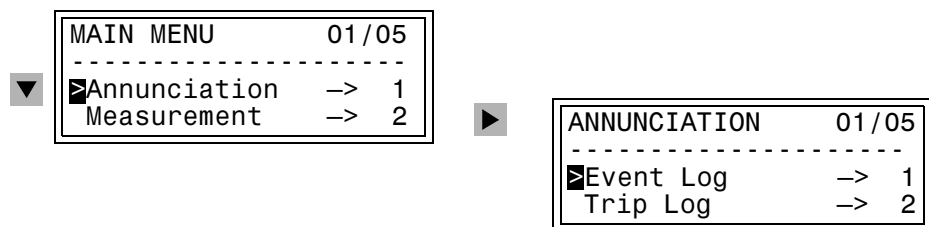
Figure 7-1 Selection of Messages on the Operator Control Panel

PC–Interfaces A PC running the DIGSI® 4 program can be connected to the serial port on the front of the device or to the DIGSI interface port on the rear of the device to retrieve the messages. The rear DIGSI port connection can be RS232, RS485, or a multimode fiber optic. The rear port is typically connected to a station computer or modem.

Details about the operation of DIGSI® 4 are contained in the "DIGSI® 4 Device Operation" handbook, order no. E50417-H1176-C097.
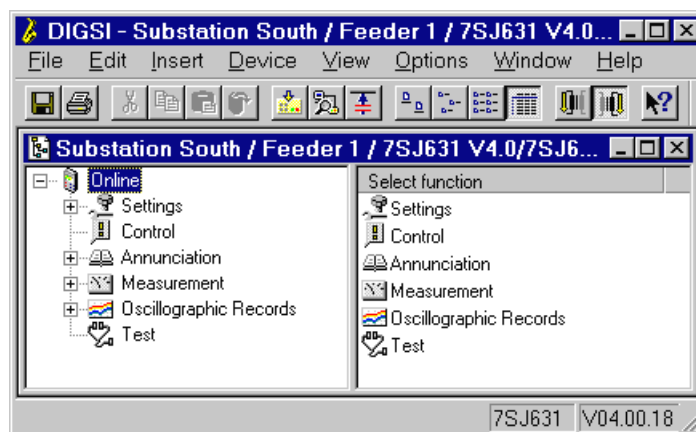
Figure 7-2 Function Selection Window in DIGSI® 4

If the DIGSI® 4 **Online** directory is opened with a double-click, the operating functions for the device appear in the navigation window (Figure 7-2). By double clicking on **Annunciation**, the tree structure expands and shows the individual message groups. The groups are described in detail below.

SCADA Interface (system interface)

The SCADA interface (if available) is generally connected to a RTU, SAS, Station Computer or directly to a SCADA system. RS232, RS485, and multimode fiber optic connections are available. Real-Time monitoring and breaker control are availble via the SCADA interface.

Division of Messages

The messages are categorized as follows:

- Event Log: These are message that can occur during the operation of the device. They include information about the status of device functions, measurement data, system data, recording of control commands, and similar information.

- Trip Log: Fault messages are message from the last 8 network faults that were processed by the device.

- Sensitive Groung Fault Log: Ground fault messages, if the device has sensitive ground fault detection.

- Statistics: These values include a counter for the trip commands initiated by the device, accumulated currents interrupted by the individual poles of the circuit breaker, and the operating hours of the network or equipment being protected.

A complete list of all message and output functions that can be generated by the device, with the associated information number (FNo), can be found in Section A.5 of the Appendix. The lists also indicate where each message can be sent. The lists are based on a SIPROTEC® 4 device with the maximum number of functions. If functions are not present in the specific version of the device, or if they are set as "*Disabled*" in Device Configuration, then the associated messages cannot appear.

7.1.1.2 Event Log (Operating messages)

The Event Log contains operating messages that the device generates during operation. All operating messages are stored in the **Annuncitaion** Logs. Up to 200 operating messages are recorded in chronological order in the device. New messages are added at the end of the list. If the memory has been exceeded, then the oldest message is written-over for each new message.

Faults in the power system are indicated with "Network Fault" and the present fault number. The **Trip Log** contain details about the progressions of faults. This topic is discussed in Sub-section 7.1.1.3.

Ground fault messages are indicated with "Ground Fault" and the present ground fault number (only for devices with sensitive ground fault detection). The **Ground Fault Log** contains details about the ground faults, associated with the sensitive ground fault function. The topic is discussed in Sub-section 7.1.1.4.

All predefined operating messages are listed and explained in a table in the Appendix. In a specific case, of course, only the appropriate messages appear in the display. The appendix also shows whether the message is only issued as "ON" (to indicate an event), or as "ON" (asserted) and "OFF" (deasserted) (to designate the beginning and end of a condition).

From the DeviceFront

With a device ready for operation, first press the <mark>MENU</mark> key. The MAIN MENU appears. The first menu item (*Annunciation*) is marked.

Press the ▶ key to enter the **ANNUNCIATION** menu (see Figure 7-1).

Here, select the menu item *Event Log* (already marked). The **EVENT LOG** table appears.

If no messages are present, then the text "list is empty" appears. Otherwise important events and changes in conditions are listed in chronological order (see Figure 7-3 as an example). Upon entering the menu, the newest (last) message is displayed at first. The applicable date and time are noted in the display line directly above the message. If the memory for the operating messages is not full, then the end of the entries is indicated by "END".

▼

```
EVENT LOG       19/19
--------------------
06/19/99 11:52:05.625
Reset LED          ON
```

Figure 7-3   Example of an Operating Message in the HMI of the Device

The [▼ and ▲ keys can be used to move up and down in the Event Log.

Press the <mark>MENU</mark> key to return to the **MAIN MENU**.

From PC with DIGSI® 4

Click on Annunciation. The options appear in the data window (Figure 7-4).

Double click on the desired message group in the data window, in this case **Event Log**. A date and time appear in the data window as shown in Figure 7-4.

Double click on the date and time and the contents of the message group are displayed in another window.
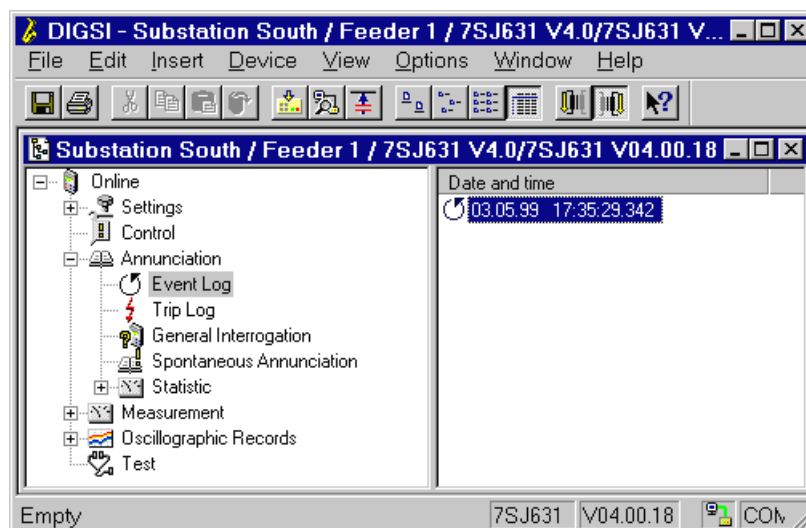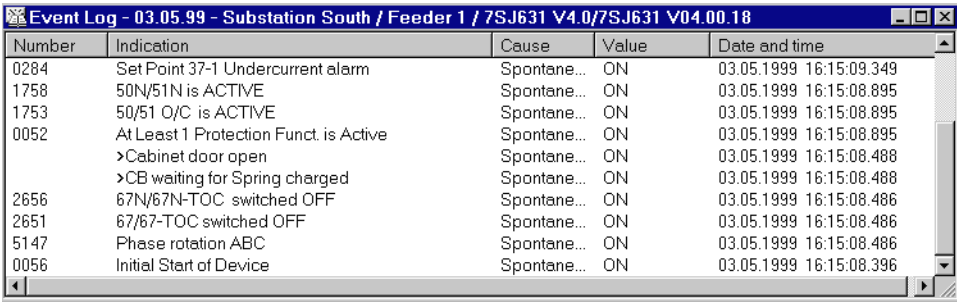
Figure 7-4   DIGSI® 4 Selection of Event Log

```
Event Log - 03.05.99 - Substation South / Feeder 1 / 7SJ631 V4.0/7SJ631 V04.00.18    _ □ ×
Number   Indication                          Cause      Value   Date and time
0284     Set Point 37-1 Undercurrent alarm   Spontane...  ON    03.05.1999 16:15:09.349
1758     50N/51N is ACTIVE                   Spontane...  ON    03.05.1999 16:15:08.895
1753     50/51 O/C is ACTIVE                 Spontane...  ON    03.05.1999 16:15:08.895
0052     At Least 1 Protection Funct. is Active  Spontane... ON  03.05.1999 16:15:08.488
         >Cabinet door open                  Spontane...  ON    03.05.1999 16:15:08.488
         >CB waiting for Spring charged      Spontane...  ON    03.05.1999 16:15:08.488
2656     67N/67N-TOC switched OFF            Spontane...  ON    03.05.1999 16:15:08.486
2651     67/67-TOC switched OFF              Spontane...  ON    03.05.1999 16:15:08.486
5147     Phase rotation ABC                  Spontane...  ON    03.05.1999 16:15:08.486
0056     Initial Start of Device             Spontane...  ON    03.05.1999 16:15:08.396
```

Figure 7-5   DIGSI® 4 Event Log Window — Example

7.1.1.3   Trip Log (Fault Messages)

Spontaneous messages

The spontaneous messages that can be viewed on the device front serve to display the most important data about a fault. The messages appear automatically in the display, after a general pickup of the device, in the sequence shown in Figure 7-6.

```
50−1 picked up
50−1 TRIP
T − Pickup=  320ms
T − OFF   =  197ms
```

Protective Function that picked up first;
Protective Function that dropped out last;
Running time from general pickup to dropout;
Running time from general pickup to the first trip command

Figure 7-6 Display of Spontaneous Messages in the HMI – Example

The spontaneous messages can be acknowledged by pressing the LED key. After acknowledgment, the default display is shown.

Retrieved messages

The messages for the last eight network faults can be retrieved. The definition of a network fault is such that the time period from fault detection up to final clearing of the disturbance is considered to be one network fault. If auto-reclosing occurs, then the network fault ends after the last reclosing shot, which means after a successful reclosing or lockout. Therefore the entire clearing process, including all reclosing shots, occupies only one fault record. Within a network fault, several indications can occur (from the first pickup of a protective function to the last dropout of a protective function). These indications are recorded.

In total 600 indications can be recorded. Oldest data are erased for newest data when the buffer is full.

All available indications are displayed and explained in the Appendix. In a specific case, of course, only the applicable messages appear on the display.

From the Device Front

With a device ready for operation, first press the MENU key. The MAIN MENU appears. The first menu item (*Annunciation*) is marked.

Press the ▶ key to enter the **ANNUNCIATION** sub-menu (see Figure 7-1).

Using the ▼ key, select the sub-menu item ***Trip Log*** and move to the Trip Log sub-menu using the ▶ key. The **TRIP LOG** selection appears.

In this sub-menu, the indications for the last 8 network faults can be selected, again using the ▼ and ▶ keys. See the example in Figure 7-7.

If no messages are present for a fault record, then enterance is denied and "List Empty" is displayed.

The messages within a fault record are listed in chronological order and numbered, from the oldest to the newest.

The inception of a fault is identified with the date and time in hours, minutes, and seconds (resolution to ms). See the example in Figure 7-7.

The individual messages that are associated with the fault are given a relative time. At least one complete individual message always appears in the display.

```
       ┌─────────────────────┐              ┌─────────────────────┐
       │ TRIP LOG      01/08 │              │ LAST FAULT    01/10 │
  ▼    │─────────────────────│     ▶        │─────────────────────│
       │▷Last Fault     —> 1 │              │ 06/22  23:49:34,845 │
       │ 2nd Last Fault —> 2 │              │ Network Fault  6  ON│
       └─────────────────────┘              └─────────────────────┘
                 etc
```
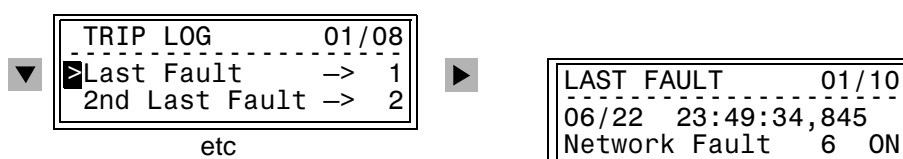
Figure 7-7   Example of Fault Messages in the HMI

Use the ▼ and ▲ keys to move up and down in the fault record.

Use the ◀ key to move back into the **TRIP LOG** level; press the MENU key to go back to the **MAIN MENU**.

From PC with DIGSI® 4

Click on Annunciation. The options appear in the data window (see Figure 7-2).

Double click on the desired message group in the data window, in this case the **Trip Log**. A list appears in the data window, as shown in Figure 7-8.

By double clicking on an entry in the list view, the associated contents of the network fault are displayed in another window. The entries are chronologically listed with the newest message appearing first.
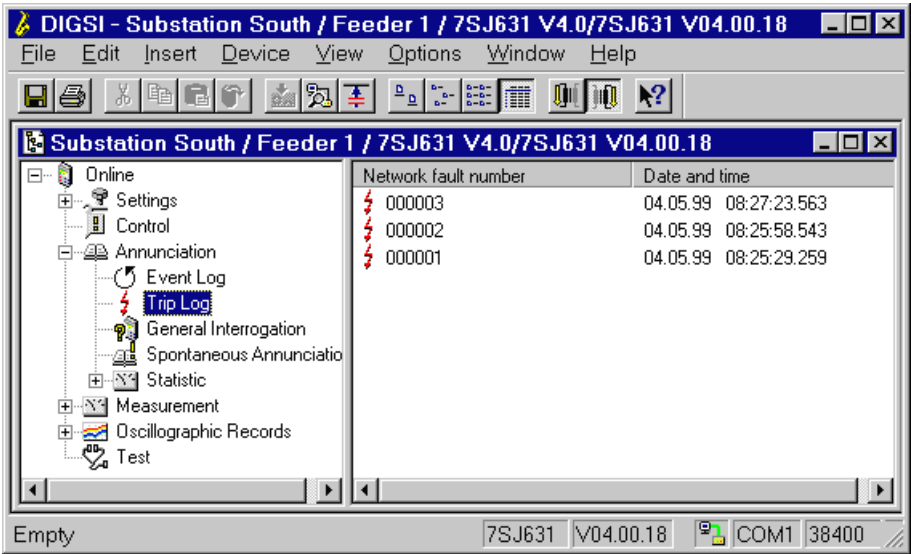
Figure 7-8   DIGSI® 4 Selection of Trip Log with Faults Listed in the Data Window

Figure 7-9   DIGSI® 4 Example of Indications for a Fault, Trip Log Window

7.1.1.4   Ground Fault Messages (Ground Fault messages associated with the sensitive ground fault function)

For devices with sensitive ground fault detection, special ground fault records are available. Messages are provided if the protection is set for "*Alarm Only*" in Address 3101, and the ground fault remains long enough for the time delay to expire.

Up to 15 messages can be recorded for the last 3 faults.

All available messages are displayed in table form and explained in the Appendix. In a specific case, only the applicable messages appear on the display.

From the Device Front

With a device ready for operation, first press the MENU key. The MAIN MENU appears. The first menu item *Annunciation* is marked.

Press the ▶ key to enter the **ANNUNCIATION** sub-menu (see Figure 7-1).

Select the menu *Ground Fault Log* using the ▼ key, and move to the records with the ▶ key. The **GROUND FAULT LOG** selection appears.

In this sub-menu, messages from the last 3 ground faults can be selected, again using the ▼ key and moving on with the ► key. See the example in Figure 7-10.

If no messages are present for a fault record, then access is denied and the message "List Empty" appears.

The messages within a ground fault record are listed in chronological order and numbered, from the oldest to the newest.

The inception of a ground fault is identified with the date (without year) and the time in hours, minutes, and seconds (resolution to ms). See the example in Figure 7-10.

```
      ┌─────────────────────────┐
      │GND FAULT LOG  01/03      │
      │- - - - - - - - - - - - - │
▼     │>Last           ─>    1   │      ►
      │ Next to Last   ─>    2   │
      └─────────────────────────┘
            Etc.
```

```
┌─────────────────────────┐
│LAST               01/04  │
│- - - - - - - - - - - - - │
│>06/11 09:37:23.203       │
│ Sens. Gnd 01          0  │
└─────────────────────────┘
┌─────────────────────────┐
│ SensGnd Forward       0  │
└─────────────────────────┘
```
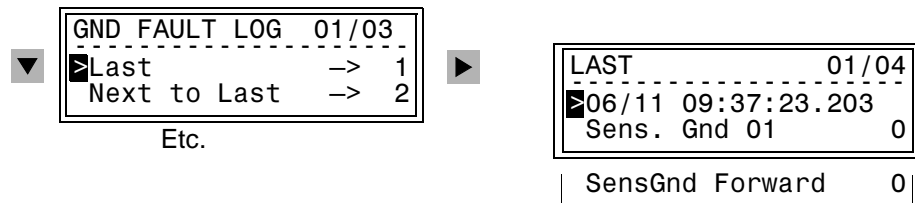
Figure 7-10   Example of a Ground Fault Message in the HMI

Use the ▼ and ▲ keys to view the messages for a fault.

Use the ◄ key to move back into the **GROUND FAULT LOG** sub-menu; the <mark>MENU</mark> key to go back to the **MAIN MENU**.

From PC with DIGSI® 4

Click on **Annunciation**. The options appear in the data window (see Figure 7-2).

Double click on the desired message group, in this case **Ground Fault Log**. A list appears in the data window, as shown in Figure 7-11.

By double clicking on an entry in the list view, the associated contents of the ground fault record are displayed in another window, as shown in Figure 7-12.
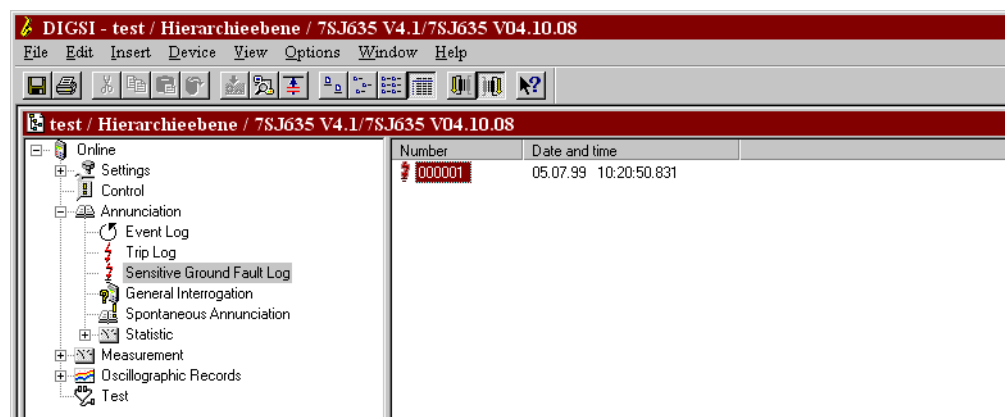
Figure 7-11   DIGSI® 4 Selection of Ground Fault Log with a Fault Indicated in the Data Window

Number	Indication	Cause	Value	Date and time
0303	sensitive Ground fault		1 - ON	05.07.1999 10:20:50.831
1276	Sensitive Gnd fault in forward direction		ON	0 ms

Figure 7-12   DIGSI® 4 Example of Indications for a Ground Fault, Ground Fault Log

7.1.1.5   Saving and Erasing the Messages

Normally, erasing the messages is not necessary because the oldest messages are automatically erased when new events are entered, if the memory is full at the time. However, erasure of the stored messages may be useful, for instance, after revision or commissioning, so that in the future the memory only contains information about actual events. Erasing the memory takes place separately for each of the Fault Logs.

Note:

When Trip Log is erased, the fault records and counters for network fault number and indication data number are set to zero. If, however, a fault record is erased, the counters are unaffected.

From the Device Front

If erasure is desired, first press the MENU key. The **MAIN MENU** appears. The first menu item *Annunciation* is marked.

Press the ▶ key to enter the **ANNUNCIATION** menu (see Figure 7-1).

Using the ▼ key, select the item *Set/Reset*, and switch to the sub-menu using the ▶ key.

Here, select the message group to be erased using the ▼ key, and then press the ENTER key. See Figure 7-13.

Password No. 5 (for setting changes) is required at this point. After entering the password and confirming with the ENTER key, the safety question "**Are you sure?**" appears. The response "**YES**" is the default (Figure 7-13). Confirm with the ENTER key, if the message group should really be erased. If the message group should not be erased, press the ▶ key so that the response "**NO**" is highlighted, and confirm this answer with the ENTER key. Before confirming with the ENTER key, the responses can be toggled between "**YES**" and "**NO**" using the ◀ and ▶ keys. Alternatively, the ESC key can be pressed to cancel the erasure procedure.

```
┌─────────────────────────┐
│ SET/RESET        01/04 │
│ - - - - - - - - - - - - │
▼ │>Event Log          1 │
│  Trip Log           2 │
└─────────────────────────┘
        Etc
```

Press the associated number key to se-lect the messages to be erased.

```
┌─────────────────────────┐
│ PW Parameter Change?   │
│     =-------           │
└─────────────────────────┘
```
ENTER

Enter Password No. 5 (for setting change) and confirm with ENTER

```
┌ - - - - - - - - - - - - ┐
  Are you sure?
│>YES      NO            │
└ - - - - - - - - - - - - ┘
```

Confirm "YES" with the ENTER key and com-plete the erasing of the selected messag-es, or switch to "NO" with the ▶ key and cancel the erasure with the ENTER key.
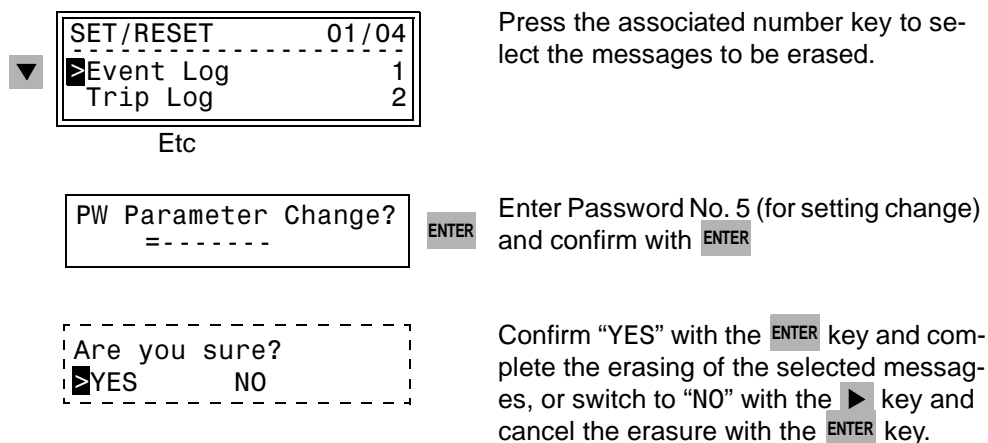
Figure 7-13   Erasing Messages from the Operator Control Panel

From PC with DIGSI® 4

When operating with DIGSI® 4, the device messages can be saved on the hard drive of a personal computer before they are erased from the device. To do this, follow ex-actly the same steps taken to retrieve the messages. Instead of double clicking on the message group in the message list to open the group, select the option **File → Save** in the DIGSI® 4 window menu bar. DIGSI® 4 then automatically creates a directory for the messages — if one does not exist — and saves the message group in this direc-tory. For details, see the "DIGSI® 4 Device Operation" Handbook, order no. E50417–H1176–C097, Sub-section 9.4.

When all of the desired message groups have been saved on the PC, they can be erased from the device as described above.

Of course, you can erase the saved data from the hard drive of your PC as every file.

7.1.1.6   General Interrogation

From PC with DIGSI® 4

The present condition of a SIPROTEC® 4 device can be retrieved by using DIGSI® 4.

The messages are found by double-clicking on **Annunciation** (see Figure 7-2), double-clicking on **General Interrogation**, and double-clicking on the date and time that appear in the right window. All messages are shown along with the present status.

7.1.1.7   Spontaneous Annunciations
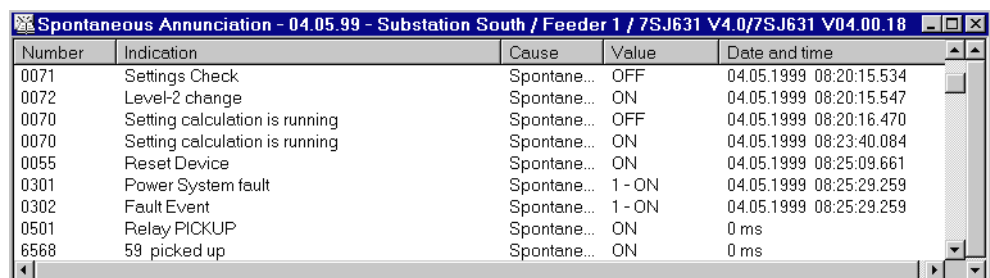
From PC with DIGSI® 4

The spontaneous annunciations that can be displayed via DIGSI® 4 are refreshed im-mediately, an event or status change occur.

Find the message groups by clicking on **Annunciation** (Figure 7-2).

Double click **Spontaneous Annunciation** in the data window. The date and time appear in the data window. By double clicking on them, the Spontaneous Annunciation window opens, as shown in the following figure. Each entering message appears immediately, without requiring that an update be initiated.

Number	Indication	Cause	Value	Date and time
0071	Settings Check	Spontane...	OFF	04.05.1999 08:20:15.534
0072	Level-2 change	Spontane...	ON	04.05.1999 08:20:15.547
0070	Setting calculation is running	Spontane...	OFF	04.05.1999 08:20:16.470
0070	Setting calculation is running	Spontane...	ON	04.05.1999 08:23:40.084
0055	Reset Device	Spontane...	ON	04.05.1999 08:25:09.661
0301	Power System fault	Spontane...	1 - ON	04.05.1999 08:25:29.259
0302	Fault Event	Spontane...	1 - ON	04.05.1999 08:25:29.259
0501	Relay PICKUP	Spontane...	ON	0 ms
6568	59 picked up	Spontane...	ON	0 ms

Spontaneous Annunciation – 04.05.99 - Substation South / Feeder 1 / 7SJ631 V4.0/7SJ631 V04.00.18

Figure 7-14 DIGSI® 4 Spontaneous Annunciation Window — Example

7.1.2 Statistics

The messages in statistics are counters for the accumulation of interrupted current by each of the breaker poles, the number of trips issued by the device to the breaker, and the operating hours of the breaker and protected equipment. The interrupted currents are in primary terms.

Statistics can be viewed on the LCD of the device, or on a PC running DIGSI® 4 and connected to the operating or service interface.

A password is not required to read statistics; however, a password is required to change or delete the statistics.

7.1.2.1 Retrieve the Statistics

For each trip command initiated by a protective element of the device, the magnitude of interrupted current for each circuit breaker pole is determined and recorded. The current magnitudes are added to previously interrupted currents, and the values are accumulated. The number of circuit breaker operations is counted in the device based on the feedback information from the circuit breaker contacts. A precondition is that binary inputs are wired to the circuit breaker auxiliary contacts, and these binary inputs are masked for counting.

In addition, the operating hours for the protected equipment are counted. The protected equipment is considered to be in operation whenever the current threshold, set under Address 0212 (**BkrClosed I MIN**), is exceeded by at least one phase current.

The counter are retained during a loss of power supply voltage.

From the DeviceFront

With a device ready for operation, first press the MENU key. The MAIN MENU appears. The first menu item *Annunciation* is marked.

Press the ▶ key to enter the **ANNUNCIATION** sub-menu (see Figure 7-1).

Use the ▼ key to select the item *Statistic*, and switch to the list of statistics values using the ▶ key. The **STATISTIC** list appears. See figure 7-15.

▼
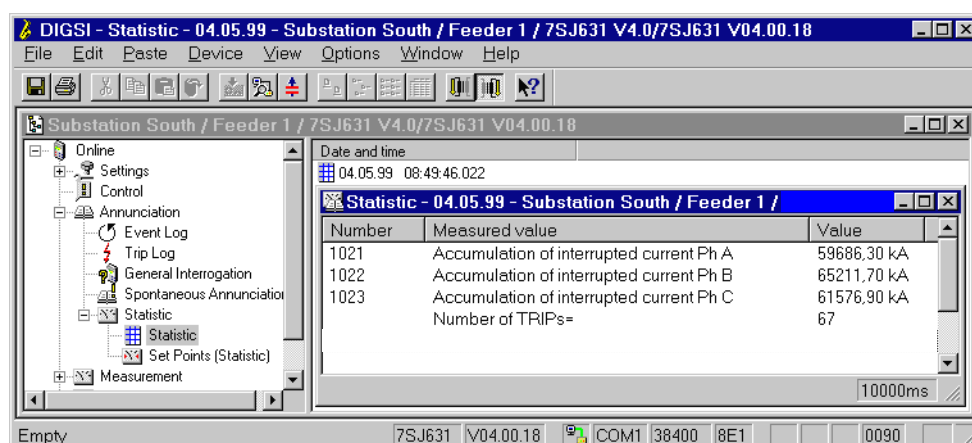
```
┌─────────────────────────┐
│ STATISTICS        1/05  │
│ ----------------------  │
│  Σ Ia=          0.00kA  │
│  Σ Ib=          0.00kA  │
└─────────────────────────┘
```

Etc.

Figure 7-15   Statistics Viewed from the Front Display

From PC with DIGSI® 4

Under Annunciation (Figure 7-2), the statistics can be found by double clicking. Double click on Statistic. The sub-menus Statistic and Set Points (Statistic) appear in the data window. By double clicking on one of the two alternatives, the associated contents are displayed in another window. See Figure 7-16.

Figure 7-16 DIGSI® 4 List of Statistic Values

7.1.2.2   Resetting and Setting the Statistics

The statistics are secured against a loss of power supply voltage. The values can, however, be set to zero, or to any desired value within the setting limits.

From the DeviceFront

In the STATISTIC sub-menu, select the value to be set by using the ▼ key, and then press the ENTER key. See Figure 7-17 for an example of changing the operating hours counter. After a password is entered, the cursor blinks and the number value is highlighted in a box. The number can be overwritten using the number keys. If the new value is outside of the allowable range, either above or below, then the maximum or minimum limit value appears at the bottom edge of the display. Confirm the change with the ENTER key.

```
┌──────────────────────────┐
│STATISTIC        04/05    │
│--------------------------│
│#of TRIPs=      16        │
│Op.Hours =     ▶342hour   │
└──────────────────────────┘
```
▼

ENTER

```
┌──────────────────────────┐
│Op.Hours=  ┌342 ─ ─ ─┐    │
│           └─▬─ ─ ─ ─┘    │
│                          │
└──────────────────────────┘
```
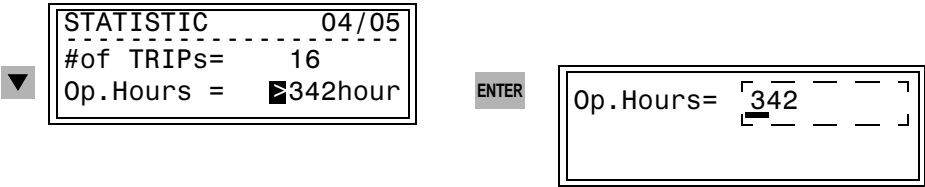
Figure 7-17   Setting Statistics Values from the Device Front

From PC with DIGSI® 4

In the **Statistic** window, mark the value that is to be set. With the *right* mouse button, open a context menu and select *Set*. See figure 7-18. After the password for individual settings is entered, the previous value in the window can be overwritten.
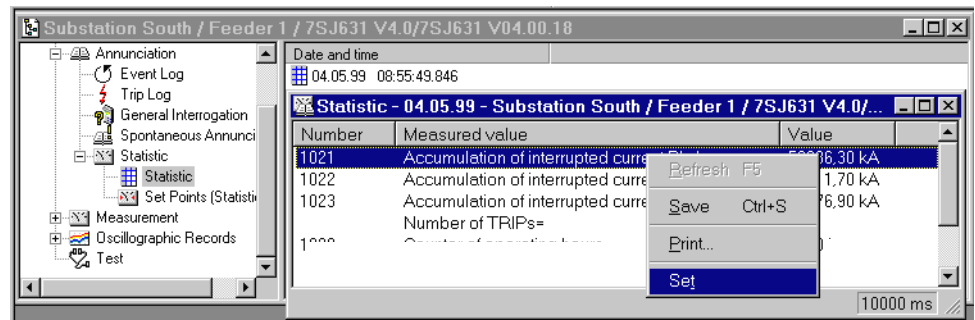
Figure 7-18 Digsi® 4 Setting Statistic Values

7.1.2.3   Setting Limit Values for the Statistics Counters

From the Device Front

In the **ANNUNCIATION** sub-menu, use the ▼ key to select the sub-item **Set/Reset,** and enter this sub-menu. Use the ▼ key to select the item **SetPoint(Stat)** and move with the ▶ key to set the Operating Hours Counter. See Figure 7-19. Then press the ENTER key. After the password for individual settings is entered, the cursor blinks and the counter value is highlighted with a box. The value can be overwritten using the number keys. Confirm the change using the ENTER key.

```
┌──────────────────────────┐
│SETPOINT(STAT)            │
│--------------------------│
│OpHrs.> ▶10000h           │
│                          │
└──────────────────────────┘
```
▼

ENTER

```
┌──────────────────────────┐
│OpHrs > ┌10000h ─ ─┐      │
│        └─▬─ ─ ─ ─ ┘      │
│                          │
└──────────────────────────┘
```
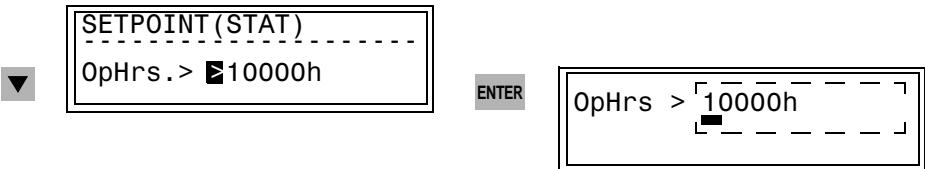
Figure 7-19 Setting the Limit Value, Example on the Front Display

The message **"Are you sure?"** appears in the display, with the response **"Yes"** as the default. Confirm with the ENTER key if a change to the limit value is really desired. If a change to the limit value is not wanted, press the ▶ key so that the response "**No**" is higlighted, and confirm with the ENTER key. Before confirming with the ENTER key, the ◀ and ▶ keys can be used to toggle between "**Yes**" and "**No**."

From PC with DIGSI® 4

Move to the item **Set Points (Statistic)** under **Statistic** in the **Annunciation**. By double clicking, the associated contents are displayed in another window, as shown in Figure 7-20. Overwriting the default value sets a new limit value. Entry of password No. 5 for individual settings is required to do this.
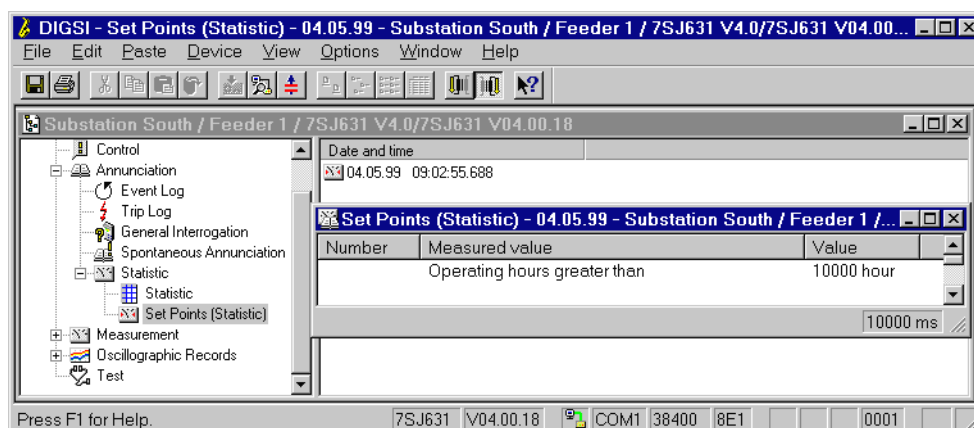
Figure 7-20 Digsi® 4 Setting Statistics Values — Example

7.1.3 Measured and Metered Values

Operating measured values and metered values are determined in the background by the processor system. They can be viewed from the front of the device, read out via the operating interface using a PC with DIGSI® 4, or transferred to a center via the SCADA interface.

No password entry is required to view the measured or metered values. The values are updated every few seconds.

Most measured values can be displayed in primary quantities, secondary quantities, and percentages based on nominal values. A precondition for correct display is that the nominal values be correctly set in the system data (Addresses 0202 to 0208).

The secondary values are either the measured or calculated. Table 7-1 gives an overview about the formulas to convert secondary values to primary/percentage values.

Tabelle 7-1 Convertion formula between secondary values and primary/percentage values

Measured Value	Secondary	Primary	%
I_A, I_B, I_C, I_0, I_1, I_2	$I_{SEC.}$	$\dfrac{\text{CT PRIMARY}}{\text{CT SECONDARY}} \cdot I_{SEC.}$	$\dfrac{I_{prim.}}{\text{I PRIMARY OP.}}$
I_N	$I_{N\ SEC.}$	$\text{CT N} / \text{CT Ph} \cdot \dfrac{\text{CT PRIMARY}}{\text{CT SECONDARY}} \cdot I_{N\ SEC.}$	$\dfrac{I_{N\ prim.}}{\text{I PRIMARY OP.}}$
I_{Ns}	$I_{Ns\ SEC.}$	$\text{CT Ns} / \text{CT Ph} \cdot \dfrac{\text{CT PRIMARY}}{\text{CT SECONDARY}} \cdot I_{Ns\ SEC.}$	$\dfrac{I_{Ns\ prim.}}{\text{I PRIMARY OP.}}$

Settings	Address
CT PRIMARY	204
CT SECONDARY	205
CT N/CT Ph	207
CT Ns/CT Ph	208
I PRIMARY OP.	1102

7.1.3.1 Measured Values

Readout of Measured Values

In a fully configured 7SJ61 device, the following measured values are available:

- Ia, Ib, Ic, In: phase currents and ground current, primary in A and kA, secondary in A and in % of the device nominal current.

- I_{Ns}: ground current, primary in A and kA, secondary in A and in % of the device nominal current, only for devices with the sensitive ground current measurement input.

- I_1, I_2: positive and negative sequence components of the currents, primary in A and kA, secondary in A and in % of the device nominal current.

- Θ/Θ_{TRIP}: thermal value ratio, calculated temperature rise in % of the trip temperature rise or limit temperature rise.

From the Device Front

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Use the ▼ key to select the menu item ***Measurement***, and switch to the list of measured values using the ▶ key. The **MEASUREMENT** selection appears. See figure 7-21.

```
┌──────────────────────────────┐
│MAIN MENU         02/05       │
│------------------------------│
│  Annunciation    ─>  1       │
│ >Measurement     ─>  2       │
└──────────────────────────────┘
```

```
┌──────────────────────────────┐
│MEASUREMENT         01/12     │
│------------------------------│
│>Operation. pri       01      │
│ Operation. sec       02      │
└──────────────────────────────┘
```
Etc.
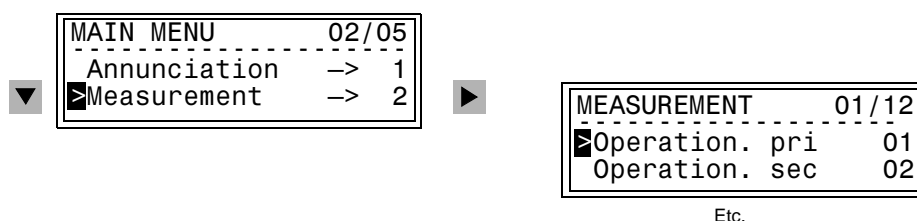
Figure 7-21 Selection of Measured Values in the HMI — Example

The measured values are divided into the following groups:

1. ***Operation. pri***   Operating measured values, primary.
The measured values are converted from secondary to primary according to the settings entered for the current and voltage transformers, and the nominal device values.

2. ***INs primary***   Ground fault value, primary.
The measured value is converted from secondary to primary according to the settings entered for the current transformers, and the nominal device values.

3. ***Operation. sec***   Operating measured values, secondary.
The values of the measurement quantities that are present directly at the terminals of the device are issued.

4. ***INs secondary***   Ground fault measured value, secondary.
The value of the measurement quantities present directly at the device terminals are given.

5. ***Percent***   Operating measured values, in percent of nominal quantities.
The nominal quantities are determined by the version of the device and possibly nominal data settings entered (address 1102 **I PRIMARY OP.**, refer subsection 6.1.3)

6. ***Demand***   Long-term average, in primary quantities.
The measured values are converted from secondary to primary according to the settings entered for the current transformers, and the nominal device values.

7. ***Min/Max Demand***   Minimum and maximum of the averages, with the date and time that they occurred, in primary quantities.
The measured values are converted from secondary to primary according to the settings entered for the current transformers, and the nominal device values.

8. ***I, Min/Max***   Minimum and maximum of the currents, with the date and time that they occurred, in primary quantities.
The measured values are converted from secondary to primary according to the settings entered for the current transformers, and the nominal device values.

9. ***Thermal Meter***   Thermal values from protective functions that calculate them, such as overload protection, provided such functions are present.
The percentages given are relative to the tripping temperature rise for overload protection, and to the maximum allowable rotor temperature rise for restart blocking.

10.***User Defined***   Measured values that are defined by the user during initial setting of the device (see Section 5.2).

11.***Set Points (MV)***   See Sub-section 7.1.3.2.

12.***Reset***   See Sub-section 7.1.3.3.

If a measured value is not available (for example, thermal values, if the device does not have thermal protection, or if this protection is set as "***disabled***"), then instead of the measured value, 3 dots appear. If the value is undefined, then "---" appears (3 horizontal bars). If a measured value overruns, then "★★★" (3 asterisks) is displayed.

Use the ▼ key to select the measured value group that has the values desired, and switch to the display of this group with the ► key. Figure 7-22 shows an example for the display of operating measured values.
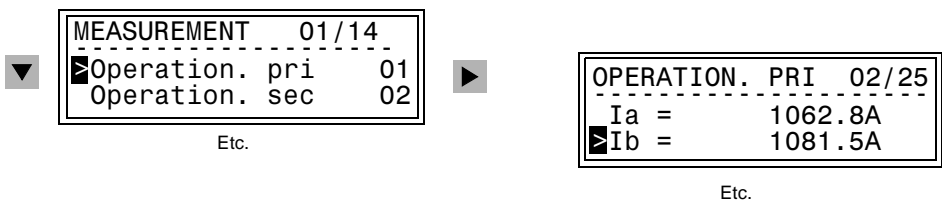
Figure 7-22   Viewing Operating Measured Values on the Front Display

Move up and down in the table of measured value groups using the ▼ and ▲ keys.

Use the ◄ key to return to the **MEASUREMENT** sub-menu. Use the MENU key to return to the **MAIN MENU**.

From PC with DIGSI® 4   The measured value groups are found under Measurement (Figure 7-2) with a double click, as shown in Figure 7-23, left.
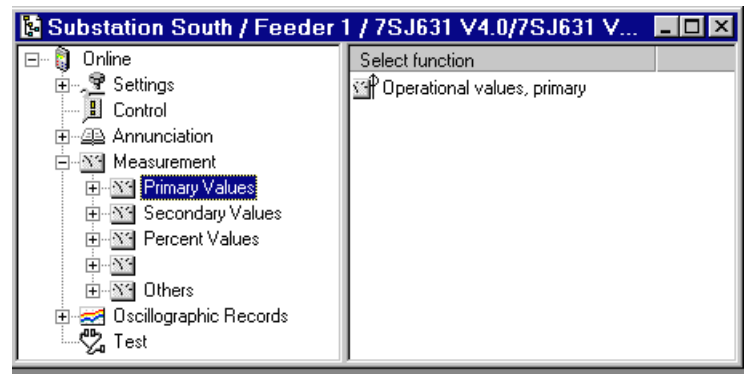
Figure 7-23   Measurement Window in DIGSI® 4

The measured values are divided into the following groups:

1. ***Primary***   Measured values, primary.
The measured values are converted from secondary to primary according to the settings entered for the current transformers and the nominal device quantities.

2. **Secondary**   Measured values, secondary
The operating measured values for the measurement quantities present directly at the device terminals.

3. **Percent**   Measured values, as a percentage of the nominal quantities.
The nominal quantities are determined by the version of the device and possibly the nominal value settings (address 1102 **I PRIMARY OP.**, refer subsection 6.1.3).

4. **Min/Max/Dmd**   Minimum, maximum, and average values, in primary quantities.
These are further subdivided into:
Averages over a defined time period;
Minimum and maximum values for currents, with the date and time of the occurrences;
Minimum and maximum values for the averages, with the date and time of the occurrences;
The measured values are converted from secondary to primary according to the settings entered for the current transformers and the nominal device quantities.

5. **Statistics**   See Sub-section 7.1.2.

6. **Others**   Other measured or calculated values. These are further subdivided into:
Thermal measured values from protective functions that calculate them, such as overload protection, if such functions are present; the percentages are relative to the tripping temperature rise or the maximum allowable temperature rise;
User-defined measured values, which are measured values that are defined by the user during initial setting of the device (see Section 5.2).

7. **Set Points**   See Sub-section 7.1.3.3.

If a measured value is not available (for example, thermal values, if the device does not have thermal protection, or if the protection is set as "**disabled**"), then instead of the measured value, 3 dots appear. If the value is undefined, then "—" appears (a long dash). If the measured value overruns, then "★★★" (3 asterisks) are displayed.

Double click on the desired measure value group; e.g **Primary Values**. The next subgroup is displayed. See Figure 7-24.

Double click on the desired sub-group; e.g. **Operational values, primary**.

By double clicking on an entry in the list on the right side of the window, the associated contents of the measured value group are displayed in another window, as shown in Figure 7-25.
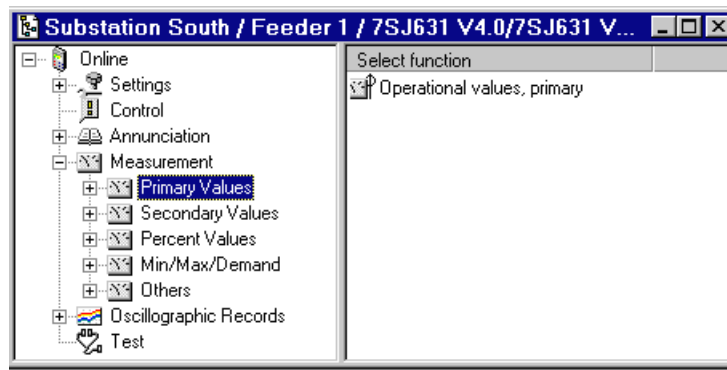
Figure 7-24 Measured Values Window in DIGSI® 4

Figure 7-25 Example of Measured Values shown in DIGSI® 4

7.1.3.2 Setting Limit Values

The limit values for certain important measurement and metered quantities can be set. If one of these limit values is reached or exceeded during operation, then the device generates an alarm that is displayed as an operating message. This message can – like all operating messages – can operate an LED and/or a binary output. The message can be transferred via the interfaces to other equipment as well.

Limits can be set for the following measurement and metered values:

- 37-1: falling below a preset current in any phase.

- I Admd>: exceeding a preset current maximum average in phase a.

- I Bdmd>: exceeding a preset current maximum average in phase b.

- I Cdmd>: exceeding a preset current maximum average in phase c.

- I1dmd>: exceeding a preset positive sequence current maximum average.

Additional limit values can be set using CFC and other measured and metered quantities. See Section 5.3.

From the Device Front

With a device ready for operation, first press the MENU key. The MAIN MENU appears.

Use the ▼ key to select the menu item *Measurement*, and switch to the list of measured values using the ► key. The **MEASUREMENT** selection appears.

There, select the menu item *Set Points (MV)* with the ▼ key, and switch to the list of limit values using the ► key (see Figure 7-26).

```
          MEASUREMENT    13/14
          --------------------
    ▼     >Set Points(MV)    71      ►
           Reset             81
```

```
          SET POINTS (MV) 01/11
          ---------------------
          37-1<      >80.0%
          IA dmd>    120.0%
```
Etc.

```
          PW Settings?
               =-------
```
ENTER

Enter Password No. 5 (individual settings) and confirm with ENTER

```
          IL<          ⌐ 9̲0.0% ⌐
                       L _ _ _ ⌐
```
ENTER

```
          Are You Sure?
          >YES NO Escape
```
ENTER
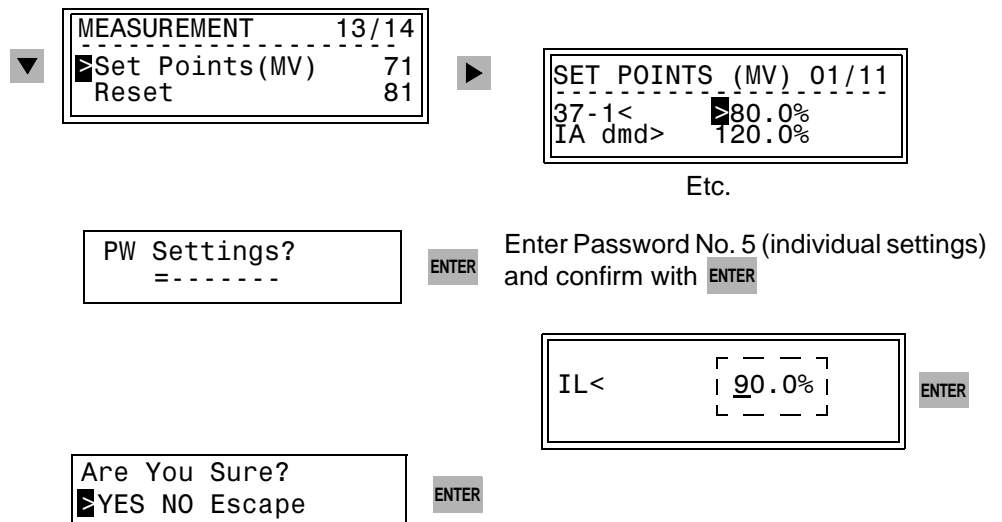
Figure 7-26   Setting Limit Values at the Front Panel — Example

To change a limit value, mark the specific value using the ▼ and ▲ keys, and then press the ENTER key.

A request for Password No. 5 (for settings parameters) is given. After password entry and confirmation with the ENTER key, the previous value appears in a box with a flashing cursor. Overwrite the previous value with the desired new value using the number keys. If the entered value is outside the allowable value range, then the maximum or minimum limit value appears at the bottom of the display.

Press the ENTER key. The new value appears in the list of limit values.

Other limit values can be changed in the same manner.

Upon leaving this level using the ◄ or MENU keys, the safety inquiry "Are you sure?" appears, with the default answer "**Yes**" (Figure 7-26). Confirm with the ENTER key if the value should become effective. If a change to the value is not desired, press the ► key so that the answer "**No**" is marked, and confirm this with the ENTER key. To correct the value, mark "**Escape**", confirm this with the ENTER key, and enter the value again

From PC with DIGSI® 4

The metered value groups are found under Measurement (Figure 7-2) with a double click. Select **Other** and then **Set Points (Measured Values)**.

Note: Set points are only in online–mode available!

By double clicking on an entry in the list view in the right side of the window, the limit values are loaded. Mark the number of the value that is to be changed. With the *right* mouse button, open the context menu and click on **Set,** as shown in Figure 7-27. A password inquiry (password for individual settings) occurs. Next, the dialog field **Set Metered Value** is opened. Enter the desired value in the entry field. Then click on **OK**.

The entered value is transferred to the device and the display within the window in Figure 7-27 is updated.
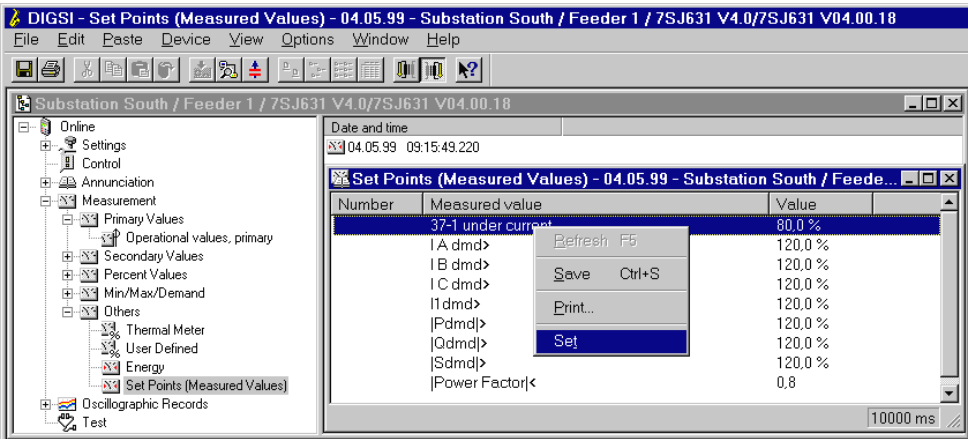
Figure 7-27 Set Limit Values in DIGSI® 4

7.1.3.3   Resetting Metered Values and Min/Max Values

Metered values and minimum/maximum values can be reset.

From the Device Front

With a device ready for operation, first press the MENU key. The MAIN MENU appears.

Use the ▼ key to select the menu item *Measurement*, and switch to the list of measured values using the ▶ key. The **MEASUREMENT** selection appears.

Using the ▼ key, select the menu item *Reset* and switch to the reset possibilities using the ▶ key. See Figure ????-??.
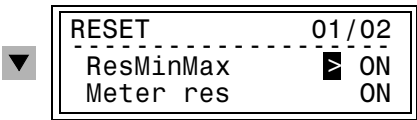
Figure 7-28   Resetting Metered Values and Min/Max Values Using the Front Panel.

Moving up and down in the table is done with the ▼ and ▲ keys.

To reset a values, mark the values using the ▼ and ▲ keys, and then press the ENTER key. The reset command is offered as "ON".

Press the ENTER key. The display confirms with "Change OK Continue".

Confirm once again with the ENTER key. The reset is complete.

Other counters are reset in the same manner.

Use the ◀ key to return to the **MEASUREMENT** sub-menu; press the MENU key to return to the **MAIN MENU**.

From PC with DIGSI® 4

Resetting of limit values, metered values, min/max values, or statistics values always takes place in a group.

To set values to zero, *right* click on the group in the navigation to open a context menu. Click on **Reset**.

Note:

By selecting the **Reset** command, all values are reset to zero without further inquiry. This procedure <u>cannot</u> be undone.

7.1.4   Waveform Capture

Waveform data is stored in the device and can be graphically represented on a PC using DIGSI® 4, together with the program DIGRA® 4. The settings associated with waveform capturing — such as duration and pre- and post-trigger times — are set according to Chapter 6.

7.1.4.1   Retrieving of Waveform Capture

From PC with DIGSI® 4

To view the waveform data on a PC, one of the programs DIGRA® 4 or Comtrade Viewer (included with SIMATIC Manager) is needed. Do the following:

Double click on **Oscillographic Fault Records** (Figure 7-29). The folders listed in the right window show an overview of oscillographic records. The records are identified with a network fault number, a fault record number, and the date and time.

By double clicking on an fault record in the list view in the right side of the window, one of the above programs is opened, and the selected waveform data are loaded. (See also DIGSI® 4, Operating Handbook, order no. E50417–H1176–C097, Sub-section 8.3.3.).
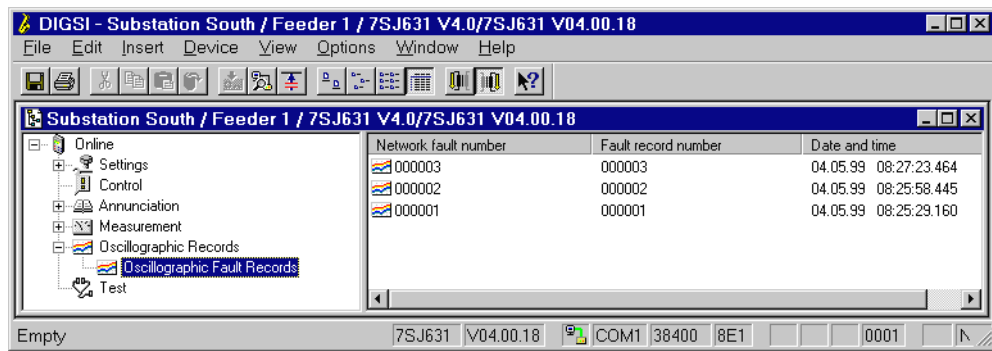
Figure 7-29   Retrieval of Oscillographic Records in DIGSI® 4

DIGRA® 4 provides support in the analysis of faults on the power system. The program graphically prepares the data recorded during a fault, and calculates additional measurement quantities, such as impedances or rms values.

The quantities can be represented in these views:

- Time signals
- Vector diagrams
- Locus diagrams
- Harmonics

Selection takes place using the menu bar (**View**), or in the symbol bar above the represented switching fields. Figure 7-30 shows all four views simultaneously.

The waveform data read into the PC memory are first shown in full on the monitor. Current, and possibly voltage, for each phase and the ground are represented separately. The fault number, data and time, network, and feeder are also displayed.

Representation of primary or secondary quantities can be selected. The base values for currents and voltages are the nominal values of the transformers (CTs or VTs). An identical scale is used for all currents, relative to the largest occurring secondary current value (instantaneous value), and for all voltages, relative to the largest occurring secondary voltage value (instantaneous value).
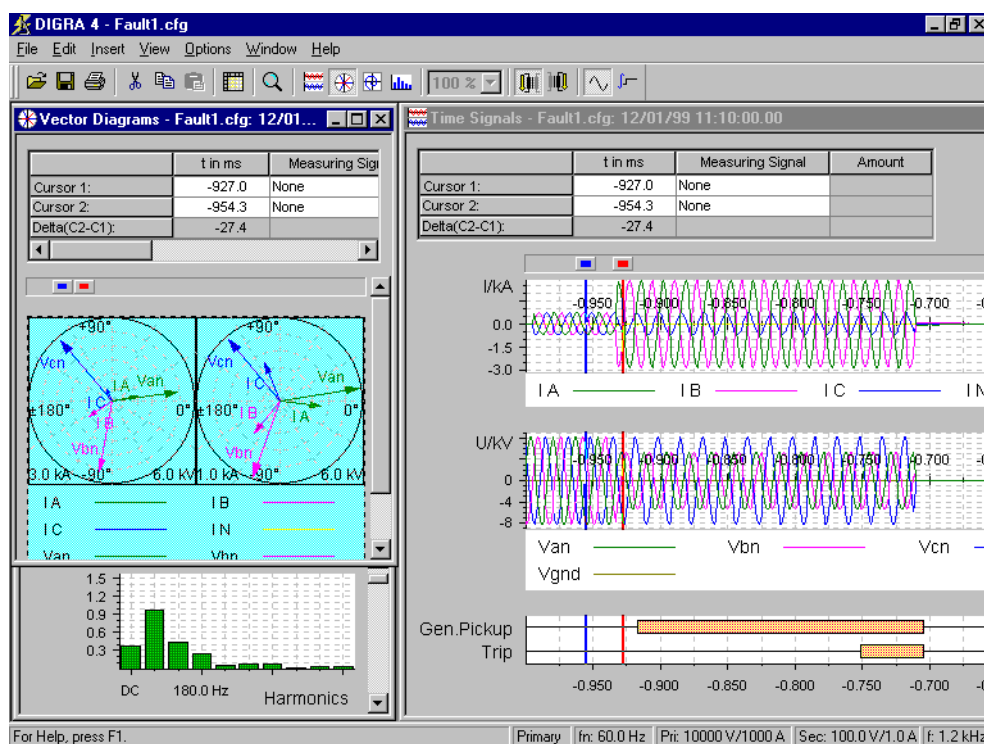
Figure 7-30   DIGRA 4, Diagrams in the Four Possible Views

During configuration any signal can be selected in its properties to be displayed in the oscillographic record. (See chapter 5.2.3).

Further details about the many possibilities that DIGRA $^®$ 4 offers can be found in the DIGRA handbook (Order No. E50417–H1176–C070).

7.1.4.2   Saving of Waveform Capture

Storage of Oscillographic Data

Oscillographic records that are received are not automatically saved in the PC. The data can, however, be saved in files.

For more details, see the DIGSI$^®$ 4 Operating Handbook, Order No. E50417–H1176–C097, Section 9.4.

The oscillographic records saved in the device do not need to be erased, since the data are written in a revolving buffer. The oldest data are automatically overwritten by the newest data.

7.2 Control of Device Functions

The user can change individual functions and messages in a 7SJ61 while the device is in-service. Some examples are given above, including erasing saved information (Sub-section 7.1.1.5) and setting/resetting counters and limits (Sub-sections 7.1.2.2 and 7.1.3.3). In this section, three other control capabilities are discussed. They are correcting the date and time, changing the settings group, and affecting information at the SCADA interface during test operations.

7.2.1 Display and Set Date and Time

The 7SJ61 device can be connected to an external synchronization signal, binary input or use the internal RTC for time and date stamping.

Time Status

Besides the display of date and time, the status of these readings is also provided. The text of the status display can have the appearances given in Table 7-2, under regular conditions of time control.

Table 7-2   Time Status

Status Text	No.	
-- -- -- --	1	synchronized
-- -- -- ST	2	
-- -- ER --	3	not synchronized
-- -- ER ST	4	
-- NS ER --	5	
-- NS -- --	6	

The text symbols, or "status bits", for the time status have the following meanings:

NS	Not synchronized	Time was neither set manually nor synchronized after power-up.
ER	Time Error	At the moment, there is no cyclical synchronization within the tolerance times (time can jump)
ST	Daylight Savings Time	The latest synchronization signal received supplied a daylight savings time bit

Representation of the Time

Various representations of the date and time stamp may be given in the **DATE**/**TIME** sub-menu and in all messages stamped with the date and time. The year number and the values of the status bits "time invalid" and "time malfunction" determine the repre-

sentations. The possible representations and the associated causes are listed in Table 7-3.

Table 7-3   Representations of Date and Time:

Nr.	Display (Example)		Year	Time Malfunc-tion	Time Invalid
	Date	**Time**			
1	★★.★★.★★★★	**15?07:15**	Year = 1990	irrelevant	
2	**04/19/1999**	**15?07:15**		Yes	No
3	**04?19/1999**	**15?07:15**	1990<Year<2090	Yes	Yes
4	**04/09/1998**	**15:07:15**		No	No
5	★★?★★.★★★★	**15?07:15**		No	Yes

? appearing in the date and time field indicate that the clock synchronisation has been lost.

No. 1 appears if the internal clock (RTC) did not have a valid time upon start-up. The messages in the memory buffers are dated 01/01/1990.
Corrective action: Set the date and time manually (see item "Changing the time" below).

No. 2 appears if the time was actually set, but not synchronized. This can happen:
– Briefly upon device power-up,
– If synchronization is lost; that is, if the cyclical synchronization is interrupted for a time longer than the set tolerance time (**Error Time**).
Corrective action: If an external synchronizing source is being used, check the source and the connection.

No. 3 is displayed if the RTC had a valid value upon device start-up, and the time was neither manually set nor synchronized since.
Corrective action: Set the date and time manually, or wait until the cyclical synchronization takes effect.

No. 4 displays the normal condition; that is, the time is synchronized cyclically according to the type of operation.

No. 5 is displayed if synchronization via the SCADA interface is marked as "invalid".

Changing the Time   The time can be changed

– By setting the time manually, using the integrated control panel or DIGSI® 4,

– By adjusting the settings for time control.

The date and time can be manually set during operation, provided the device allows this. A precondition is that the appropriate type of operation for time control must be selected (see Sub-section 5.7).

When the source of time synchronisation is "internal" or "pulse via binary input" the date and time can be manually set during operation at any instant. The annunciations "time malfunction ON" and "time malfunction OFF" appear in the annunciation log to indicate time synchronisation and loss of time synchronisation, respectively.

In the other operating modes, manual adjustments are only accepted if the synchronization is momentarily lost. The messages "time malfunction ON" and "time malfunction OFF" are given when manually changing the year in the IRIG B mode.

Without healthy or external time synchronisation the free running date and time can also be relatively adjusted (+/– 23:59:59) using the entry field "Diff.–time".

This input possibility is not to be confused with the parameter **Offset** (see Section 5.7), which affects the specific general offset to the received synchronization time of the radio clock receiver (e.g. local time vs. GMT time).

From the Device Front

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Select *Settings*, and in the sub-menu **SETUP/EXTRAS**. To set the date and time manually, choose the selection *Date/Time* and move to the **Date/Time** display using the ▶ key. See Figure 7-31.

```
                    SETUP/EXTRAS   01/06
                    -------------------
              ▼     ▶Date/Time    –>  1          ▶     DATE/TIME
                     Clock Setup  –>  2                Status:       -- -- --
                                                      ▶06/24/1999 21:07:32
                                                       Diff.–time: --------
```
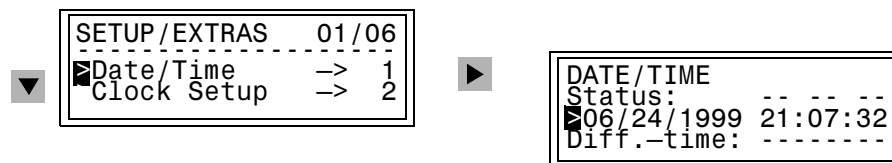
Figure 7-31   Manual Date and Time Adjustment from the Operator Control Panel

To change one of the previous settings (date, time, differential time), mark the item using the ▼ and ▲ keys, and then press the ENTER key.

The previous setting appears in a frame with a blinking cursor. Overwrite the previous setting with the desired new one using the number keys. Be careful to enter the format properly.

Confirm the change with the ENTER key.

To change the time offset or the tolerance time for a malfunction of the clock signal, select *Clock Setup* under **SETUP/EXTRAS**, as shown in Figure 7-32. Under *Offset*, the time offset can be changed. Under *Error Time*, the time delay for the alarm can be adjusted. These adjustments are done in the same manner as setting the time, by overwriting the displayed values and confirming with the ENTER key.

To return to the **SETUP/EXTRAS** level, press the ◀ key, several times if necessary. To return to the **MAIN MENU**, press the MENU key.

```
                    SETUP/EXTRAS   02/06
                    -------------------
              ▼      Date/Time    –>  1          ▶     CLOCK SETUP    01/03
                    ▶Clock Setup  –>  2                -------------------
                                                        Offset        ▶0min
                                                        Error Time     2min

                                                        Source      Internal
```
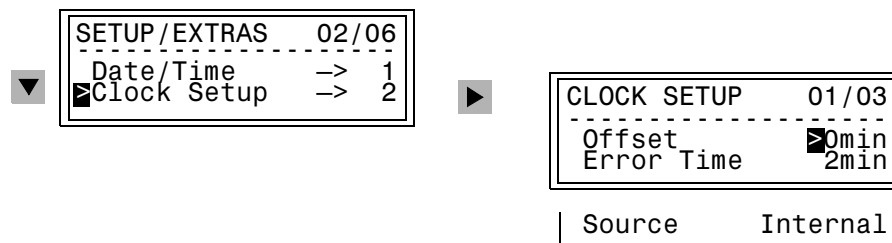
Figure 7-32   Date and Time Control Settings from the Operator Control Panel

From PC with DIGSI® 4

To manually enter the date and time into the device:

Click on **Device** in the menu bar as shown in Figure 7-33. Select the command **Set Clock**.
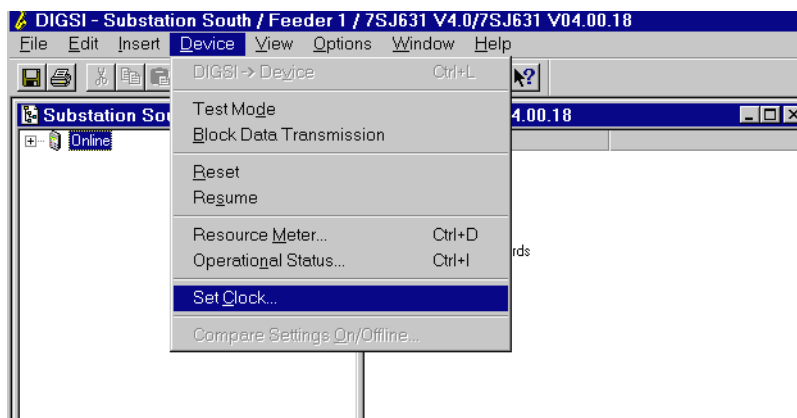
Figure 7-33   Selecting The Command **Set Clock** in DIGSI® 4

A dialog field, **Set clock & date in device**, is opened. The displayed values are the present date and time. The day of the week is automatically derived from the date — and cannot be edited.

- Edit the input fields **Date** and **Time**. The format depends on your regional settings of the PC. See Figure 7-34.

  Date: mm/dd/yyyy or dd.mm.yyyy
  Time: hh.mm.ss

Click on **OK** to transfer the entered values into the device. The previous values are changed and the dialog field is closed.
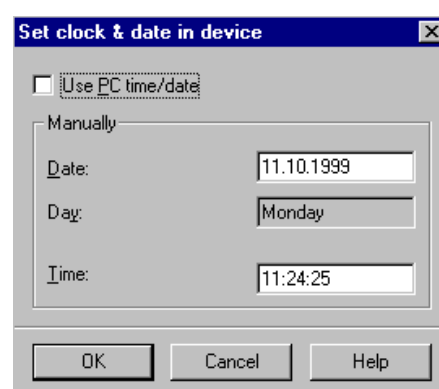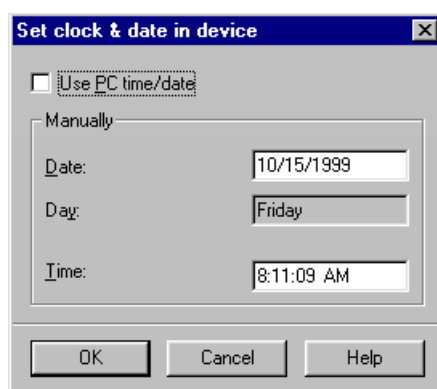
Figure 7-34 Dialog Field: **Set clock & date in device**

To change the time offset or tolerance time for clock signal error, double click on **Settings** in the navigation window. See Figure 7-35.
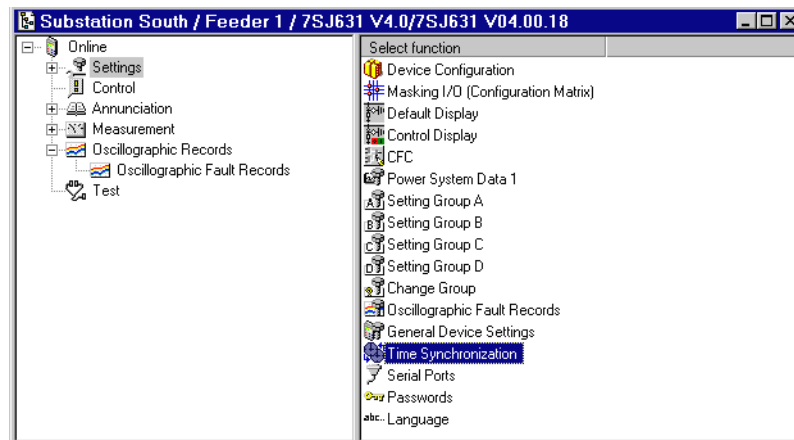
Figure 7-35   Setting Window in DIGSI® 4

Double click on **Time Synchronization** in the data window. This give access to change:

− Source of time synchronisation

− Time delay alarm

− Time format

− Time correction.
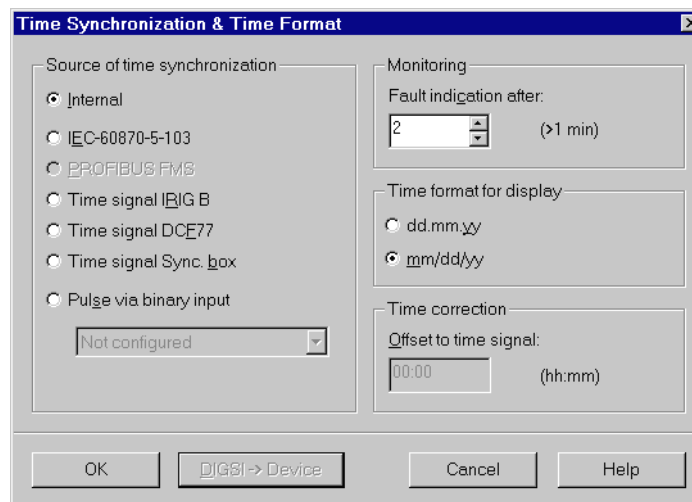
Figure 7-36   Window for Time Synchronization and Time Format Settings in DIGSI® 4

7.2.2   Changeover of Setting Groups

Four different setting groups for the protective functions are available. The active group can be changed onsite while the 7SJ61 is in-service by using the HMI on the device or the operating interface on a PC running DIGSI® 4. The active setting group

can also be remotely controlled via binary inputs or the SCADA interface. User-defined logic capabilities offer even more possibilities.

Password No. 5 (password for individual settings) is required to change setting groups.

The first setting group is called group A. The others are groups B, C, and D. If setting group changing is to be used, then settings for the groups to be employed must be entered (see Section 6) and the changeover facility must be *Enabled* under Address 0103 `Grp Chge OPTION`.

From the Device Front

When a device is ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Settings* and switch to the settings with the ▶ key. The selection **SETTINGS** appears.

Using the ▼ key, select the item *Change Group* and move to the selection of groups with the ▶ key. The sub-menu **CHANGE GROUP** appears, as shown in Figure 7-37.

The first Address 0301 is marked. The address displays the setting group presently in effect (in Figure 7-37, the active group is *Group A*).

Using the ▼ key, select Address 0302 and confirm with the ENTER key.

Enter the password for individual settings (password No. 5), and confirm.

Using the ▼ key, one of the four groups A, B, C, or D can be selected, or control can be given to another source.

If *Binary Input* (activation using binary inputs) is selected, setting group changeover is controlled by binary inputs, provided appropriate masking has been done and the necessary physical connections are present (see Sub-section 5.2).

If *via Protocol* is chosen, setting group changes can be controlled via the system serial interface.

```
CHANGE GROUP   01/02
--------------------
0301 ACTIVE GROUP
       Group A
```

The currently-active setting group is displayed under Address 0301.

```
0302 CHANGE to
    ▶Group A
```

```
▶Group A
 Group B              ↓
 Group C
 Group D
 via Binary Input
 IEC 60870-5-103¹)
```

¹)via Protocol

```
Are you sure?
Yes        No
```

The setting group can be changed under Address 0302: by pressing the ENTER key, after entering the password, two possible alternatives are displayed in a new window each time:

Using the ▼ ▲ keys, select one of the alternatives and confirm with the ENTER key;

The next question (**"Are you sure?"**) is answered with **Yes** and the selected alternative is confirmed, or is answered with **No** using the ▶ key and the change is canceled with the ENTER key.

Figure 7-37   Changeover Setting Groups from the Operator Control Panel

Control of the setting groups can always be regained by changeover to one of the Groups A through D.

The ◄ key can be used to return to the **SETTINGS** sub-menu; the <mark>MENU</mark> key can be pressed to returns to the **MAIN MENU**.

From PC with DIGSI® 4

By opening the **Online** directory with a double click in DIGSI® 4, the operating functions for the device appear in the left part of the window. See Figure 7-38.
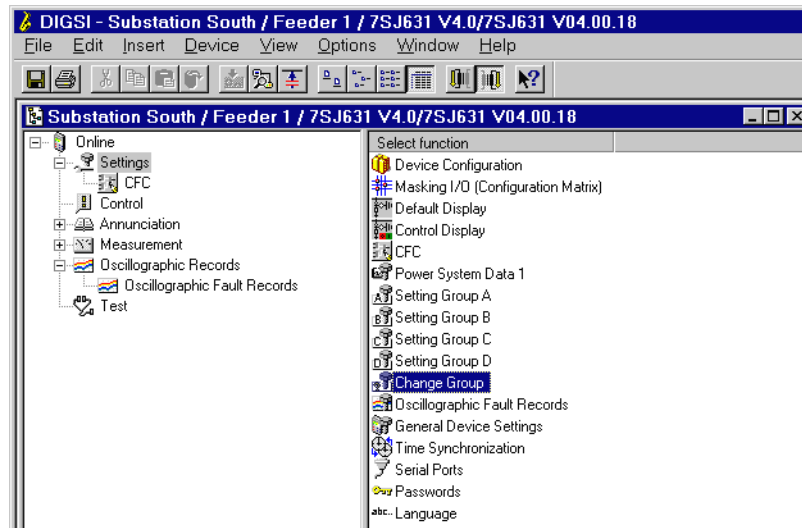
Figure 7-38   Function Selection Window in DIGSI® 4

Double click on **Settings** to find **Change Group** in the data window (Figure 7-38 right).

Double click on **Change Group**. The **Change Group** window is opened, as shown in Figure 7-39.
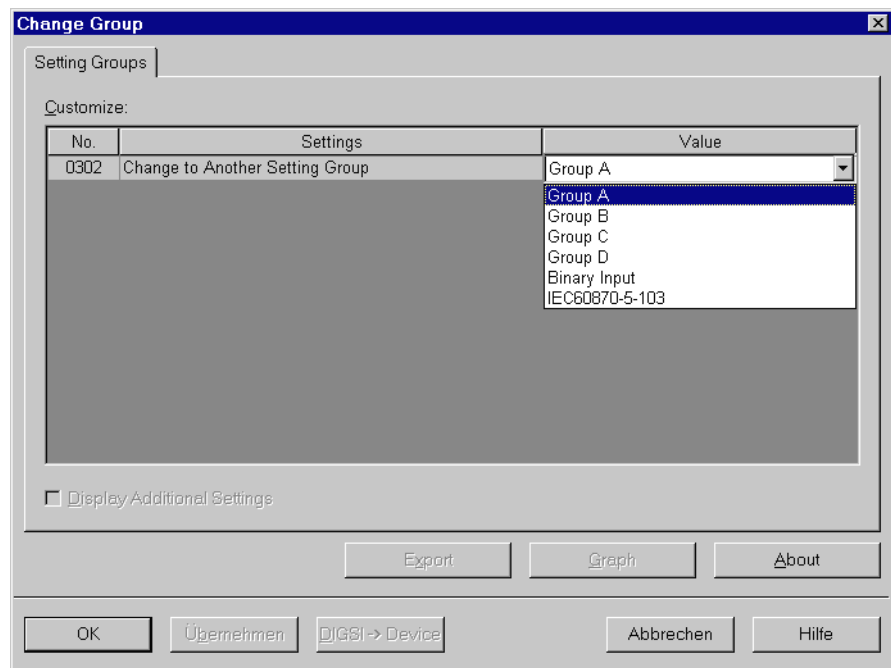
Figure 7-39   Setting Group Changeover Window in DIGSI® 4

The active setting group is displayed. To switch to another setting group, click on the field **Value** and select the desired option from the drop-down list. Before closing the window, transfer the change to the device. This is done by clicking on the button **Digsi → Device**. A request for Password No. 5 (password for single settings) is given. Enter the correct password, and then click on **OK**.

7.2.3   Test Messages to the SCADA Interface during Test Operation

Depending on the type of protocol, all messages and measured values transferred to the central control system can be identified with an added message "test operation"-bit while the device is being tested onsite (test mode). This identification prevents the messages from being incorrectly interpreted as resulting from an actual power system disturbance or event. As another option, all messages and measured values normally transferred via the SCADA interface can be blocked during the testing (block data transmission).

A password for test and diagnostics is required to block the messages and measured values.

Data transmission block can be accomplished by controlling binary inputs, by using the operating panel on the device, or via DIGSI® 4.

If binary inputs are used, then the appropriate inputs must be configured.

From the Device Front

With a device ready for operation, first press the <mark>MENU</mark> key. The **MAIN MENU** appears.

Using the ▼ key, highlight the menu item *Test/Diagnose*, and then press the ▶ key to enter sub-menu. **TEST/DIAGNOSE** will appear at the top of the menu.

At this point, highlight the menu item *Test Enable* using the ▼ key, and then press the ▶ key to enter sub-menu. **TEST ENABLE** will appear at the top of the menu. See Figure 7-40.

```
          TEST DIAGNOSE  02/06
          --------------------
          Device Reset  ->  1
    ▼    ▶Test Enable   ->  2        ▶        TEST ENABLE
          Blk Data Trans->  3                 -----------------
          Hardware Test ->  4                ▶Test mode     OFF
          Set/Reset     -> 11
          SIEMENS Intern   12
```
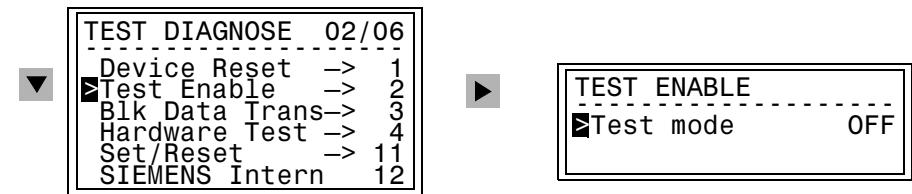
Figure 7-40   Applying Test Mode from the Operator Control Panel

To start Test mode, press the ENTER key, enter the password for test and diagnostics, and confirm with the ENTER key. A new window appears with the options *ON* and *OFF*. Use the ▼ and ▲ keys to select the desired mode, and press the ENTER key. The question "**Are you sure?**" is displayed. Highlight the desired response and press the ENTER key. If the mode is changed, the device responds with the message "Control Executed".

Use the ◀ key to return to the **TEST/DIAGNOSE** level; press the <mark>MENU</mark> key to return to the **MAIN MENU**.

The procedure for changing the Block Data Transmission mode is the same. See Figure 7-41 (simplified).

```
          TEST/DIAGNOSE  03/06
          --------------------
    ▼    ▶Blk Data Trans->  3        ▶        BLK DATA TRANS
          Hardware Test ->  4                 -----------------
                                             ▶DataStop       OFF
```
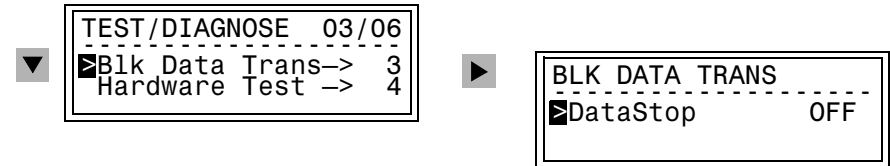
Figure 7-41   Applying a Block of Data Transmission from the Front Panel (simplified)

The settings for the test mode and the data transmission block are normally **OFF**. Definitions:

– **Test mode** – With the *ON* setting, the "test mode"-bit is transferred for messages compatible with IEC 60 870–5–103.

– **DataStop** – With the *ON* setting, no messages or measured values are transferred ("transfer block").

From PC with DIGSI® 4

Click on **Device** in the menu bar to reach the commands **Block Data Transmission** and **Test Mode**. See Figure 7-42.
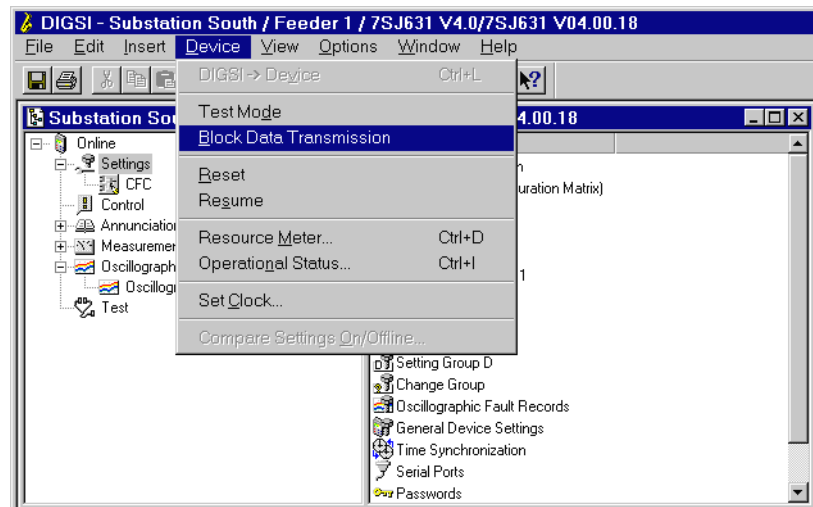
Figure 7-42   Example: Transfer Block Activated in DIGSI® 4

Click on **Block Data Transmission** to activate or deactivate the transfer block. After entry of Password No. 4 for test and diagnostics, and confirmation with **OK**, the setting change is complete.

Activation is indicated with a check mark in front of the command.

Follow the same procedure for the command **Test Mode**, if this option is desired.

Note:

Remember to change the settings for **Block Data Transmission** and **Test Mode** back to the desired, in-service settings (both typically *OFF*) when the tests are complete.

7.3   Control of Switchgear

A SIPROTEC® 4 device 7SJ61 contains control functions that allow for opening and closing of power system switching devices (i.e. circuit breakers). Local control is possible utilizing different elements of the 7SJ61. Breaker control from a remote location is also possible using the SCADA interface or DIGSI® 4. (Performing control functions with a PC running DIGSI® 4, connected to the front serial port, is considered a "remote" operation for breaker control purposes.) Some control actions from a 7SJ61 include unsynchronized commands for circuit breakers, circuit switchers, ground switches, etc., and stepping commands for increasing or decreasing transformer LTC steps.

Safety mechanisms in the command path ensure a command can only take place if the check of previously defined safety criteria is concluded positively.

If a power system switching device has auxiliary contacts that indicate the position of the device and these contacts are connected to the 7SJ61 and configured as double-point indications then the switching device provides feedback indication that are monitored for plausibility of control actions. If a switching device does not indicate either the closed or open position, the display for the switching device indicates an unvalid position in the 7SJ61. All subsequent control operations to the equipment are interlocked.

Control from a 7SJ61 to a power system equipment can originate from four sources:

− Local operation using the operator control panel,

− Binary inputs,

− Remote operation using the SCADA interface,

− Operation with a PC, via the operating interface and DIGSI® 4.

Switching priority for the four command sources is set using the Switching Authority.

For Interlocked Switching, all programmed interlocking conditions are checked before a control operation is performed. If one of the conditions is not met, then the command is rejected and an error message is recorded and displayed. Fixed, predefined, standard interlocking features are implemented in the 7SJ61 and can be configured (activated) for the specific application. The following tests can be activated (on) or deactivated (off) for a switching device:

• Device Position (check SCHEDULED = ACTUAL comparison).

• Substation controller, to be implemented with Version 4.2,

• Zone controlled (Field interlocking e.g., logic in CFC),

• Blocking by protection (control operations blocked by protective functions),

• Double operation (blocking of multiple control operations),

• Switching authority (Local/Remote),

7.3.1 Display Equipment Position and Control

**From the
DeviceFront**

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control*, and go to editing the control functions with the ▶ key. The selection **CONTROL** appears (See Figure 7-43).

```
┌─────────────────────┐
│ MAIN MENU     03/05 │
│ ------------------- │
│  Messurement   -> 2 │
│ ▶Control       -> 3 │
└─────────────────────┘
```

▼   ▶

```
┌─────────────────────┐
│ CONTROL       01/03 │
│ ------------------- │
│ ▶Breaker/Switch -> 1│
│  Tagging       -> 2 │
└─────────────────────┘
```

Figure 7-43   Control Selections from the Front Panel

Select, by means of the ▼ key, the item *Breaker/Switch*, and continue with the item by pressing the ▶ key. The selection **BREAKER/SWITCH** appears. See Figure 7-44.

Select *Display* (default) and press the ▶ key. The selection **DISPLAY** appears, in which the positions of all planned switching devices can be read out.

```
┌─────────────────────┐
│ BREAKER/SWITCH 01/04│
│ ------------------- │
│ ▶Display       -> 1 │
│  Control       -> 2 │
└─────────────────────┘
```

▼   ▶

```
┌─────────────────────┐
│ DISPLAY       01/03 │
│ ------------------- │
│ ▶52Breaker     OPEN │
│  Disc.Swit.    CLOS │
└─────────────────────┘
```
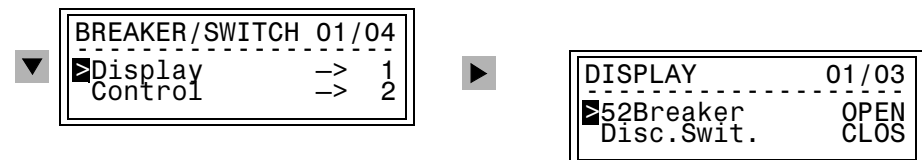
Figure 7-44   Display of Switch Positions in the HMI (example)

The ◀ key can be used to return to **BREAKER/SWITCH**.

To control a switching device, select the option *Control* in the **BREAKER/SWITCH** sub-menu and press the ▶ key to go to the table of operating resources that can be controlled. See Figure 7-45. All planned switching devices appear. The actual position of each switch is displayed first. Use the ▲ and ▼ keys to move to the desired switch.

```
┌─────────────────────┐
│ BREAKER/SWITCH 02/04│
│ ------------------- │
│  Display       -> 1 │
│ ▶Control       -> 2 │
└─────────────────────┘
```

▼   ▶

```
┌─────────────────────┐
│ CONTROL       01/03 │
│ ------------------- │
│  52Breaker    ▶CLOS │
│  Disc.Swit.    CLOS │
│  GndSwit.      OFF  │
└─────────────────────┘
```
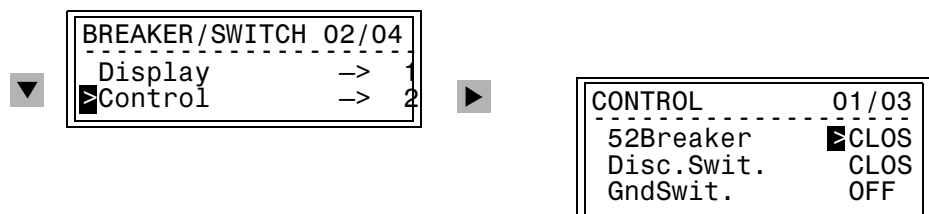
Figure 7-45   Control of Switching Devices from the Operator Control Panel

Select the switch to be controlled using the ▲ and ▼ keys and press the ENTER key.

Enter Password No. 1 (for interlocked switching) and acknowledge with the ENTER key. Note: if the switching mode is **NON−INTERLOCKED (Test)** (Sub-section 7.3.7), all switching operations are only possible with Password No. 2 (for non-interlocked switching).

A new window appears. Depending on the operating and command type of the selected switching device, various options are offered. Move between them using the ▼ and ▲ keys.

```
CONTR ┌ ─ ─ ─ ─ ─ ─ ─ ─ ┐ 1/03
 ─ ─ ─ │ ▶OPEN          │ ─ ─ ─
PS     │  CLOSE    ↓     │    ON
Tre    │  Escape        │    ON
       └ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

Figure 7-46   Selection Window for Control Operations on the Front Panel (example)

To perform control, confirm with the ENTER key. A safety inquiry appears, "**Are you sure?**". If the response is "**YES**", the switching operation is initiated (provided the Local command is allowed). A message is displayed and recorded indicating the results of the control action. Acknowledge this by pressing the ENTER key once again.

The command is not executed if the switching operation is restricted. The operation may be restricted for reasons pertaining to, for example, switching authority (see Sub-section 7.3.6) or interlocking (see Sub-section 7.3.7). A message is displayed and recorded indicating the results of the control action. Acknowledge the message by pressing the ENTER key. Parameters to set control properties can be examined in the display. Refer to Sub-section 7.3.4.

The ◀ key can be used to return to **BREAKER/SWITCH**. Press the MENU key to return to the **MAIN MENU**.

From PC with DIGSI® 4   When the **Online** window in DIGSI® 4 is opened with a double click, the operating functions for the device appear in the left part of the window (Figure 7-38). Clicking on **Control** displays the associated function selection in the data window. See Figure 7-47.
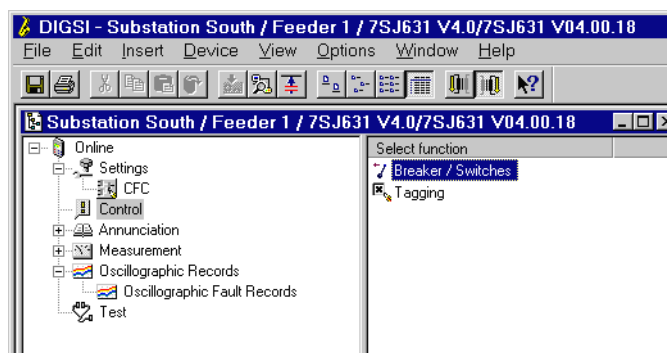
Figure 7-47   Window for Control of Operating Resources in DIGSI® 4

By double clicking on **Breaker/Switches**, a dialog field is opened in which the present status of each switch is visible. See Figure 7-48. Control can be performed from this dialog box provided the switching authority is set to **REMOTE**.

The switching authority is first transferred to DIGSI® 4 at the moment the control window shown in Figure 7-48 is opened. The configuration matrix discussed in Section 5.2 determines the control devices that have information displayed in this field.

Figure 7-48   Dialog Box for Performing Control in DIGSI® 4

A description of the switching device is displayed in the left column of the dialog field. This represents the contents of the **Long Text** column within the configuration matrix.

The actual position of the switch is displayed in the **Status** column (*OPEN*, *CLOSE*, *Intermediat*). The switching possibilities are displayed in the **Scheduled** column.

Four control fields are shown in the right part of the dialog field. If a check mark is displayed in one of these fields, **AB** (Access Block = Block Input Acquisition), **TB** (Transmission Block = Serial Interface Blocked), **TR** (Manual Overwriting), and **CB** (Chatter Block), the associated block function is set or the feedback indications of the device have been simulated.

Normally, operating devices are switched in the ***interlocked (Normal)*** mode. The configured interlocking conditions are checked before a control command is carried out. As soon as a control command is entered in the **Scheduled** column, Password No. 1 for interlocked switching is requested for safety reasons. Further control possibilities remain possible until the control dialog field is closed, or the switching mode is changed.

If a control command is successfully executed, then the display of the actual condition of the affected switch is updated in the window.

Operating resources can be switched without interlocking condition checks; however, the correct Password No. 2 for non-interlocked switching must be entered. Mark the option *Unlock* by clicking on the field.

DANGER!

Only highly qualified personnel who have an exact knowledge of the power system conditions shall perform non-interlocked switching. Inappropriate switching operations can lead to death, serious personnel injury and property damage.

7.3.2   Manual Overwriting

When using the **Control with Feedback** feature, the device checks the feedback indications (i.e. 52-a and 52-b) before and after a control command is issued. If for some reason, the physical connection from a circuit breaker auxiliary contact to the binary inputs of the device is broken, inadvertently shorted, or disconnected, commands may be blocked. If this situation occurs, and the affected switching device is to be operated, the desired device position indication can be simulated through "manual overwriting" (Input Tagging). The entered device position indication in the 7SJ61 can be used to simulate and check interlocking conditions.

To accomplish manual overwriting in the 7SJ61 the binary inputs of the affected device must be decoupled first. **AB** (Access Block = Block Input Acquisition) This decoupling of the system is accomplished by setting the respective status. The decoupling is discussed in Sub-section 7.3.3.

From the Device Front

To enter the desired position indication for a switching device:

With a 7SJ61 ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control* and go to the control functions with the ▶ key. The selection **CONTROL** appears.

By pressing the ▶ key, the **BREAKER/SWITCH** sub-menu is entered (see Figure 7-49).

Select the item *Man. Overwrite* using the ▼ key, and move to the next selection using the ▶ key. **MAN. OVERWRITE** appears, as shown in Figure 7-49.

The actual position of each switching device is displayed. Move to the desired switch using the ▼ and ▲ keys.

```
        ┌─────────────────────┐
        │BREAKER/SWITCH 03/04 │
        │---------------------│
  ▼     │ Display      —> 1   │                ┌─────────────────────┐
        │ Control      —> 2   │                │ MAN. OVERWRITE 01/03 │
        │▶Man. Overwrite —> 3 │      ▶         │---------------------│
        │ Set status   —> 4   │                │ 52Breaker    ▶OPEN  │
        └─────────────────────┘                │ Disc.Swit.    CLOS  │
                                               │ GndSwit.      OPEN  │
                                               └─────────────────────┘
```
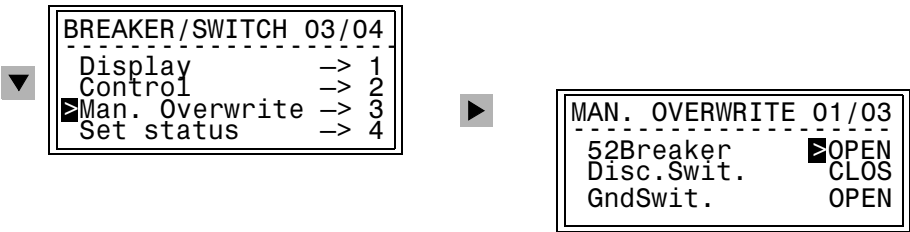
Figure 7-49   Manual Overwriting for Switching Devices from the Front Panel

By pressing the ENTER key, a selection window is opened for the marked switch, in which manual overwriting can be done with the options *OPEN*/*CLOSE*. See Figure 7-50.

Make the selection using the ▲ and ▼ keys, and confirm with the ENTER key.

Enter Password No. 2 (for non-interlocked switching) and acknowledge with the ENTER key.
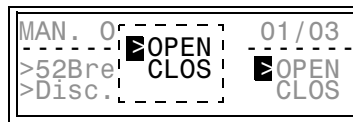
Figure 7-50   Selection Window for Manual Overwriting of a Switch Position, Front Panel

A safety inquiry appears: "**Are you sure?**" Provided manual overwriting is allowed, a response of "**YES**" results in an appropriate message on the display. Acknowledge the message by pressing the `ENTER` key again.

Manual overwriting is cancelled if the process is restricted because, for example, "**input ignored**" is not set (see Sub-section 7.3.3). Manual overwriting is also canceled if the user aborts the procedure. The display provides an appropriate message if manual overwriting is canceled. Acknowledge the message by pressing the `ENTER` key.

Return to the **BREAKER/SWITCH** sub-menu using the ◀ key, or the **MAIN MENU** by pressing the `MENU` key.

From PC with DIGSI® 4
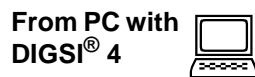
For safety reasons, manual overwriting is only possible locally using the keypad on the front panel of the device. The feature is not available in DIGSI® 4.

7.3.3 Set Status

A feature of the 7SJ61 that is especially useful during testing and commissioning of the device is the capability of temporarily removing the coupling between a switching device and the 7SJ61, or between the SCADA and the 7SJ61, without physically disconnecting the equipment. This type of separation is also necessary, for instance, if a switch position feedback message is not functioning properly (refer to Sub-section 7.3.2). The menu item **SET STATUS** is used to perform the decoupling.

The menu displays a list of all planned switching devices and associated status information identified by a letter. The letters have the following meanings:

- **T** Device is tagged (manually overwritten).

- **I** Input ignored, which means the acquisition of an input status is de-coupled from the process (from the switch-gear).

- **B** Blocked, which means data transmissions to the central device (or SCADASCA-DA) are blocked.

- **C** Chatter block active, which means, because of frequent message changes, the chatter block was set.

- **O** Output block active, which means the command output is de-coupled from the process (from the system).

- **–** None of the listed limitations is in effect.

	Note:
ℹ️	Input ignored only works for physical inputs! Do not set the block for indications created by CFC.

From the Device Front

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control* and go to editing the control functions with the ▶ key. The selection **CONTROL** appears.

Enter the **BREAKER/SWITCH** menu by pressing the ▶ key.

Select the item *Set Status* with the ▼ key and switch to the next option using the ▶ key. **SET STATUS** appears, as shown in Figure 7-51.

```
    BREAKER/SWITCH 04/04
    --------------------
 ▼  Display        -> 1
    Control        -> 2
    Man. Overwrite -> 3
   ▶Set status     -> 4
```

```
 ▶  SET STATUS  02/03
    --------------------
     52Breaker T I - - O
     Disc.Swit.->- - - -
     GndSwit.   - - - - -
```

1. 2. 3. 4. 5. Column
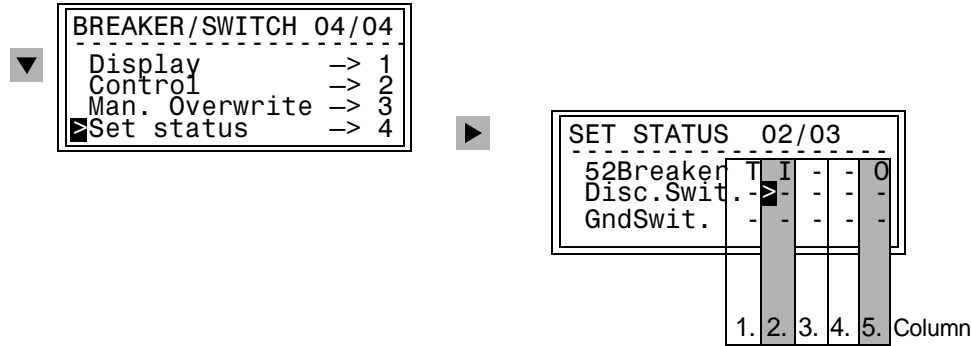
Figure 7-51   Set Status at the Front Panel

Move the cursor, using the ▶ and ◀ keys, to each of the second (Input Ignore) and fifth (Control Block) columns of the switching device for which a status change is desired. Entries in this table can only be made in these two columns.

Press the ENTER key. A selection window is opened that displays the meaning of the field and the change options that are available.

The second column is reserved for setting Input Ignore (I); the fifth for setting the output block (O). The first, third, and fourth columns can only be read in this menu.

The example in Figure 7-51 shows the position for the circuit breaker (52) was tagged (**T**) after the input ignore (**I**) was set, which means the message input was de-coupled from the system. The output block is active (**O**), so the command output is also de-coupled from the system. For the disconnect switch and the ground switch, no limitations are set.

Select the desired changes using the ▼ and ▲ keys, and confirm with the ENTER key.

Enter Password No. 2 (for non-interlocked switching) and acknowledge with the ENTER key.

A safety inquiry appears: "Are you sure?" If the response is "**YES**", and provided the return routing is allowed, then the display gives an appropriate message.

To return to the **BREAKER/SWITCH** level, press the ◀ key as necessary. Press the MENU key to return to the **MAIN MENU**.

From PC Using DIGSI® 4 🖥️ For safety reasons, Status changes are only possible locally using the keypad on the front panel of the device. Status changes are not possible in DIGSI® 4.

7.3.4 Interlocking

Operating equipment such as circuit breakers, circuit switchers and ground switches can be subject to interlocking conditions. These conditions can be viewed at the device under the menu item **INTERLOCK**; however, the conditions cannot be changed.

The Interlock display has an object table similar to the one described for Set Status. The table provides the set interlocking conditions, which prevent, or could prevent, a local control operation. Letters identify the interlocking conditions. The meanings of the letters are:

- **L** Local/Remote (Switching Authority),

- **S** Equipment is subject to System Interlocking (in Substation Controller). Commands entered locally are sent to the central computer or controller,

- **Z** Zone controlled (Field- or Bay-Interlocking),

- **P** Check switch position (test actual vs. scheduled),

- **B** Blocking by picked-up protection elements,

- **–** Non-Interlocked.

From PC with DIGSI® 4 🖥️ With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control* and move to editing the control functions with the ▶ key. The selection **CONTROL** appears.

Select the item *Interlock* with the ▼ key and switch to the next selection using the ▶ key. The selection **INTERLOCK** appears. See Figure 7-52.

Figure 7-52   Example of Interlocking Conditions for Switching Equipment, Front Panel

From PC with DIGSI® 4 🖥️ Interlocking is set for each switching device during project planning (see Sub-section 5.2.4) using the matrix and the dialog box "Object Properties". Readout of the actively set interlocking is always possible, across the entire path, without a password.

If the **Online** window in DIGSI® 4 is opened with a double click, the operating functions for the device appear in the left part of the window (Figure 7-38). Double clicking on **Settings** brings up the function selection in the right side of the window. By dou-

ble clicking on **Masking I/O**, the matrix is opened. Mark the switching device (in the line for the operating message of the switching device). Using the *right* mouse key, the properties of the switching device can now be called up. The conditions for **Interlock Switching**, among other items, are recognizable in the dialog box that opens. Active test conditions are identified with a check mark.

7.3.5   Tagging

To identify unusual operating conditions in the power system, tagging can be done. The tagging can, for example, be entered as additional operating conditions in interlocking checks, which are set up with CFC. Tagging is configured in the same way as for operating devices.

From PC with DIGSI® 4

With a device ready for operation, first press the <mark>MENU</mark> key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control* and move to editing the control functions with the ▶ key. The selection **CONTROL** appears.
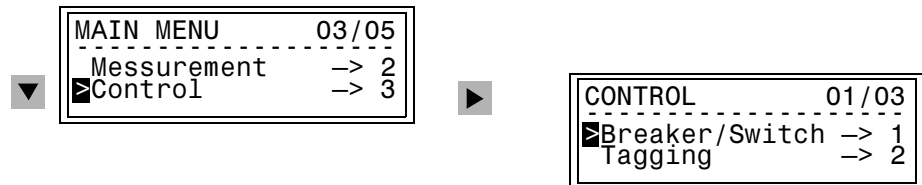
Select the item *Tagging* with the ▼ key and switch to the next selection using the ▶ key. The selection **TAGGING** appears. See Figure 7-53.

- The status of the tagging is displayed **Tagging → Display**,

or changed using

- **Tagging → Set**.

```
MAIN MENU       03/05
--------------------
Annunciation   ->   1
Measurement    ->   2
Control        ->   3
```
▶
```
CONTROL         02/03
--------------------
Breaker/Switch ->   1
Tagging        ->   2
Interlock      ->   3
```
▶
```
TAGGING         01/02
--------------------
Display        ->   1
Set            ->   2
```
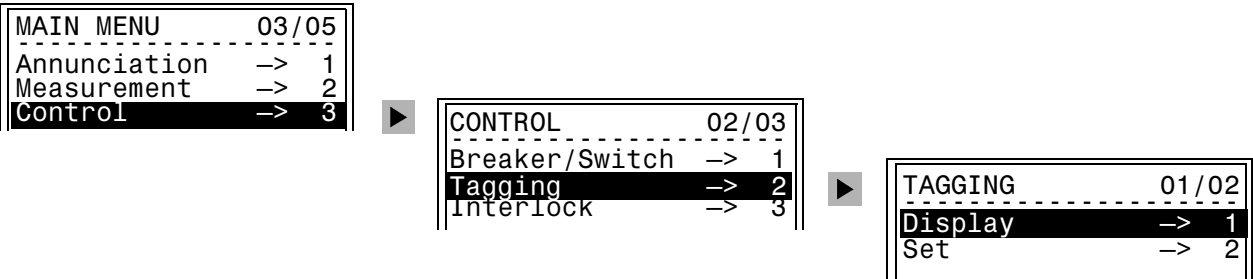
Figure 7-53   Tagging Equipment from the HMI

Note:

The Manual Overwrite function is always done using the HMI on the SIPROTEC® 4 devices.

7.3.6 Switching Authority

Switching authority determines the command sources that are permitted for control.

From the
Device Front

With a device ready for operation, first press the <mark>MENU</mark> key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control* and move to editing the control functions with the ▶ key. The selection **CONTROL** appears.

Here, select the menu item *Control Auth.* with the ▼ key and switch to the next selection using the ▶ key. The selection **CONTROL AUTH.** appears (see Figure 7-54).

▼
```
CONTROL        04/05
--------------------
 Interlock      -> 3
▶Control Auth.  -> 4
```
▶
```
CONTROL AUTH.
--------------------
 Switch Auth.> Local
```

```
PW Unlock Control?
    =-------
```
ENTER
Enter password No. 2 (for non-interlocked switching) and acknowledge with ENTER

▲
▼
```
CONTRO
 Switc ▶Remote      Local
        Local
```
ENTER
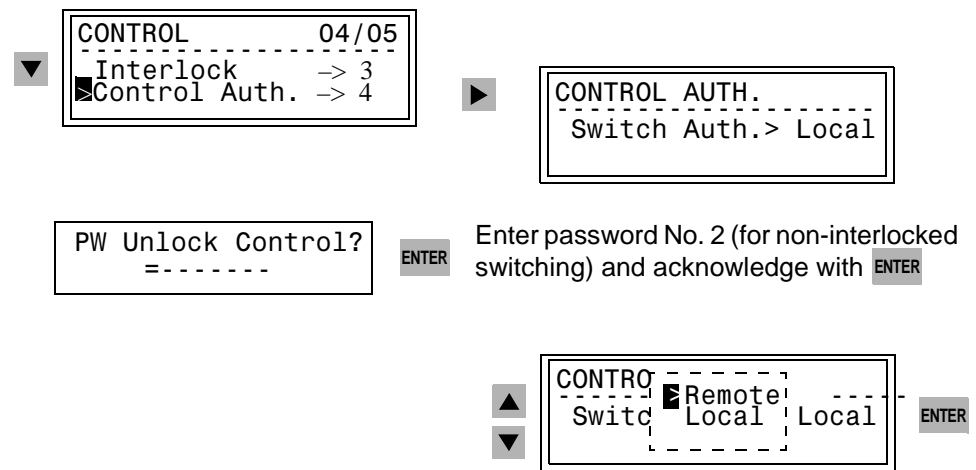
Figure 7-54   Setting Switching Authority with the Operator Control Panel

Pressing the ENTER key opens a selection window in which the options *LOCAL* / *REMOTE* are offered.

Choose the desired option using the ▼ and ▲ keys, and confirm with the ENTER key.

Acknowledge the subsequent message pressing the ENTER key.

Use the ◀ key to return to the **SWITCH AUTH** level; the <mark>MENU</mark> key to return to the **MAIN MENU**.

From PC with
DIGSI® 4

For safety reasons, switching authority can only be changed locally using the keypad on the front panel of the device. Switching authority cannot be changed with DIGSI® 4.

To perform control with DIGSI® 4, switching authority at the device must be set to **REMOTE**, or the test conditions for remote control of switching authority must not be set to active. Switching authority is first transferred to DIGSI® 4 when the control window (see Figure 7-48) is opened.

7.3.7 Switching Mode

The switching mode can be changed during operation; so, for example, non-interlocked switching can be enabled during the commissioning of the installed equipment.

⚡ **DANGER!**

Only highly qualified personnel who have an exact knowledge of the power system conditions shall perform non-interlocked switching. Inappropriate switching operations can lead to death, serious personnel injury and property damage.

From the Device Front

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item *Control* and move to editing the control functions with the ▶ key. The selection **CONTROL** appears.

Here, select the menu item *Switch Mode* with the ▼ key and switch to the next selection using the ▶ key. The selection **SWITCH MODE** appears (see Figure 7-55).

```
CONTROL        05/05
--------------------
 Switch Auth  ->   4
▶Switch Mode  ->   5
```

```
SWI-------------------
---▶INTERLOCKED      -
IN  NON—INTERLOCKED
NO--------------------
```

Figure 7-55   Operating Menu for Switching Mode Using Front Panel

Pressing the ENTER key opens a selection window in which the options **INTERLOCKED/NON-INTERLOCKED** are offered.

Make the choice using the ▲ and ▼ keys, and confirm with the ENTER key.

Acknowledge the safety inquiry that follows by again pressing the ENTER key. Use the ◀ key to return to the **CONTROL** level. Press the MENU key to return to the **MAIN MENU**.

From PC with DIGSI® 4

When the **On-line** window in DIGSI® 4 is opened with a double click, the operating functions for the device appear in the left part of the window (Figure 7-38). Clicking on **Controls** brings up the function selection in the right side of the window (Figure 7-47). By double clicking on **Breaker/Switches**, a dialog field is opened in which, among other options, the option for interlocked and non-interlocked (Unlock) switching is offered.

To switch operating resources without a check of the associated interlocking conditions, mark the option *Unlock* by clicking in that field, see section 7.3.1.

To set the switching mode for interlocked switching, the aforementioned option field must not be marked. The marking is removed by clicking in the field again.

Further switching operations are possible until the dialog field *Breaker/Switches* is closed, or the switching mode is changed.

7.3.8   Control Messages

In the course of system control, the device generates several messages that document the process. For example, messages may be given to report the end of a command or provide the reason for a command denial. These messages and the associ-

ated causes are listed in Table 7-4, together with other messages for the control of device functions.

Table 7-4   Possible Control Messages

Message Text	Message Cause
System Error	Interruption by system error
Man.Overwrite OK	Return routing carried out
Man.Overwrite Fail	Return routing cannot be carried out
Control Abort OK	Command interruption carried out correctly
Control Abort Fail	Process cannot be interrupted because no command is issued, command runs in different switching direction, or interruption is not planned or set up.
Control Executed	Command was correctly executed and ended
Control Failed	Refusal because the command number or the origination source is not permitted
Interlocked	Refusal because the communication interface was blocked or the command object is blocked by a protective function.
Switchgr.Intlocked	Refusal because the command object is subject to field interlocking
Switch in Position	Refusal because the present switch position = command direction
Setting Error	Refusal because of a parameter fault, such as unknown command type
Not Authorized	Command from ON-SITE refused because command object is subject to switching authority, which is set to REMOTE
Control Expired	Refusal because command is too old (expiry monitor)
No Control Device	Information address is not planned as command output
Config. Error	Refusal because no relay is assigned to this object, or the relay jumpered in the device does not exist
Control Blocked	Refusal because an output block is set
System Overload?	Refusal because a relay to be controlled is already active (e.g., by another command)
SW: 1 to n error?	Refusal because another relay is already controlled
System Overload	No more free timers available
UpperSett. Limit	For transformer LTC step commands, highest level already reached
Lower Sett. Limit	For transformer LTC step commands, lowest level already reached
Executing Control	New command refused because a command is already in processing
Command Timeout	Feedback indication missing
BinaryInp. Ignored	Recording block set
Chatter Active	Flutter block is active
Sett.Change Active	Refusal because parameter loading process is running
Status Change OK	Status command executed
Status Change Fail	Status command cannot be executed
Change OK	Marking executed
Change Failed	Marking cannot be executed

Table 7-4   Possible Control Messages

Message Text	Message Cause
Checking Interlock	Command is sent to the central unit to check system interlocking
Settings are OK	Parameter change was correctly accepted
Time Limit Expired	Parameter change was interrupted because time expired
Terminated-Pickup	Parameter change interrupted because a fault became active during parameterization
Restore Parameters	As a reaction to a fault recognized during parameterization, the last active parameter set is activated again
Please Wait…	Initiated process running and requires some time
Checking Settings	The changed parameters are tested before acceptance
Swgr. Feedback OK	Return message: destination reached
Swgr. Feedback Fail	Return message: destination not reached
Change Rejected	Parameter change was rejected (e.g., because time expired, or abnormal occurrence during parameterization)
Control OK	Positive conclusion message for commands
Value Incorrect	Plausibility error in command

7.3.9   Other Commands

The device is equipped with a serial interface for connection to SCADA. From there, the device can receive standardized commands (according to the supported protocol) and transmit them to the respective switching devices, or activate internal functions, e.g. block inputs/outputs or set tags (manual overwrite), or release processing of functions in the CFC. This command processing is determined during project planning and configuration of the matrix.

■

Installation and Commissioning

8

This section is primarily for personnel who are experienced in installing, testing, and commissioning protective and control systems, and are familiar with applicable safety rules, safety regulations, and the operation of a power system.

Installation of the 7SJ61 is described in this section. Connections for the device are discussed. Hardware modifications that might be needed in certain cases are explained. Connection verifications required before the device is put in service are also given. Commissioning tests are provided. Some of the tests require the protected line or equipment to carry load. Preparation for the initial energization of the device is covered.

8.1 Installation and Connections

Warning!

Trouble free and safe use of this SIPROTEC® 4 device depends on proper transport, storage, installation, and application of the device according to the warnings in this instruction manual.

Of particular importance are the general installation and safety regulations for work in a high-voltage environment (for example, ANSI, IEC, EN, DIN, or other national and international regulations.) These regulations must be observed. Failure to observe these precautions can result in death, personal injury, or severe damage of property.

Requirements   Verification of the 7SJ61 according to Sub-section 3.2.1 and the connected external equipment must be verified.

8.1.1 Installation

Panel Flush Mounting
❑ Remove the four covers on the corners of the front cover. Four elongated holes in the mounting angle strips become accessible.
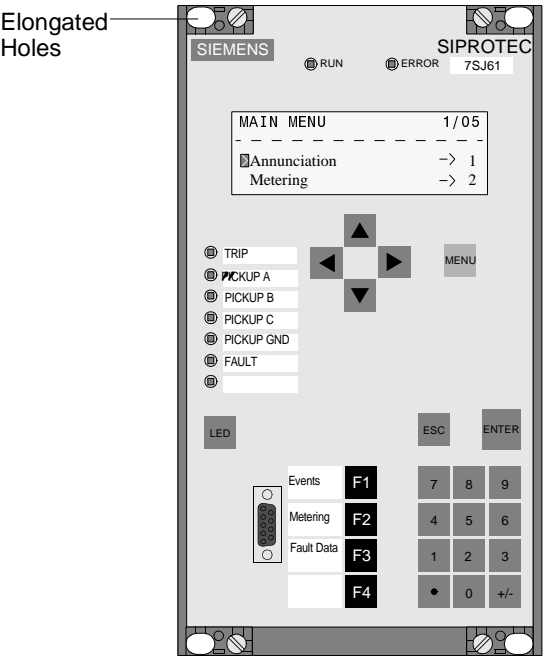
Figure 8-1   Panel Mounting of a 7SJ61

❑ Insert the device into the panel cutout and fasten with four screws. Refer to Figure 10-7 in Section 10.15 for dimensions.

❑ Replace the four covers.

❑ Connect the ground on the rear plate of the device to the protective ground of the panel. Use at least one M4 screw for the device ground. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-sectional area of the ground wire must be at least AWG 13.

❑ Connect the plug terminals and/or the threaded terminals on the rear side of the device according to the elementary diagram for the panel.
When using spade lugs or directly connecting wires to threaded terminals, the screws must be tightened so that the heads are even with the terminal block before the lugs or wires are inserted.
A ring lug must be centered in the connection chamber so that the screw thread fits in the hole of the lug.
Section 2.1 has pertinent information regarding wire size, lugs, bending radii (optical cables), etc.

Rack Mounting   Two mounting brackets are necessary to install the 7SJ61 in a rack. The order number for the brackets is given in the Appendix, Sub-section A.1.3.
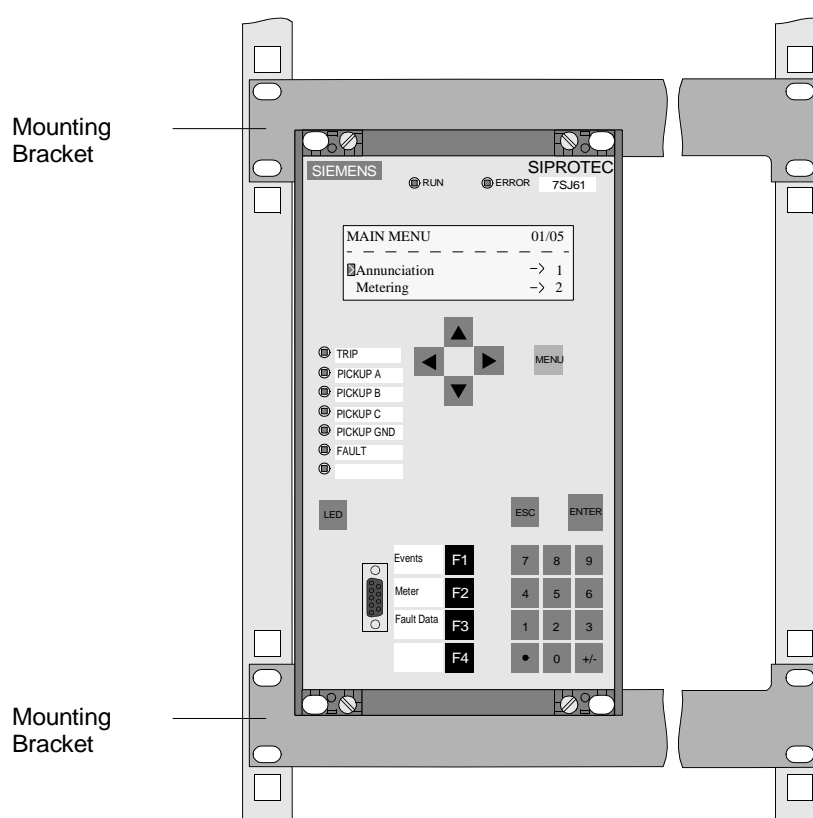
Figure 8-2   Installing a 7SJ61 in a Rack

❑ Loosely screw the two mounting brackets in the rack with four screws.

❑ Remove the four covers on the corners of the front cover of the device. Four elongated holes in the mounting angle strips become accessible.

❑ Fasten the device to the mounting brackets with four screws.

❑ Replace the four covers.

❑ Tighten the mounting brackets to the rack using 8 screws.

❑ Connect the ground on the rear plate of the device to the protective ground of the rack. Use at least one M4 screw for the device ground. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-sectional area of the ground wire must be at least AWG 13.

❑ Connect the plug terminals and/or the threaded terminals on the rear side of the device according to the elementary diagram for the rack.
When using spade lugs or directly connecting wires to threaded terminals, the screws must be tightened so that the heads are even with the terminal block before the lugs or wires are inserted.
A ring lug must be centered in the connection chamber so that the screw thread fits in the hole of the lug.
Section 2.1 has pertinent information regarding wire size, lugs, bending radius (fiber cables), etc.

Panel Surface Mounting

❑ Secure the device to the panel with four screws. Refer to Figure 10-8 in Section 10.19 for dimensions.

❑ Connect the ground of the device to the protective ground of the panel. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-sectional area of the ground wire must be at least AWG 13.

❑ Solid, low impedance operational grounding (cross-sectional area ≥ AWG 13) must be connected to the grounding surface on the side. Use at least one M4 screw for the device ground.

❑ Connect the threaded terminals on the top and bottom of the device according to the elementary diagram for the panel. Section 2.2 has pertinent information regarding wire size, lugs, bending radius (fiber cable), etc.

8.1.2 Connections

Currents

CT connections for a 7SJ61 are shown in the Appendix, Section A.3. Figures A-8 to A-12 show examples of current transformer circuit connections for grounded, ungrounded, and compensated (European practice with arc suppression/Petersen-coils) power systems using two or three CTs.

Binary Inputs and Outputs

Figures A-1 to A-6 in the Appendix show the default masking (programming) of the binary inputs and outputs of the different versions of the device. The programming (masking) options of the inputs and outputs are described in Section 5.2.

Changing Setting Groups with Binary Inputs

If binary inputs are used to switch setting groups:

- Two binary inputs must be dedicated for the purpose of changing setting groups when four groups are to be switched. One binary input must be set for ">Set Group Bit 0". The other input must be set for ">Set Group Bit 1". If either Event 7 or Event 8 is not assigned to an input, then that event is considered not to be controlled.

- To control two setting groups, one binary input set for ">Set Group Bit 0" is sufficient. Since the binary input ">Set Group Bit 1" is not masked and not controlled.

- The status of the signals controlling the binary inputs to activate a particular setting group must remain constant as long as that particular group is to remain active.

Table 8-1 shows the relationship between ">Set Group Bit 0", ">Set Group Bit 1", and the setting groups A to D. Simplified connection diagrams for the two binary inputs are configured in Figure 8-3. The figure illustrates an example in which both Set Group Bits 0 and 1 are configured to be controlled (actuated) when the associated binary input is energized (high). If desired, either one Set Group Bit, or both Set Group Bits, can be triggered when the associated binary input is de-energized (low, Normally Closed Contact Logic).

Table 8-1   Setting Group Selection with Binary Inputs

Binary Input Events		Active Group
>Set Group Bit 0	>Set Group Bit 1	
no	no	Group A
yes	no	Group B
no	yes	Group C
yes	yes	Group D

no   = not energized
yes = energized
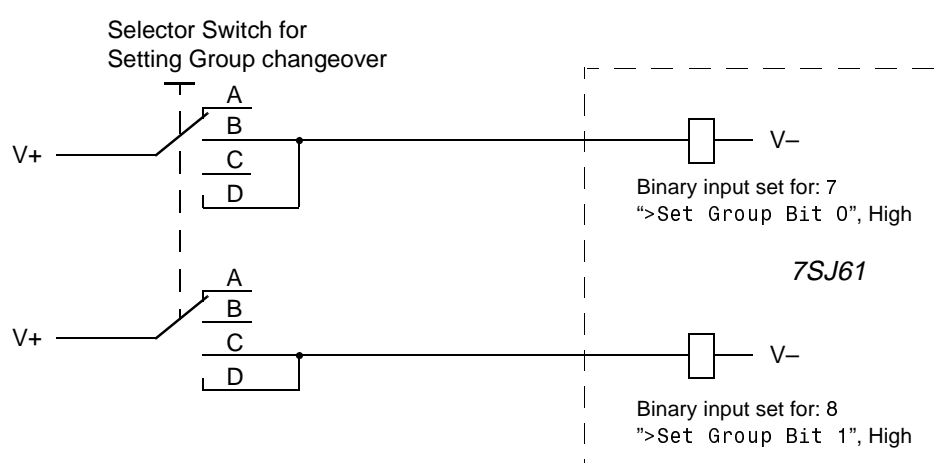
Figure 8-3   Connection Diagram (Example) for Setting Group Changeover with Binary Inputs

Trip Circuit Monitoring

One or two binary inputs can be used for monitoring a circuit breaker trip coil. An alarm can be given if the coil is interrupted when the breaker circuit position is closed or open (2 inputs used).

When *one* binary input is used for trip circuit monitoring, the calculation for the necessary resistance R must be done according to Sub-section 6.17.2.2. A resistor with the necessary value must be included in the circuit branch with 52/b as shown in Figure 6-60, Sub-section 6.17.1.5.

For either method of trip circuit monitoring, the components are connected in series - the two binary inputs or the binary input and the resistor R. The pickup threshold of the binary inputs must be less than <u>half</u> of the nominal value of the DC control voltage.

8.1.3   Hardware Modifications

Hardware adjustments might be necessary or desired. For example, a change of the pickup threshold for some of the binary inputs might be advantageous in certain applications. Terminating resistors might be required for the communication bus. In either case, hardware modifications are needed. The modifications are done with jumpers on the printed circuit boards inside the 7SJ61. Follow the procedure below, "Jumpers on the Printed Circuit Boards", whenever hardware modifications are done.

Power Supply Voltage

There are different ranges for the input voltage of the various power supplies. Refer to the data for the 7SJ61 ordering numbers in Section A.1 of the Appendix. The power supplies with the ratings [60/110/125 VDC] and [110/125/220/250 VDC 115 VAC] are interchangeable. Four jumper settings determine the rating. The settings necessary to convert one range to the other are provided below, "Jumpers on the Printed Circuit Boards". When the device is delivered, these jumpers are set according to the nameplate sticker. Typically, these settings are not changed.

Nominal Currents

The rating of the current input transformers of the device can be changed to 1 A or 5 A with jumper settings that determine the secondary loading of the transformers. The physical arrangements of these jumpers that correspond to the different current ratings are described below, "Jumpers on the Printed Circuit Boards".

All these jumpers (X61 to X64 and X60) must be in the same position: 1 A or 5 A. If the highly sensitive current input is used, jumper X64 is omitted.

If nominal current ratings are changed, then the new ratings must be altered under Address 0205 **CT SECONDARY** in the **P.System Data1** (see Sub-section 6.1.1).

Control Voltages for Binary Inputs

When the device is delivered from the factory, the binary inputs are set to operate with a DC control voltage that corresponds to the rated DC voltage of the power supply. In general, to optimize the operation of the inputs, the pickup voltage of the inputs should be set to most closely match the actual control voltage being used. In some cases such as the one described in the note below, lowering the pickup voltage might be necessary. Each binary input has a pickup voltage that can be independently adjusted; therefore, each input can be set according to the function performed.

A jumper position is changed to adjust the pickup voltage of a binary input. The physical arrangement of the binary input jumpers in relation to the pickup voltages is explained below, "Jumpers on the Printed Circuit Boards".

	Note:
	If the 7SJ61 performs trip circuit monitoring, two binary inputs, or one binary input and a resistor, are connected in series. The pickup voltage of these inputs must be less than half of the nominal DC voltage of the trip circuit.

Serial Interfaces

When the device is delivered from the factory, the serial interfaces are matched to the ordered version according to the 11th and 12th figure of the ordering code. The configuration is determined by jumpers on the interface module. The physical arrangement is described below, "Jumpers on the Printed Circuit Boards".

For reliable data transmission, an RS 485 bus should be terminated with resistors at the last device on the bus. Terminating resistors are provided in a 7SJ61. As delivered from the factory, the resistors are switched out. Two jumper positions must be changed to switch-in the resistors. The jumper positions and the corresponding states of the resistors are covered below, "Jumpers on the Printed Circuit Boards". Both jumpers must always be set in the same position.

Jumpers on the Printed Circuit Boards

If changes to jumper settings are required to modify the rating of the power supply, the nominal rating of the current input transformers, the pickup voltage of binary inputs, or the state of the terminating resistors, proceed as follows:

Caution!

Jumper-setting changes that affect nominal values of the device render the ordering number and the corresponding nominal values on the nameplate sticker invalid. If such changes are necessary, the changes should be clearly and fully noted on the device. Self adhesive stickers are available that can be used as replacement nameplates.

☐ The following equipment is needed:

– Grounded mat for protecting components subject to damage from electrostatic discharges (ESD).

– Screwdriver with a 6 mm wide tip,

– #1 Phillips screwdriver,

– 4.5 mm socket or nut driver.

☐ Unfasten the screw-posts of the D-subminiature connector on the back panel at location "A". This activity does not apply if the device is for surface mounting.

☐ If the device has more communication interfaces at locations "B" and/or "C" on the rear, the screws located diagonally to the interfaces must be removed. This activity is not necessary if the device is for surface-mounting.

☐ Remove the four corner caps on the front cover and loosen the screws that become accessible.

☐ Carefully pull off the front cover. The front cover is connected to the CPU board with a short ribbon-cable.

![Warning triangle icon] **Caution!**

Electrostatic discharges through the connections of the components, wiring, plugs, and jumpers must be avoided. Wearing a grounded wrist strap is preferred. Otherwise, first touch a grounded metal part.

☐ At one end, disconnect the ribbon-cable between the front cover and the CPU board. To disconnect the cable, push up the top latch of the plug connector and push down the bottom latch of the plug connector. Carefully set aside the front cover.

The locations of the printed circuit boards are shown in Figure 8-4.

☐ Disconnect the ribbon-cables between the CPU board (❶) and the I/O board (❷).

☐ Remove the boards and set them on the grounded mat to protect them from ESD damage. A greater effort is required to withdraw the CPU board, especially in versions of the device for surface-mounting, because of the communication connectors.

☐ Check the jumpers according to Figures 8-5 to 8-9, and Tables 8-2 to 8-6. Change or remove the jumpers as necessary.

❶ Processor Printed Circuit Board CPU
❷ Input/Output Printed Circuit Board I/O

Slot 5   Slot 19
❶   ❷
BI1 to   BI4 to   ◄──── Binary Inputs (BI)
BI3   BI11
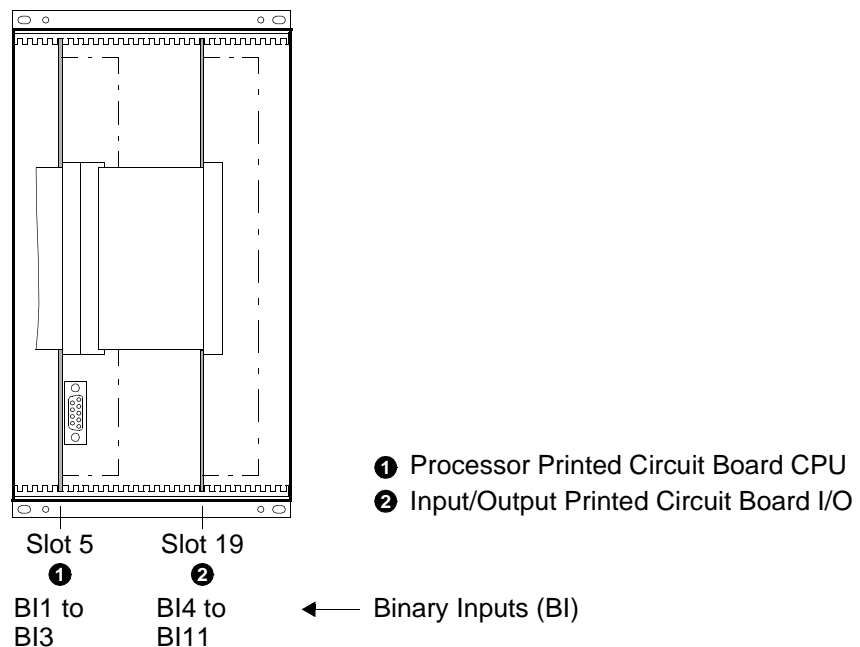
Figure 8-4   Front View After Removing the Front Cover (Simplified and Reduced)

On the CPU board, check the provided nominal voltage of the integrated power supply according to Table 8-2 and the selected pickup voltages of the binary inputs BI1 through BI3 according to Table 8-3.
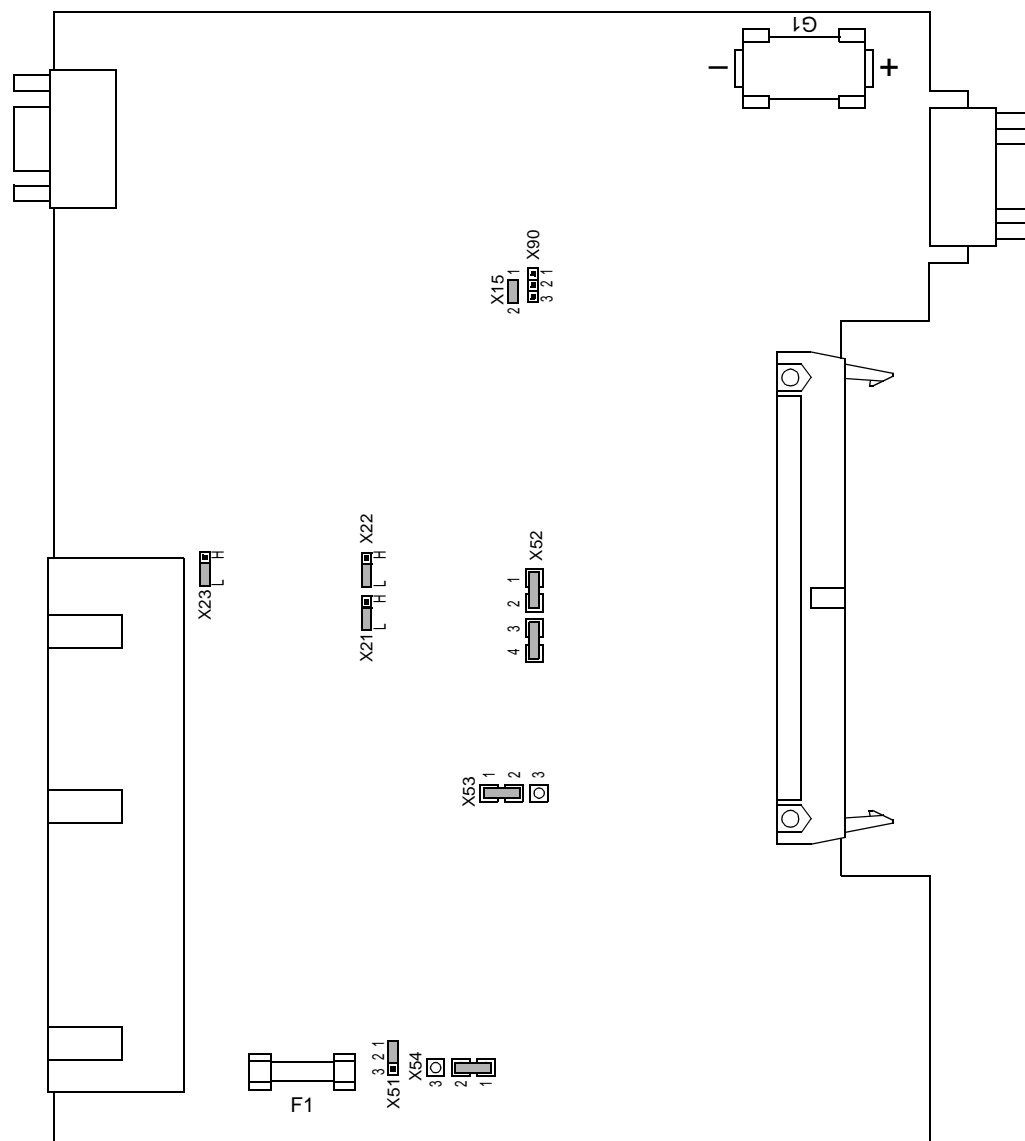
Figure 8-5   Jumpers On The CPU Board For The Power Supply And Binary Inputs BI1 To BI3 (Simplified)

Table 8-2   Jumper Settings for the Nominal Voltage of the Integrated **Power Supply** on the CPU Board

Jumper	Nominal Voltage		
	60/110/125 VDC	110/125/220/250 VDC 115 VAC	24/48 VDC 230 VAC
X51	1-2	2-3	Jumpers X51 through X54 are not used
X52	1-2 and 3-4	2-3	
X53	1-2	2-3	
X54	1-2	2-3	
	Can be interchanged		Not changeable

Table 8-3   Jumper Settings for the **Pickup Voltages** of the Binary Inputs BI1 through BI3 on the CPU Board

Binary Input	Jumper	17 VDC Pickup[1]	73 VDC Pickup[2]
BI1	X21	L	H
BI2	X22	L	H
BI3	X23	L	H

[1]) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC.
[2]) Factory settings for devices with power supply voltages of 110 VDC to 220 VDC and 115/ 230 VAC.

Table 8-4   Factory jumper settings for the **Pickup Voltages** of the binary inputs BI4 through BI11 on the I/O board

Binary Input	Jumper	17 VDC Pickup[1]	73 VDC Pickup[2]
BI4	X21	L	H
BI5	X22	L	H
BI6	X23	L	H
BI7	X24	L	H
BI8	X25	L	H
BI9	X26	L	H
BI10	X27	L	H
BI11	X28	L	H

[1]) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC.
[2]) Factory settings for devices with power supply voltages of 110 VDC to 220 VDC and 115/ 230 VAC.

On the I/O board, check the supplied nominal current ratings of the current transformers (5 jumpers) and the selected pickup voltages for the binary inputs BI4 through BI11 according to Table 8-4.
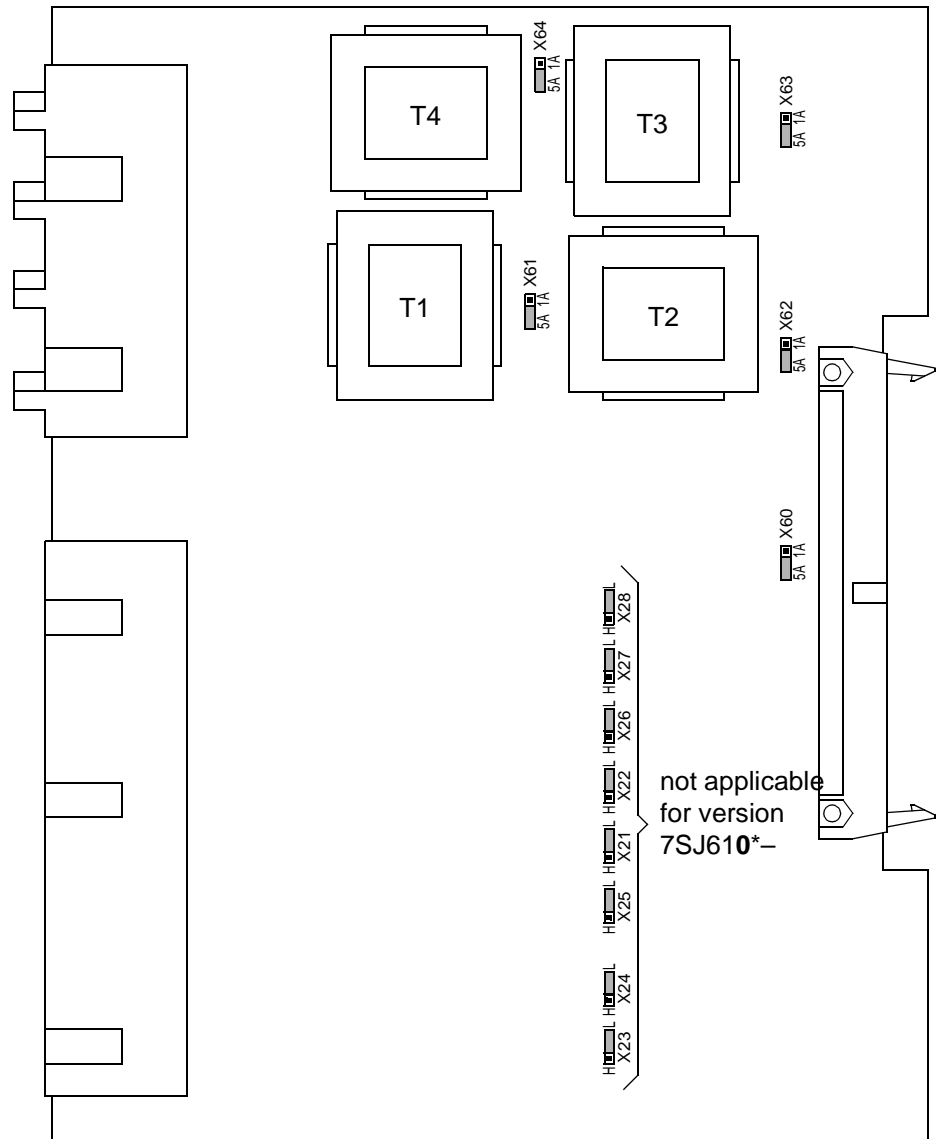
Figure 8-6   Jumpers on the I/O Board for the Current Transformers and the Binary Inputs BI4 to BI11 (simplified)

The X3 and X4 jumpers for configuring the terminating resistors of a serial interface are on a card that is located on the CPU board. The card is attached to the associated serial port at location "B" or location "C" (designated on the rear of the 7SJ61). There can be one or two cards. There are two variations of the card that are differentiated only by the arrangement of the components. See Figures 8-7 and 8-8. The jumpers are set according to Table 8-7 and 8-8. Jumpers X3 and X4 must always have the same setting. The factory settings for the jumpers are 1-2.

Table 8-5   Configuration of Jumpers for **RS 232 or RS 485** on the Interface Card (Circuit Board Number C53207-A322-B80, Figure 8-7)

Jumper	X5	X6	X7	X8	X9	X10	X11
RS 232	1–2	1–2	1–2	1–2	1–2	1–2	2–3
RS 485	2–3	2–3	2–3	2–3	2–3	2–3	2–3

Jumpers X5 through X10 must be set on the same position!

Table 8-6   Configuration of Jumpers for **RS 232 or RS 485** on the Interface Card (Circuit Board Number C53207-A324-B180, Figure 8-8)

Jumper	X5	X6	X7	X8	X10	X11	X12	X13
RS 232	1–2	1–2	1–2	1–2	1–2	2–3	1–2	1–2
RS 485	2–3	2–3	2–3	2–3	2–3	2–3	1–2	1–2

Jumpers X5 through X10 must be set on the same position!

The jumpers are set at the factory based on the configuration ordered.

Jumpers X3 and X4 for bus termination of an RS 485 interface are also shown in Figure 8-7 and Figure 8-8.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2*)
X4	2-3	1-2*)

*) Factory Set
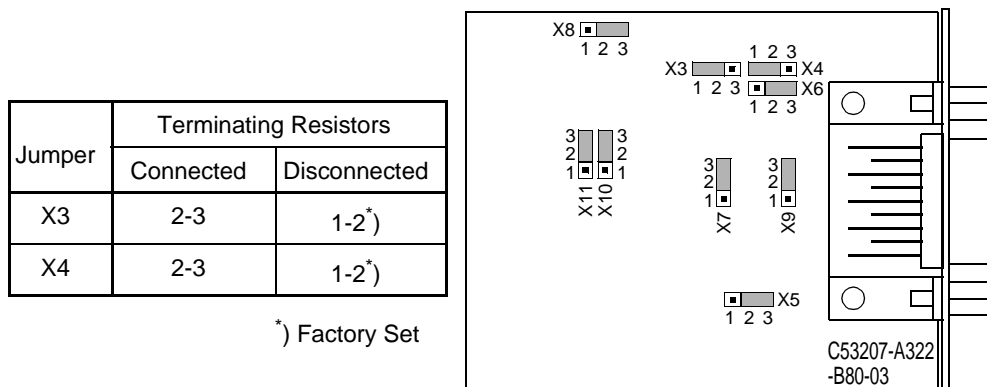
Figure 8-7   Location of the Jumpers for Configuring the Terminating Resistors of the Interface on Card Version C53207-A322-B80

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2*)
X4	2-3	1-2*)

*) Factory Set

Figure 8-8   Location of the Jumpers for Configuring the Terminating Resistors of the Interface on Card Version C53207-A324-B180

The Profibus–Interface has two Jumpers X3 and X4, as shown in Figure 8-9.

Jumpers X3 and X4 are set at the factory so that the terminating resistors are switched-out.

Both jumpers must always be set for the same position.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3[*])
X4	1-2	2-3[*])

[*]) Factory Set
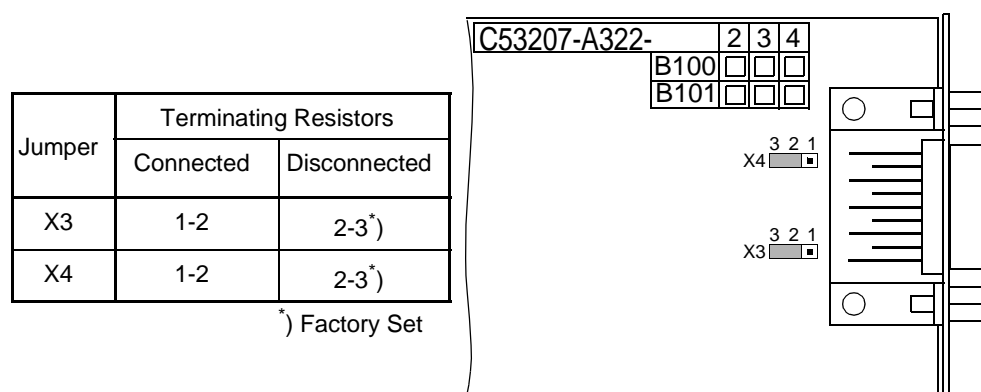
Figure 8-9   Location of the Jumpers for Configuring the Profibus–Interface Terminating Resistors

To reassemble the device:

☐ Carefully insert the boards into the case. The installation locations of the boards are shown in Figure 8-4. For the model of the device designed for surface-mounting, use the metal lever to insert the CPU board. The installation is easier with the lever.

☐ Insert and tighten the screw-posts for the D-subminiature connector at location "A" on the rear of the device. This task does not apply if the device is for surface mounting.

☐ Insert and tighten the screws for the communication interfaces at locations "B" and "C" on the back panel of the device. This task is not necessary if the device is for surface-mounting.

☐ By first attaching to the I/O board, connect the ribbon cable between the I/O board and the CPU board. Be especially careful not to bend any of the connector pins! Do not use any force! Be sure that the plug connectors latch.

☐ Connect the ribbon cable between the CPU board and the front cover. Be especially careful not to bend any of the connector pins! Do not use any force! Be sure that the plug connectors latch.

☐ Carefully replace the front cover being mindful of the ribbon-cable. Fasten the cover to the case with the screws.

☐ Replace the four corner covers.

8.2   Checking Connections

8.2.1   Data Connections

Table 8-7 shows the pin-assignments for the various serial interfaces of the device. Table 8-8 refers to the time synchronization interface.

PC Interface at Front   When the recommended communication cable is used, correct connection between the SIPROTEC® device and the PC is automatically ensured. See the Appendix, Subsection A.1.3 for an ordering description of the cable.

SCADA Interface   When a serial interface of the device is connected to a SCADA, the data connection must be checked. A visual check of the transmit channel and the receive channel is important. Each connection is dedicated to one transmission direction. The data output of one device must be connected to the data input of the other device, and vice versa.

The data cable connections must conform to DIN 66020 and ISO 2110 (see also Table 8-7):

− TxD data transmit

− RxD data receive

− $\overline{\text{RTS}}$ request to send

− $\overline{\text{CTS}}$ clear to send

− DGND signal/chassis ground

The cable shield is to be grounded at only **one end** so that potential differences cannot cause circulating currents to flow along the shield.

Table 8-7   Installation of the D-Subminiature Ports

Pin No.	PC Interface at Front	RS 232	RS 485	Profibus FMS Slave, RS 485
1	Shield (with shield ends electrically connected)			
2	RxD	RxD	–	–
3	TxD	TxD	A/A' (RxD/TxD–N)	B/B' (RxD/TxD–P)
4	–	–	–	CNTR–A (TTL)
5	DGND	DGND	C/C' (DGND)	C/C' (DGND)
6	–	–	–	+ 5V voltage supply (max. load < 100 mA)
7	–	$\overline{\text{RTS}}$	–*)	–*)
8	–	$\overline{\text{CTS}}$	B/B' (RxD/TxD–P)	A/A' (RxD/TxD–N)
9	–	–	–	–

*)   Pin 7 also can carry the RS 232 $\overline{\text{RTS}}$ signal to an RS 485 interface. Pin 7 must therefore not be connected!

RS 485 Termination

The RS 485 interface is capable of half-duplex mode with the signals A/A' and B/B' with a common relative potential C/C' (DGND). Verify that only the last device on the bus has the terminating resistors connected, and that the other devices on the bus do not. The jumpers for the terminating resistors are on the interface card mounted on the CPU board. Refer to Figures 8-7 to 8-9.

If the bus is extended, make sure again that only the last device on the bus has the terminating resistors switched-in, and that all other devices on the bus do not.

Time Synchronization Interface

Either 5 VDC, 12 VDC or 24 VDC time synchronization signals can be processed if the connections are made as indicated in Table 8-8.

Table 8-8   Pin-assignments for the D-subminiature port of the Time Synchronization Interface

Pin-No.	Designation	Signal Meaning
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return Line
4	–	–
5	Shield	Shield Potential
6	–	–
7	P12_TSIG	Input 12 V
8	–	–
9	Shield	Shield Potential

Optical Fibers

Signals transmitted via optical fibers are unaffected by interference. The fibers guarantee electrical isolation between the connections. Transmit and receive connections are shown with the symbols ●→ for transmit and →● for receive.

The normal setting for the optical fiber interface is "Light off." If this setting is to be changed, use the operating program DIGSI® 4, as described in Section 5.5.

8.2.2   Substation Connections

Warning!

The following procedures are carried out with dangerous voltages present. Therefore, only qualified people who are familiar with and adhere to the safety procedures and precautionary measures shall perform the procedures.

⚠️

Caution!

Operating the device on a battery charger without a connected battery can lead to unusually high voltages and consequently, the destruction of the device. For limit values see Sub-section 10.2.1 under Technical Data.

Before the device is energized for the first time, the device should be in the final operating environment for at least 2 hours to equalize the temperature, to minimize humidity and avoid condensation.

☐ Protective switches (e.g. test switches, fuses, or circuit breakers) for the power supply and the measured voltages must be open or tripped.

☐ Compare all current transformer connections with system and connection diagrams:

  ❑ Are the current transformers grounded properly?

  ❑ Are the polarities of the current transformers the same?

  ❑ Is the phase relationship of the current transformers correct?

  ❑ Is the polarity for current input I_n or current input I_{Ns} (if used) correct?

☐ Check the functions of all test switches that are installed for the purposes of secondary testing and isolation of the device. Of particular importance are test switches in current transformer circuits. Be sure these switches short-circuit the current transformers when they are in the test mode.

☐ The short-circuit feature of the current circuits of the device are to be checked. An ohmmeter or other test equipment for checking continuity is needed.

  ❑ Remove the front panel of the device (see Figure 8-4).

  ❑ Remove the ribbon cable connected to the I/O board (❷ in Figure 8-4), and pull the board out until there is no contact between the board and the rear connections of the device.

  ❑ At the terminals of the device, check continuity for each pair of terminals that receives current from the CTs.

  ❑ Firmly re-insert the I/O board. Carefully connect the ribbon cable. Do not bend any connector pins! Do not use force!

  ❑ Check continuity for each of the current terminal-pairs again.

  ❑ Attach the front panel and tighten the screws.

☐ Connect an ammeter in the supply circuit of the power supply. A range of about 1 A for the meter is appropriate.

☐ Close the protective switches to apply voltage to the power supply. The measured steady state current should be insignificant. Transient movement of the ammeter merely indicates the charging current of capacitors.

☐ Check the polarity and magnitude of the voltage at the device terminals.

☐ Power consumption by the power supply should be in accordance with the quiescent specification.

☐ Remove the voltage from the power supply by opening the protective switches.

☐ Disconnect the measuring test equipment; restore the normal power supply connections.

☐ Apply voltage to the power supply.

☐ Verify that the current phase rotation at the device terminals is correct. Note that the device can be set for ABC rotation or ACB rotation under Address 0209 **PHASE SEQ.** in **P.System Data1**. See also Sub-section 6.1.1.

☐ Open the protective switches for the the power supply.

☐ Check the trip and close circuits to the power system circuit breakers and the other primary equipment that is to be controlled by the 7SJ61.

☐ Verify that the control wiring to and from other devices is correct.

☐ Check the signalling connections.

☐ Close the protective switches to apply voltage to the power supply.

8.3   Commissioning

> ⚠️ **Warning!**
>
> When operating an electrical device, certain parts of the device inevitably have dangerous voltages. Severe personal injury or property damage can result if the device is not handled properly.
>
> Only qualified people shall work on and around this device after becoming thoroughly familiar with all warnings and safety notices in this instruction manual as well as with the applicable safety steps, safety regulations, and precautionary measures.
>
> The main points to observe are:
>
> - The device is to be grounded to the substation ground before any other connections are made.
>
> - Hazardous voltages can exist in the power supply and at the connections to current transformers, voltage transformers, and test circuits.
>
> - Hazardous voltages can be present in the device even after the power supply voltage has been removed, i.e. capacitors can still be charged.
>
> - After removing voltage from the power supply, wait a minimum of 10 seconds before re-energizing the power supply. This wait allows the initial conditions to be firmly established before the device is re-energized.
>
> - The limit values given in Technical Data (Chapter 10) must not be exceeded, neither during testing nor during commissioning.

When testing the device with directly connected test equipment, make sure that no other measurement quantities are connected and that the trip and close circuits to the circuit breakers and other primary switches are disconnected from the device.

> ⚡ **DANGER!**
>
> **Current transformer secondary circuits must be short-circuited before the current leads to the device are disconnected!**
>
> If test switches are installed that automatically short-circuit the current transformer circuits, opening these test switches (placing them in the "Test" position) is sufficient provided the short-circuit function has been previously tested.

8.3.1   Current and Phase Rotation Testing

Load Current
≥ [10% I_N]

The connections of the current transformers are tested using primary quantities. Secondary load current of at least 10 % of the nominal current of the device is necessary. With proper connections of the measuring circuits, none of the measured-values supervision elements in the device should pick up. If an element detects a problem, the

relevant condition can be viewed in the Event Log. If current summation errors occur, then check the matching factors. See Sub-section 6.17.2.1.

Messages from the symmetry monitoring could occur because there actually are asymmetrical conditions in the network. If these asymmetrical conditions are normal service conditions, the corresponding monitoring functions should be made less sensitive. See Sub-section 6.17.2.1.

Current Values Currents can be seen in the display field on the front of the device under **Measure-ment**. The quantities can also be viewed under **Measurement** in the DIGSI® 4 window. The currents displayed by the device can be compared to the quantities measured by an independent source.

Phase Rotation The actual phase rotation of the voltages must correspond to the setting under Address 0209 **PHASE SEQ.** in **P.Sytem Data1**; otherwise, an alarm message occurs. If the alarm occurs, then the phase sequence of the measured quantities should be checked, and the proper corrections made.

8.3.2 Testing the Reverse Interlocking Scheme (if applicable)

This testing causes trip contacts of the 7SJ61 to close. If tripping of the relevant circuit breakers and primary interrupting devices is to be avoided, the 7SJ61 trip contacts must be isolated. Proper backup relaying should exist.

An operational check of the reverse interlocking scheme might cause tripping by the protective relays that block the 7SJ61 (depending on the procedure used). If the blocking relays will trip, the trip contacts that control primary interrupting devices must be isolated if the devices are not to be operated. Again, proper backup relaying should exist.

Simple methods of testing and operational checking a reverse interlocking scheme are illustrated with an example. In this example, the 50-2 element and the 50N-2 element of the 7SJ61 are employed in a reverse interlocking scheme that provides bus protection in a radial distribution system with three feeders. The tripping of both elements is blocked when Binary Input 1 is energized. The input mask is [>BLOCK 50-2 (H) or >BLOCK 50N-2 (H)]. The elements have slight time delays to provide coordination with the blocking protective relays. The blocking relays are the three feeder relays. Each feeder relay has a blocking contact programmed to close when the 51 element or 51N element picks up. The three contacts are connected in parallel to apply control voltage to Binary Input 1 when any one of them closes.

An actual scheme might employ elements and binary inputs other than those given in the example. The binary inputs could also be set to block tripping when the inputs are de-energized. The blocking devices might be configured differently as well. In any case, testing and operationally checking a reverse interlocking scheme are typically simple. The procedures below can be adapted as needed.

⚠

Caution!

During testing, observe the current ratings of the inputs given in Technical Data, Subsection 10.1.1. Continuous currents for the phase and ground inputs must be less than or equal to [$4 \cdot I_N$]. The continuous rating for the sensitive ground input is different. Allow a cool-down period if the continuous ratings are exceeded.

With the 7SJ61 isolated from the current transformers and tripping circuits, inject test current into any one phase current input and the ground current input. Slowly ramp-up the current until the pickup values of 50-2 and 50N-2 are found (monitor contacts or LEDs). Slowly decrease the current until the dropout values are found. Verify that the pickup and dropout values are as expected.

The time delays of the elements can be measured with a timer set to start on the application of current and stop on the closure of the trip contact masked to close when either 50-2 or 50N-2 trips. Test one element at a time. For either element, first set the time delay for 0.00 second. Suddenly apply current greater than the pickup value. Record the time. Repeat the test with the time delay included. The difference between the results provides an estimate of the time delay. Be sure the time delays are as expected.

The tripping block can be verified by manually applying voltage to Binary Input 1, and injecting a test current above the pickup of the element under consideration, for a time period much longer than the time delay setting.

To operationally check the scheme, current can be simultaneously injected into the 7SJ61 and one of the feeder relays. The feeder relay must be isolated from current transformers and trip circuits of primary equipment. Proper backup relaying should be available. The magnitude of the test current must be high enough to pickup both the feeder blocking element and the 7SJ61 tripping element. (The blocking element could be less sensitive in secondary terms.) Suddenly apply the current and verify that 50-2 and 50N-2 are blocked. Suddenly remove the current and verify that 50-2 and 50N-2 do not trip. If the blocking element has an equal or higher sensitivity than the tripping element, then tests in which the current is slowly decreased can be done to verify that there are no element dropout-miscoordinations.

Repeat the testing for each blocking device.

Restore the current and tripping circuits of the 7SJ61 and the feeder relays.

8.3.3 Testing the Breaker Failure Scheme (if applicable)

Precise timing tests of the breaker failure scheme within the device are better suited for a lab environment, but on-site functional tests are practical. Current injection from a test set directly into the 7SJ61 is recommended for these functional tests. The device must be isolated from the current transformers.

If tripping of circuit breakers and other primary equipment is to be avoided, the trip contacts of the 7SJ61 must be isolated for these tests. This is critical because breaker failure schemes are designed to trip all surrounding circuit breakers (that allow fault current contributions) and possibly transfer trip remote circuit breakers. Failure to properly isolate the breaker failure tripping can therefore have serious consequences.

Lockout relays (86) are commonly used in breaker failure schemes to provide contact multiplication and control of circuit breaker close circuits. Typically, all of the 86 contacts must be isolated during testing if circuit breaker operations are to be avoided.

A trip command from the 7SJ61 initiates the breaker failure scheme. If the current in a phase exceeds the setting under Address 0212 **BkrClosed I MIN** (typically set very sensitive), the breaker failure timer under Address 7005 **TRIP–Timer** begins to run. The timer continues as long as the current element associated with address 0212 is picked up. If the timer expires, a breaker failure condition is detected and immediate tripping is initiated.

To simulate a breaker failure condition, inject current into the 7SJ61 to trip one of the protective elements programmed to cause a trip command from the device, and maintain the current for a period longer than the breaker failure timer. The current must also exceed the setting under Address 0212 during the entire test. Verify that all device contacts close that are programmed to trip for a breaker failure condition.

A binary input can be masked with "1431 >50BF initiated externally" to initiate the breaker failure scheme. For such schemes, the binary input can be energized (1431 set for H) or de-energized (1431 set for L) while current, greater than the setting under Address 0212, is injected for a time period longer than the breaker failure timer.

A full functional test of the breaker failure scheme, in which all controlled circuit breakers are tripped and locked out, is usually only practical when the substation or feeder is a new installation and not yet energized. After the substation is put in-service, a full breaker failure functional test is typically not permitted. Therefore, check the tripping of the scheme to the point that is permitted – usually to (86).

If the breaker failure scheme initiates transfer tripping, then the system's channel should be checked.

8.3.4   Testing User-Defined Functions

A 7SJ61 has a vast capability for allowing functions to be defined by the user, especially with the CFC logic. Any special function or logic added to the device must be checked.

Naturally, general test procedures cannot be given. Rather, the configuration of these user-defined functions and the necessary associated conditions must be known and verified. Of particular importance are the possible interlocking conditions of the circuit breakers and other primary switching devices. They must be considered and tested.

8.3.5   Test Mode and Blocking Data Transmission

If the SIPROTEC®4 device is connected to a central or main computer system via the SCADA interface, then the information that is transmitted can be influenced.

If **Test mode** is set **ON**, then a message sent by the device to the main system has an additional test bit. This bit allows the message to be recognized as resulting from testing and not an actual fault or power system event.

If **DataStop** is set **ON**, transmission to the SCADA is blocked.

Both of these features should be checked. The procedures for setting **Test mode** and **DataStop** are described in Sub-section 7.2.3. Note that when DIGSI® 4 is being used, the program must be in the **Online** operating mode for the test features to be used.

8.3.6   Checking the Binary Inputs and Outputs

Preliminary Notes   The binary inputs, outputs, and LEDs of a SIPROTEC®4 device can be individually and precisely controlled in DIGSI® 4. This feature can be used, for example, to verify control wiring from the device to substation equipment (operational checks), during start-up. The test feature should **not** be used for routine maintenance when the device and protected equipment are in service ("hot" conditions).

⚠️   **DANGER!**

Changing the status of a binary input or output using the test feature of DIGSI® 4 **results in an actual and immediate, corresponding change in the SIPROTEC® device. Connected equipment such as circuit breakers will be operated by these actions!**

Note: After the Hardware Test is complete, the device enters a start-up phase. All message buffers are erased.

The Hardware Test can be done using DIGSI® 4 in the online operating mode:

❑ Open the **Online** directory by double-clicking; the operating functions for the device appear.

❑ Click on **Test**; the function selection appears in the right half of the window.

❑ Double-click in the list view on **Hardware Test**. The dialog box of the same name opens (see Figure 8-10).

Hardware Test Dialog Box   The dialog box is horizontally divided into three groups: **BI** for binary inputs, **REL** for output relays, and **LED** for light-emitting diodes. Each of these groups is associated with an appropriately marked switching area. By clicking in an area, components within the associated group can be turned on or off.

In the **Status** column, the present conditions of the hardware components are symbolically shown. The present physical conditions of the binary inputs and output relays are shown as symbols for open and closed contacts. The present condition of a light-emitting diode is shown as the symbol for an LED, turned on or off.

The possible intended condition of a hardware component is indicated with clear text under the **Schedule** column, which is next to the **Status** column. The intended condition offered for a component is always the opposite of the present state.

The right-most column indicates the operating equipment, commands, or messages that are configured (masked) to the hardware components.

Changing Hardware Conditions   The displays of the intended conditions are shown as switching fields. To change the condition of a hardware component, click on the associated switching field in the **Schedule** column.

If the password was activated for **Hardware Test**, then Password No. 6 will be requested before the first hardware modification is allowed. Only after entry of the correct password a condition change will be executed. Further condition changes remain possible while the dialog box is open.
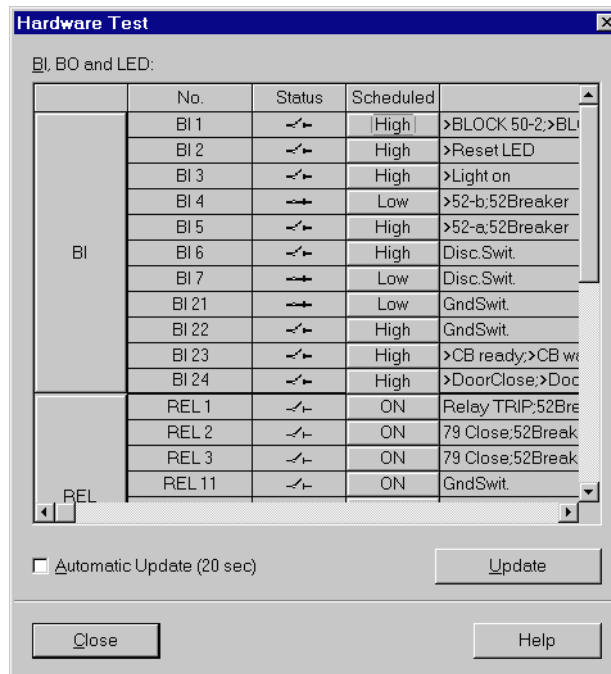
Figure 8-10   Dialog Box for Hardware Test

> *Note:*
>
> As soon as the first condition change of a hardware component is initiated under the Hardware Test, then all components in that group (BI, REL or LED) are separated from substation, or device-side, functionality. This means, for example, that external signals to binary inputs would be ignored by the device if their status conditions change and the test procedure had not been closed.
>
> Local control is re-established when the dialog box is closed.

Updating the Display

When the dialog box **Hardware Test** is opened, the present conditions of the hardware components at that moment are read in and displayed. An update occurs:

− for each component, if a command to change the condition is successfully performed,

− for all hardware components if the **Update** field is clicked,

− for all hardware components with cyclical updating if the **Automatic Update (20sec)** field is marked.

Ending the Procedure

To end the hardware test, click on **Close**. The device becomes unavailable for a brief start-up period immediately after this. The dialog box closes. Then all hardware components are returned to the operating conditions.

8.3.7   Trip/Close Tests for Primary Equipment

Control by Local Command

At the end of commissioning, actual 7SJ61 tripping and closing should be verified for all the relevant circuit breakers and primary switching devices. The feedback of the status of the primary equipment, through the equipment's auxiliary contacts to the binary inputs of the 7SJ61, should be checked during the testing. Be sure the 7SJ61 always indicates the true position of the equipment in the device messages.

The procedure for the control is described in Sub-section 7.3.1. Make sure that the switching authority is set according to the source of commands that is used. The switching mode can be chosen as interlocked or non-interlocked. Note that non-interlocked switching presents safety risks.

Trip/Close Cycle by Protective Function

Tripping of the primary equipment by protective elements can be verified if desired. However, be fully aware that such testing can result in closing of the circuit breaker by the reclosing element in the 7SJ61 or an external reclosing device. If circuit breaker closing is to be avoided, be sure the closing is defeated before the test is performed. If reclosing is desired, select an element in the 7SJ61 that initiates reclosing, and test the control by tripping this element in the testing. To avoid a trip-close-trip event, be sure the protective element is dropped out before the close occurs.

DANGER!

A successfully started test cycle can lead to the closing of the circuit breaker!

8.3.8 Triggering Oscillographic Recordings

At the end of commissioning, an investigation of a closing operation of a circuit breaker or primary switching device, under load conditions, should be done to assure the stability of the protection during the closing process. Oscillographic event recordings obtain the maximum information about the behavior of the 7SJ61.

Requirements

To obtain waveform captures, Address 0104 **OSC. FAULT REC.** under the **DEVICE CONFIG.** menu must be set to *Enabled*.

Along with the capability of storing waveform data and SER information for faults, the 7SJ61 also has the capability of capturing the same data when commands are given to the device via the service program DIGSI® 4, the serial interface, or a binary input. For the latter, the binary input must be masked with event 4, ">Trigger Waveform Capture". Triggering for the oscillographic recording then occurs when the input is energized. An auxiliary contact of the circuit breaker or primary switch may be used to control the binary input for triggering.

An oscillographic recording that is externally triggered (that is, without a protective element pickup or device trip) is processed by the device as a normal oscillographic recording with the exception that data are not given in the Trip Log for the event. The externally triggered record has a number for establishing a sequence.

Triggering with DIGSI® 4

To trigger oscillographic recording with DIGSI® 4, click on **Test** in the left part of the window. Double click the entry **Test Wave Form** in the list in the right part of the window to trigger the recording. See Figure 8-11.

A report is given in the bottom left region of the window. In addition, message segments concerning the progress of the procedure are displayed.

The DIGRA® program or the Comtrade Viewer program is required to view and analyze the oscillographic data. Refer to Sub-section 7.1.4.
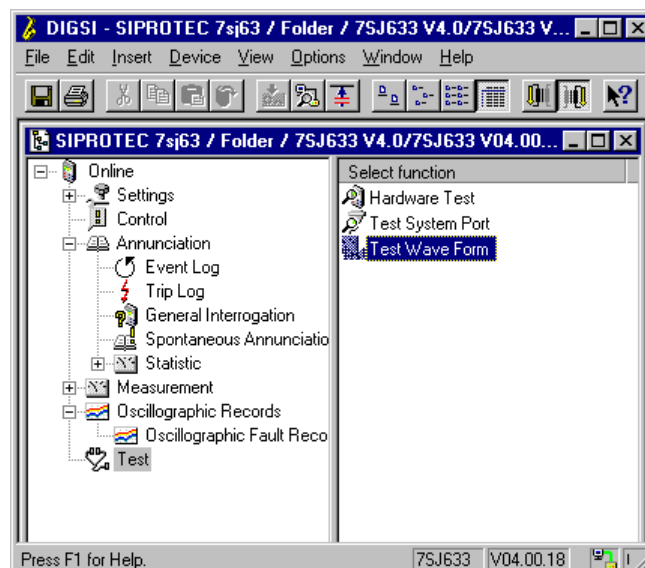
Figure 8-11   Triggering Oscillographic Recording with DIGSI® 4

8.3.9 Generate Indications

A test of the SCADA interface to verify that messages are being correctly transmitted and received can be done with DIGSI® 4. With the program **Online**, click on **Test**, and then double-click on **Test System Port** in the right window. The dialog box **Generate indications** appears, as shown in Figure 8-15.
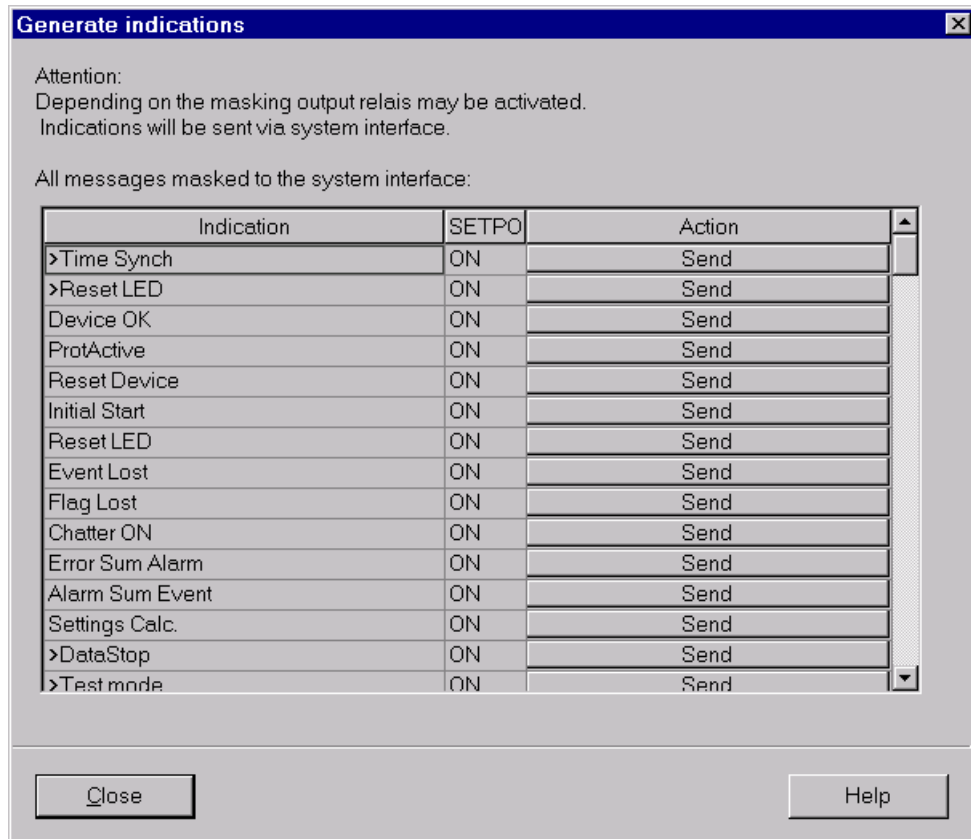
Figure 8-12   Dialog Box: Generate indications

The **Indication** column displays all of the messages that are configured (masked) for the SCADA interface in the matrix. The **SETPOINT status** column shows the value of each message. The values available depend on the message type. Most values are either ON or OFF. The value of a message to be sent can be changed by clicking on the field for the value, and selecting the desired option from the drop-down list.

Warning!

Messages issued over the SCADA interface using the System Interface Test appear as actual operational messages sent by the SIPROTEC® device. Depending on system design, the result could be the operation of primary equipment including circuit breakers or disconnectors. Knowledge of the system design is therefore important. If undesired operations can occur during the testing, then outputs of the SIPROTEC® device must be manually disconnected.

The first time a button is clicked in the **Action** column to send a message, Password No. 6 (for hardware test menus) is requested. After correct input of the password, messages can be individually transmitted. To send a message, click on the **Action** button of the corresponding line. The corresponding message is then sent. The message can be read in the Event Log of the SIPROTEC® device and in the SCADA.

The capability of sending further messages remains until the dialog box is closed.

Note:

When the System Interface Test is terminated, the device changes to the start-up mode (reboots). All hardware components are returned to the operating conditions determined by the substation settings; however, all message buffers are deleted. Any data required from the message buffers must therefore be read before the test is closed.

Ending the Procedure

To end the System Interface Test, click on `Close`. The device is briefly out of service while the start-up routine is executed. The dialog box closes.

8.4   Final Preparation of the Device

Verify all terminal screws are tight and secure. Do not overtighten. Ensure that all pin connectors are properly inserted. Verify the wires to the terminals are tightly connected. Make sure the communication cables are firmly connected; however, do not overtighten the screws.

Verify that all service settings are correct. This is a crucial step because some setting changes might have been made during commissioning. The protective settings under device configuration, input/output masking are especially important (Section 5.1) as well as the power system data, and activated Groups A through D. All desired elements and functions must be set **ON**. See Chapter 6. Keep a copy of all of the in-service settings on a PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if the element is not automatically synchronized. For assistance, refer to Sub-section 7.2.1.

The Annunciation memory buffers should be cleared, particularly the Event Log and Trip Log. Future information will then only apply for actual system events and faults. To clear the buffers, press **MAIN MENU** → **Annunciation** → **Set/Reset**. Refer to Sub-section 7.1.1 if further assistance is needed. The numbers in the switching statistics should be reset to the values that were existing prior to the testing, or to values in accordance with the user's practices. Set the statistics by pressing **MAIN MENU** → **Annunciation** → **Statistic**. Refer to Sub-section 7.1.2 if more information is needed.

Press the **ESC** key, several times if necessary, to return to the default display.

Clear the LEDs on the front panel by pressing the **LED** key. Any binary outputs that were picked up prior to clearing the LEDs are reset when the clearing action is performed. Future illuminations of the LEDs will then apply only for actual events or faults. Pressing the **LED** key also serves as a test for the LEDs because they should all light when the button is pushed. Any LEDs that are lit after the clearing attempt are displaying actual conditions.

The green "RUN" LED must be on. The red "ERROR" LED must not be lit.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

■

Routine Checks and Maintenance

9

General comments about the maintenance activities to ensure the high reliability of the 7SJ61 are given in this section. Simple routine checks and a procedure for replacing the battery are discussed. Troubleshooting advice is provided. A procedure for replacing the power supply fuse is described. Some comments concerning the return of a device to the factory are given.

9.1   General

Siemens numerical protective and control SIPROTEC® 4 devices require no special maintenance. All measurement and signal processing circuits are fully solid state. All input modules are also fully solid state. The output relays are hermetically sealed or provided with protective covers.

Since the device is almost completely self-monitored, from the measuring inputs to the output relays, hardware and software problems are automatically reported. The self-monitoring ensures the high availability of the device and generally allows for a corrective rather than preventive maintenance strategy. Therefore maintenance checks in short intervals are not required.

Operation of the device is automatically blocked when a hardware failure is detected. The "live status" contact drops out to provide an alarm. Messages related to the problem are given in the Event Log. If a problem is detected in the external measuring circuitry, the device will typically give a message in the Event Log. The output contacts are programmable; therefore, alarms for device failures can be configured by the user.

Recognized software failures result in the resetting and restarting of the processor system. If such a failure is not resolved by the restart, further restarts are initiated. If a problem is still present after three restart attempts, the device is automatically taken out of service. Then the "live status" contact drops out to provide an alarm and the red "ERROR" LED on the front panel illuminates.

The reaction of the device to failures and problems can be viewed in chronological sequence in the Event Log. The messages can be used to diagnose the problem. See Sub-section 7.1.1.

When the device communicates with a substation controller (SCADA), the event and alarm messages are also sent over the serial interface.

9.2　Routine Checks

Routine checks of the characteristic curves or pickup values of the protective elements are not necessary because they form part of the continuously supervised firmware programs. The normally scheduled interval for substation maintenance can be used for carrying out operational testing of the protective and control equipment. The maintenance serves mainly to check the serial or hardwired interfaces of the device, i.e. the connections to remote equipment.

The steps listed below are recommended for routine checks. If a problem is detected during these checks, refer to Section 9.4.

☐ Verify that the green "RUN" LED is lit on the front panel and the red "ERROR" LED is not.

☐ Check that the states of the LEDs on the front panel give an accurate image of the conditions of the device and station. Investigate any problems or uncertainties.

☐ Press the LED key. All of the LEDs should temporarily light except for the "ERROR" LED. Only the LEDs indicating specific present conditions should remain lit.

☐ Read the measurement values and compare them to an independent source to check the measuring circuits of the 7SJ61. Refer to Sub-section 7.1.3 for assistance in reading the measurement values.

☐ Review the messages given under the **Annunciation** sub-menu. Be sure there are no reports of unknown problems or abnormal occurrences related to the device, the measuring circuits, or the power system. All information should be plausible. See Sub-section 7.1.1.2 for help in reading the messages.

☐ Perform a reset (reboot) of the device. A complete check of the hardware is done. The device is effectively out of service during the reset, which lasts for about 10 to 15 seconds. To perform the reset from the operator control panel, press the MENU key and use the ▼ and ▶ keys to select the **Device Reset** under the **TEST**/**DIAGNOSE** sub-menu. Press the ENTER key, enter Password No. 4 for test and diagnostics, and answer with **Yes**. During the reset, the "ERROR" and "RUN" LEDs are lit, the other LEDs flash, and the display becomes blank. After a successful reset, the default display reappears and the LEDs return to indicate normal operation. The device is then back in-service. To perform the reset with DIGSI® 4, establish the **Online** mode, select <u>**Device**</u> in the menu bar, and then <u>**Reset.**</u> Enter the password for test and diagnostics; then **OK**.

⚠ **Warning!**

Changing of the states of the binary inputs, binary outputs, and LEDs must not be done with test features during normal operation. Any such change immediately affects the inputs and outputs of the device, and therefore the connected switching devices! This includes, for instance, non-interlocked primary switching!

☐ Other testing can be done with DIGSI® 4 on-line. In **Hardware Test** under **Test**, the conditions of all of the binary inputs, binary outputs, and LEDs can be monitored. Compare the indicated conditions with the actual conditions. Do not change the states of the device components because the station is immediately affected!

☐ The trip and close circuits for circuit breakers and other primary equipment can be verified with operator control actions. Other circuits can be checked as well. Refer to Sub-section 7.3.1 for details about system control.

9.3 Maintenance

9.3.1 Replacing the Battery

The battery is used to retain the annunciation memory and waveform data in the event of an interruption of the power supply. The battery also maintains the internal system clock with calendar after a loss of the power supply.

The battery is checked by the processor at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated.

The battery should be changed when an alarm is given, or at the latest, after 10 years of service.

Recommended Battery:

Lithium Battery 3 V/1 Ah, Type CR 1/2 AA. For example:

– VARTA Order Number 6127 501 501
– Duracell
– Eveready

The procedure for exchanging the battery is dependent upon the construction of the device. Following are the instructions for a device for flush mount and surface mounting.

The battery is located near the front edge of the CPU printed circuit board. The front panel of the device must be removed to change the battery.

To replace the battery:

☐ Save the waveform captures and the important data under the Annunciation sub-menu (all items in this sub-menu). The records and data are lost when the battery is removed. The simplest and fastest method for saving the records and data is to use the save feature in DIGSI® 4 when the program is on-line.

Note: All of the protective and control settings, including the input/output configuration and the CFC logic, are not affected by a power supply interruption. The settings are saved independently of the battery. The settings are not lost when the battery is removed, nor are the settings affected if the device operates without a battery.

☐ Have the replacement battery ready.

Caution!

Do not short the battery! Do not reverse the polarity of the battery! Do not lay the battery on the ground mat used to protect components from electrostatic discharges!

Do not recharge the battery!

☐ Isolate the power supply by opening the protective switches for both terminals.

☐ Wear a grounded wrist strap or touch grounded metal to prevent electrostatic discharges to the internal components of the device.

☐ Remove the covers on the front panel and loosen the screws that are securing the front panel.

![Caution triangle icon]

Caution!

Electrostatic discharges through the connections of the components, wiring, and connectors must be avoided. Wearing a grounded wrist strap is preferred; otherwise, touch a grounded metal part before handling the internal components.

![Warning triangle icon]

Warning!

Hazardous voltages can exist in the device, even after disconnecting the power supply or withdrawing the boards! Capacitors can be charged.

☐ Carefully pull off the front panel. The front panel is connected to the internal CPU printed circuit board with a short ribbon-cable.

☐ At one end, disconnect the ribbon-cable between the front panel and the CPU board. To disconnect the cable, push up on the top latch of the plug connector and push down on the bottom latch of the plug connector. Carefully set aside the front panel.

☐ The battery is located on the bottom-front side of the CPU (❶) board. See Figure 9-1.
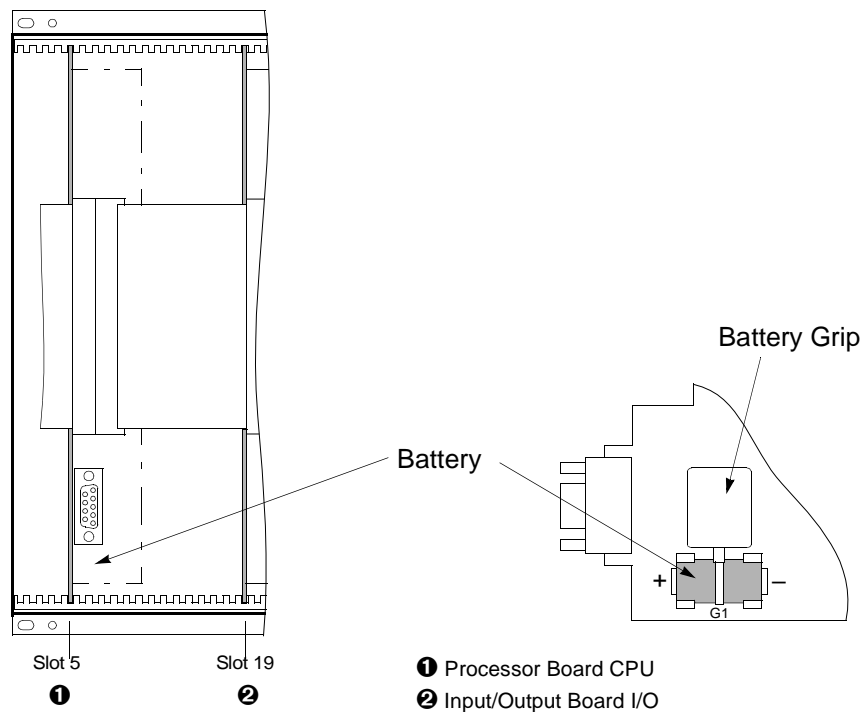
Figure 9-1   Front View without Front Panel – Position of Buffer Battery (simplified and reduced)

☐ Remove the old battery from the snap-on connector using the plastic battery grip shown in Figure 9-1.

☐ Remove the battery grip from the old battery, and place the grip on the new battery.

☐ Observing the polarity and firmly insert the new battery into the snap-on connector shown in Figure 9-1.

☐ Connect the ribbon-cable between the CPU (➊) board and the front panel. Be especially careful not to bend any of the connector pins! Do not use any force! Be sure that the plug connectors latch.

☐ Carefully replace the front panel being mindful of the ribbon-cable. Fasten the panel to the case with the screws.

☐ Replace the covers.

☐ Close the protective switches to apply voltage to the power supply.

☐ After the device is operating, data saved in DIGSI® 4 can be loaded back into the device.

If the internal system clock is not automatically synchronized via a serial interface, then the clock should be set at this point. Refer to Sub-section 7.2.1 if assistance is needed to set the clock.

⚠ **Warning!**

The used battery contains Lithium. Do not throw the battery into the trash!

Do not reverse the polarity! Do not completely discharge! Do not throw the battery into a fire! Explosion hazard!

9.4 Troubleshooting

If a device reports a problem or failure, the procedure below is recommended.

☐ If none of the LEDs on the front panel are lit, then verify that the:

❑ Printed circuit boards are fully inserted, in the correct slots, and properly connected to the front panel.

❑ Voltage magnitude and polarity are correct for the power supply. Connection drawings are shown in Section A.2 of the Appendix.

❑ Fuse in the power supply has not blown. The location of the fuse is shown in Figure 9-2. If the fuse needs to be replaced, see Sub-section 9.5.2.

☐ If the red "ERROR" LED is on and the green "RUN" LED is off, then the device has recognized an internal fault. Re-initializing the device can be attempted, see Section 9.2.

☐ If you see the following display, the device has arrived in "Monitor"-mode. In this case you may initialize the device via DIGSI® 4:

```
MONITOR          01/05
- - - - - - - - - - - -
Equipment data ―>   1
User interface ―>   2
System I-face  ―>   3
Reset          ―>   4
Siemens insten ―>   5
```

❑ Connect the SIPROTEC® 4 device to the PC and open the DIGSI® 4 application in the PC.

❑ Select **Initialize device** in the menu **Device** (Figure 9-2).
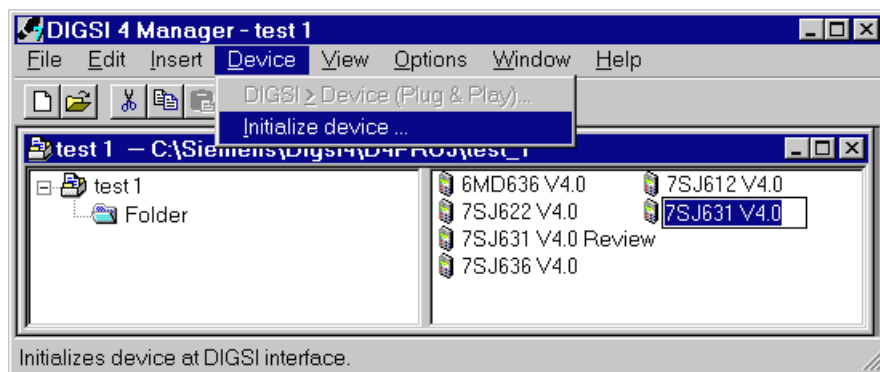
Figure 9-2   Initializing device via DIGSI® 4

❑ Enter password No. 7. The display becomes blank. After a successful initialization, the LEDs return to indicate normal operation and the default display reappears. The device settings are downloaded to the device provided they had been saved in the PC after commissioning (refer to Section 8.4). The device is then in-service.

Further Assistance   If these steps do not resolve the problem, please call your local Siemens representative or customer hotline.

Our customer hotline needs the following information to assist you:

– the complete MLFB (order number) of the device
– the serial number of the device (BF...)
– the firmware version
– the bootsystem version

This information is found in the device file which can be retrieved using DIGSI® 4 as shown in Figure 9-4. To reach this window:

❏ Open the DIGSI® 4 application in the PC and select the device.

❏ Doubleclick on this item. The **Open Device** dialog box opens, as shown in Figure 9-3.
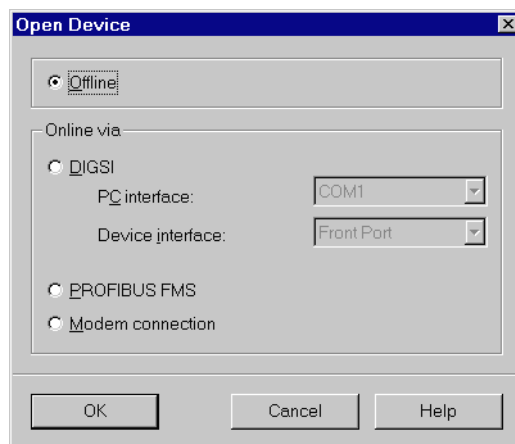
Figure 9-3   DIGSI® 4, dialog field Open Device

❏ Select the **Offline** mode and click **OK**; the initial DIGSI® 4 window opens.

❏ Select **File** → **Properties** from the menu bar. The desired information is shown.
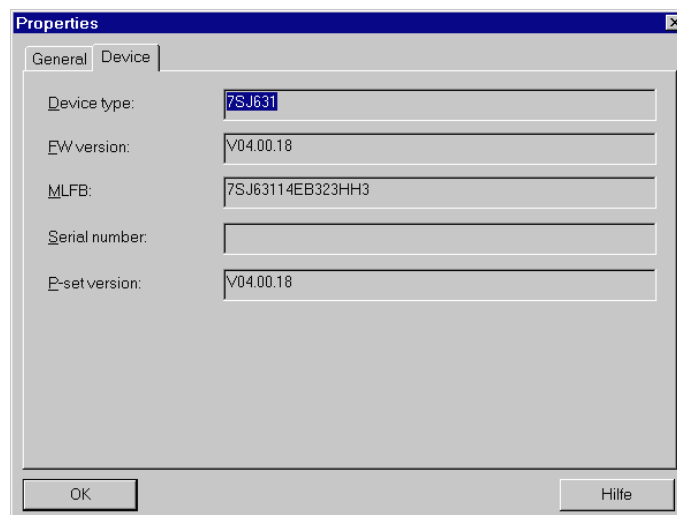
Figure 9-4   Retrieving the Device Data in the Device Properties

The MLFB number and the serial number can also be read from the label on the top of the device.

9.5 Corrective Action/Repairs

9.5.1 Software Procedures

A restart of the processor system, as described in Section 9.2, can be done as an attempt to solve a problem. Setting changes can be made to solve simple problems, such as sporadic alarms from elements of the measured-value-supervision. These attempts of solving problems can be done while the device is in service.

If a processor restart or setting change does not remedy the problem, then no further action should be done while the device is in service. Instead, replace the device with a tested spare.

9.5.2 Hardware Procedures

Hardware modifications or repair should be limited in scope to changes that are absolutely necessary. Some examples of hardware repair are changing the small fuse in the power supply and replacing a printed circuit board or module.

Hardware modifications or repair should only be done by experienced personnel. Do not insert or extract a printed circuit board unless the device is completely isolated. Soldering work must not be done on the printed circuit boards.

Disassembling the Device

The device must be disassembled if work is to be done on the printed circuit boards. The procedure below should be used.

☐ The following equipment is needed:

– Grounded mat for protecting components subject to damage from electrostatic discharges (ESD).

– Screwdriver with a 5 to 6 mm or $^{1}/_{4}$ inch tip.

– #1 Phillips screwdriver.

– 4.5 mm socket or nut driver.

☐ Open protective switches (test switches, fuses, or circuit breakers) to completely isolate the device.

☐ Disconnect all communication cables from the device. Carefully remove optical fibers from the device. Apply protective caps to the fiber ends and the communication ports on the device.
These activities do not apply if the device is for surface-mounting.

☐ Unfasten the screw-posts of the D-subminiature connector on the back panel at location "A."
This activity does not apply if the device is for surface-mounting.

☐ If the device has more communication interfaces at locations "B" and/or "C" on the rear, the screws located diagonally to the interfaces must be removed.
This step is not necessary if the device is for surface-mounting.

☐ Remove the corner covers on the front panel and loosen the screws that are holding the front panel to the device case.

☐ Carefully pull off the front panel. The component is connected to the CPU board with a short ribbon-cable.
Follow this step for a surface-mounted device. Here the front panel is not connected with a ribbon cable.

⚠ **Caution!**

Electrostatic discharges through the connections of the components, wiring, and plugs must be avoided! Wearing a grounded wrist strap is preferred. Otherwise, first touch a grounded metal part.

⚠ **Warning!**

Dangerous voltages exist in the device, even after the power supply is disconnected and the boards are withdrawn from the case! Capacitors can still be charged!

☐ At one end, disconnect the ribbon-cable between the front panel and the CPU board. To disconnect the cable, push up on the top latch of the plug connector and push down on the bottom latch of the plug connector. Carefully set the front panel on the grounded mat.
For the surface-mounted device, the 7-pin connector X16 must be disconnected from the CPU board behind the D-subminiature port, and the ribbon-cable that runs to the 68-pin connector on the back must be detached. Carefully set the front panel on the grounded mat.

☐ Disconnect the ribbon-cable between the CPU board and the I/O board.

☐ The boards can be removed and laid on the grounded mat to protect them from ESD damage.
A greater effort is required to remove the CPU board from the device designed for surface-mounting.

Replacing the Power Supply Fuse

☐ Verify that the replacement fuse has the correct amperage, delay time, dimensions, and identification.
The data are printed on the CPU board under the fuse, as shown in Figure 9-5. A single 5 x 20 mm fuse applies to all 7SJ61:
T4H250V acc. IEC 60127–2.

☐ Remove the CPU board. Place the board on the grounded mat for protection against ESD damage.
A greater effort is required to remove the CPU board in a device designed for surface-mounting. Place the board on the grounded mat.

☐ Remove the defective fuse. Figure 9-2 illustrates the fuse. The location is subject to change, but there is only one fuse on the CPU board.
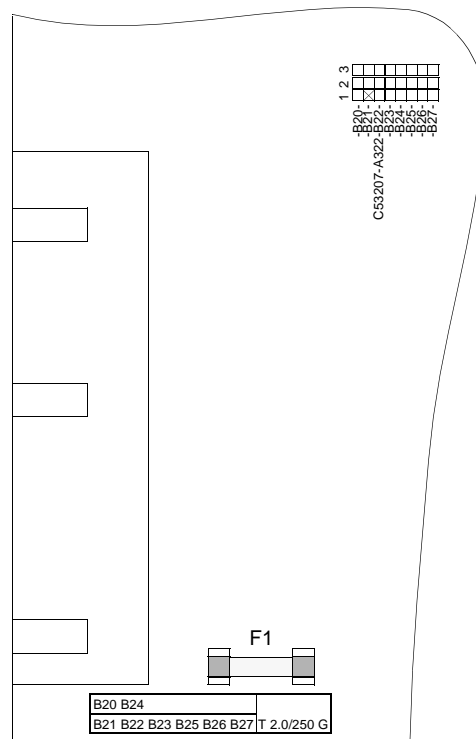
Figure 9-5   Power Supply Fuse on the Processor Printed Circuit Board CPU

☐ Install a new fuse in the holder.

☐ Carefully install the CPU board in the case. The position for the board is shown in Figure 9-1.
For the version of the device designed for surface-mounting, use the metal lever to insert the CPU board. The installation is then easier.

Reassembling the Device

To reassemble the device:

☐ By first attaching to the I/O board, connect the ribbon-cable between the I/O board and the CPU board. Be especially careful not to bend any of the connector pins! Do not use force! Be sure the connectors latch.

☐ Connect the ribbon-cable between the CPU board and the front panel. Be especially careful not to bend any of the connector pins! Do not use force! Be sure the plug connectors latch.
For the surface-mounted device, first connect the ribbon-cable from the 68-pin connector on the back of the device. Then attach connector X16 under the D-subminiature port on the CPU board. Make sure all connections are done properly.

☐ Carefully replace the front panel being mindful of the ribbon-cables. Fasten the front panel to the case with the four screws.

☐ Replace the four corner covers.

For the surface mount version the following steps are not applicable:

☐ Align and fix the rear interfaces again.

☐ Attach all Align all D-subminiature plugs to the matching D-subminiature sockets.

☐ Screw in the fiber optic cables where applicable.

Close the protective switches to apply voltage to the power supply. If the green "RUN" LED does not light, there is a fault in the power supply. The device should be sent to the factory. See Section 9.6.

9.6 Return

Siemens strongly recommends that **no** further repairs on defective devices, boards, or components be done. Special electronic components are used for which procedures for preventing electrostatic discharges must be followed. Most importantly, special production techniques are necessary to avoid damaging the wave-soldered multilayer board, the sensitive components, and the protective varnish.

If a problem cannot be solved by the procedures in Section 9.5, then it is recommended that the complete device including the housing be returned to the factory.

The original packaging material should be used for returning a device. If other packaging material is used, then the device and other contents must be provided with protection against shock according to IEC 60255–21–1 Class 2 and IEC 60255–21–2 Class 1.

Before returning a device, retrieve and save all of the protective and control settings, and any important information. Note any changes that were made to the jumpers on the internal printed circuit boards after the device was first delivered.

Note:

Repaired devices are returned from the factory with all jumpers on the printed circuit boards set in the original positions according to the ordering number. All addresses have the default setting.

■

Technical Data

10

This chapter provides the technical data of the SIPROTEC® 4 7SJ61 device and the individual functions of the device, including the limiting values that under no circumstances may be exceeded. The electrical and functional data are followed by the mechanical data, with dimensional drawings of 7SJ61 devices equipped with all options.

10.1 General Device Data

10.1.1 Analog Inputs and Outputs

	Nominal Frequency	f_N	50 Hz or 60 Hz	(adjustable)
Current Inputs	Nominal Current	I_N	1 A or 5 A	
	Ground Current, SensitiveI_{Ns}		≤ 1.6 A	

Burden per Phase and Ground Path
- At $I_N = 1$ A   approx. 0.05 VA
- At $I_N = 5$ A   approx. 0.3 VA
- Sensitive Ground Fault Detection 1 A   approx. 0.05 VA

AC Current Overload Capability
- Thermal (rms) $100 \cdot I_N \leq 1$ s
       $30 \cdot I_N \leq 10$ s
       $4 \cdot I_N$ continuous
- Dynamic (current pulse) $250 \cdot I_N$ for 0.5 cycle

AC Current Overload Capability for Sensitive Ground Fault Detection
- Thermal (rms)   300 A ≤ 1 s
       100 A ≤ 10 s
       15 A   continuous
- dynamic (impulse)   750 A   for 0.5 cycle

10.1.2 Power Supply

Direct Voltage   Voltage Supply Via Integrated Converter

Nominal Power Supply Direct Voltage $V_{PS\ nom}$	24/48 VDC	60/110/125 VDC
Permissible Voltage Ranges	19 to 58 VDC	48 to 150 V DC

Nominal Power Supply Direct Voltage V_{PSnom}	110/125/220/250 VDC	220/250 VDC
Permissible Voltage Ranges	88 to 300 V DC	176 to 350 V DC

Permissible AC Ripple Voltage, peak to peak ≤ 12 % of the power supply voltage

Power Consumption   Quiescent   approx. 4 W
                      Energized   approx. 7 W

Bridging Time for Failure/Short Circuit ≥ 50 ms at $V \geq 110$ VDC
                                             ≥ 10 ms at $V \geq 24$ VDC

Alternative Voltage   Voltage Supply via Integrated Converter

Nominal Power Supply Alternating Voltage V_{PS} AC	115 VAC	230 VAC
Permissible Voltage Ranges	92 to 132 VAC	184 to 265 VAC
Power Consumption, Quiescent	approx. 3 VA	approx. 3 VA
Power Consumption, Energized	approx. 7 VA	approx. 7 VA

Bridging Time for Failure/Short Circuit $\geq$ 10 ms

10.1.3 Binary Inputs and Outputs

Binary Inputs	Number		
	7SJ610*–		3 (configurable)
	7SJ611*–		8 (configurable)
	7SJ612*–		11 (configurable)
	Nominal Voltage Range		24 VDC to 250 VDC, bipolar
	Current Consumption, Energized		approx. 1.8 mA, independent of the control voltage
	Switching Thresholds		adjustable voltage range with jumpers
	– For Nominal Voltages 24/48/60 VDC		$V_{PU} \geq$ 19 VDC $V_{DO} \leq$ 14 VDC
	– For Nom. Voltages 110/125/220 VDC		$V_{PU} \geq$ 88 VDC $V_{DO} \leq$ 66 VDC
	Maximum Permissible Voltage		300 V DC
	Impulse Filter on Input		220 nF Coupling Capacitor at 220 V with recovery time > 60 ms
Output Relays[1]	<u>Output Relays for Commands/Annunciations</u>		
	Number		
	7SJ610*–		4 (configurable)
	7SJ611*–		8 (configurable)
	7SJ612*–		6 (configurable)
	Contacts per Relay		1 NO/form A
	Switching Capability	MAKE	1000W/VA
		BREAK	30 W/VA
			40 W resistive
			25 W at L/R $\leq$ 50 ms
	Switching Voltage		250 V
	Permissible Current per Contact		5 A continuous
	and Total Current on common path		30 A for 0.5 s
	<u>1 Live Status Alarm Relay</u>		
	Contacts		1 changeover contact/form C
	Switching Capability	MAKE	30 W/VA
		BREAK	20 W/VA
			30 W resistive
			25 W at L/R $\leq$ 50 ms
	Switching Voltage		250 V
	Permissible Current		1 A continuous

[1]) UL–listed with the following nominal value:

120 V ac	Pilot duty, B300
240 V ac	Pilot duty, B300
240 V ac	5 A General Purpose
24 V dc	5 A General Purpose

48 V dc	0.8 A General Purpose
240 V dc	0.1 A General Purpose
120 V ac	1/6 hp (4.4 FLA)
240 V ac	1/2 hp (4.9 FLA)

10.1.4 Communications Interfaces

PC Front Interface	– Connection	front panel, non-isolated, RS 232, 9-pin DSUB port for connecting a personal computer
	– Transmission Speed	min. 4800 Baud; max. 38400 Baud Factory Setting: 38400 Baud; Parity: 8E1
	– Maximum Distance of Transmission	15 meters / 49 feet
Rear Service–/Modem– Interface	– Connection	isolated interface for data transfer
	– Operation	with DIGSI® 4
	– Transmission Speed	min. 4800 Bd, max. 38400 Bd Factory Setting: 38400 Bd
	<u>RS232/RS485</u>	RS232/RS485 depends on order code
	– Connection for flush mounted case	rear panel, mounting location "C" 9 pin DSUB port
	for panel-surface mounted case	at the terminal on the case bottom
	– Test Voltage	500 V AC
	<u>RS232</u>	
	– Maximum Distance of Transmission	15 meters / 49 feet
	<u>RS485</u>	
	– Maximum Distance of Transmission	1 km / 3280 feet / 0.62 mile
	<u>Fibre Optical Link</u> – Connector Type	ST–Connector
	with flush-mounted case	rear panel, mounting location "C"
	with panel surface- mounted case	on the case bottom
	– Optical Wavelength	λ = 820 nm
	– Laser Class 1 Under EN 60825–1/ –2	using glass fiber 50/125 μm or using glass fiber 62.5/125 μm
	– Optical Link Signal Attenuation	max. 8 dB, with glass fiber 62.5/125 μm
	– Channel Distance	max. 1.5 km (0.95 miles)
	– Character Idle State	selectable: factory setting "Light off"
SCADA Interface	Profibus–FMS or IEC 60870–5–103	floating interface for data transfer to a master terminal

RS232

– Connection for flush mounted case   rear panel, mounting location "C"
                                         9 pin DSUB port

           for panel surface-   at the terminal on the case bottom
           mounted case

– Test Voltage   500 V AC

– Transmission Speed   min. 4800 Bd, max. 38400 Bd
                                         Factory Setting: 38400 Bd

– Maximum Distance of Transmission   15 meters / 49 feet

RS485
– Connection for Flush Mounted Case   rear panel, installation location "B"
                                         9 pin DSUB Port RS 485

           for panel surface-   at the terminal on the case bottom
           mounted case   Profibus cable

– Test Voltage   500 V AC

– Transmission Speed   min. 4800 Bd, max. 38400 Bd
                                         Factory Setting: 38400 Bd

– Maximum Distance of Transmission   1 km / 3280 feet / 0.62 mile

Profibus RS485
– Connection for Flush Mounted Case   rear panel, installation location "B"
                                         9 pin DSUB Port RS 485

           for panel surface-   at the terminal on the case bottom
           mounted case

– Test Voltage   500 V AC

   Transmission Speed   up to 12 M Baud

– Maximum Distance of Transmission   1 km / 3280 feet / 0.62 mile at $\leq$ 93.75 kBd
                                         500 m /1640 feet /0.31 mile at $\leq$ 187.5 kBd
                                         200 m / 660 feet at $\leq$ 1.5 MBd
                                         100 m / 330 feet at $\leq$ 12 MBd

Profibus–FMS
Fibre Optical Link
– Connection   integrated ST connector for OWG
                                         direct access,
                                         single ring or twin ring, depending on order
           For Flush-Mounted Case   rear panel, mounting location "B"
           For Panel Surface-
           Mounted Case   on the case bottom

– Transmission Speed   up to 1.5 M Baud
           recommended: > 500 k Baud

– Optical Wavelength $\lambda = 820$ nm

– Laser class 1 Under EN 60825–1/ –2   using glass fiber 50/125 μm or
                                         using glass fiber 62.5/125 μm

	– Optical Link Signal Attenuation	max. 8 dB, with glass fiber 62.5/125 μm
	– Channel Distance	max. 1.5 km (0.95 miles)
	– Character Idle State	selectable: factory setting "Light Off"

Clock	– Time Synchronization	DCF77/IRIG B–Signal
	– Connection For Flush-mounted Case	rear panel, mounting location "A"
		9 - pin DSUB port
	For Panel Surface-Mounted Case	at the terminal on the case bottom
	– Signal Rated Voltage	selectable 5 V, 12 V or 24 V
	– Signal Levels and Burdens:	

	Rated Signal Voltage		
	5 V	12 V	24 V
V_{IHigh}	6.0 V	15.8 V	31 V
V_{ILow}	1.0 V at I_{ILow} = 0.25 mA	1.4 V at I_{ILow} = 0.25 mA	1.9 V at I_{ILow} = 0.25 mA
I_{IHigh}	4.5 mA to 9.4 mA	4.5 mA to 9.3 mA	4.5 mA to 8.7 mA
R_I	890 Ω at V_I = 4 V 640 Ω at V_I = 6 V	1930 Ω at V_I = 8.7 V 1700 Ω at V_I = 15.8 V	3780 Ω at V_I = 17 V 3560 Ω at V_I = 31 V

10.1.5 Electrical Tests

Specifications	Standards:	IEC 60255 (Product Standards) ANSI/IEEE C37.90.0,.C37.90.0.1,C37.90.0.2 UL 508 DIN 57 435 Part 303 See also standards for individual functions
Insulation Tests	Standards:	IEC 60255–5, IEC 60870–2–1
	– High Voltage Test (routine test) All circuits except power supply, Binary Inputs, and Communications Interface	2.5 kV (rms) AC
	– High Voltage Test (routine test) only power supply and binary inputs	3.5 kVDC
	– High Voltage Test (routine test) Only Isolated Communications and Time Synchronization Interfaces	500 V (rms) AC
	– Impulse Voltage Test (type test) All Circuits Except Communications and Time Synchronization Interfaces, Class III	5 kV (peak): 1.2/50 μs: 0.5 Ws: 3 positive and 3 negative surges in intervals of 5 s
EMC Tests for Im-munity (Type Tests)	Standards:	IEC 60255–6 and –22, (Product standards) EN 50082–2 (Generic standard)

		DIN 57 435 Part 303 ANSI/IEEE C37.90.1 and C37.90.2
	– High Frequency Test IEC 60255–22–1, Class III and VDE 0435 Part 303, Class III	2.5 kV (Peak): 1 MHz: τ = 15 ms; 400 Surges per s: Test Duration 2 s R_i=200 Ω
	– Electrostatic Discharge IEC 60255–22–2 Class IV and IEC 61000–4–2, Class IV	8 kV contact discharge: 15 kV air-discharge, both polarities:150 pF:R_i=330 Ω
	– Irradiation with HF Field, non-modulated IEC 60255–22–3 (Report) Class III	10 V/m: 27 MHz to 500 MHz
	– Irradiation with HF Field, amplitude modulated IEC 61000–4–3, Class III	10 V/m: 80 MHz to1000 MHz: 80 % AM: 1 kHz
	– Irradiation with HF Field, Pulse Modulated IEC 61000–4–3/ENV 50204, Class III	10 V/m: 900 MHz: repetition frequency 200 Hz: duty cycle of 50 %
	– Fast Transient Disturbance Variables/ Burst IEC 60255–22–4 and IEc 61000-4-4, Class IV	4 kV: 5/50 ns: 5 kHz: Burst length = 15 ms; repetition rate 300 ms: both polarities: R_i = 50 Ω: Test Duration 1 min
	– High Energy Surge Voltages (SURGE), IEC 61000–4–5 Installation Class 3 Power Supply	common mode: 2 kV: 12 Ω: 9 μF diff. mode: 1 kV: 2 Ω: 18 μF
	Measuring Inputs, Binary Inputs and Relay Outputs	common mode: 2 kV: 42 Ω: 0.5 μF diff. mode: 1 kV: 42 Ω: 0.5 μF
	– Line Conducted HF, amplitude modul. IEC 61000–4–6, Class III	10 V: 150 kHz to 80 MHz: 80 % AM: 1 kHz
	– Power System Frequency Magnetic Field IEC 61000–4–8, Class IV IEC 60255–6	30 A/m continuous: 300 A/m for 3 s: 50 Hz 0.5 mT: 50 Hz
	– Oscillatory Surge Withstand Capability ANSI/IEEE C37.90.1	2.5 to 3 kV (Peak Value): 1MHz to 1.5 MHz damped wave: 50 surges per s: duration 2 s: R_i = 150 Ω to 200 Ω
	– Fast Transient Surge Withstand Cap. ANSI/IEEE C37.90.1	4 kV to 5 kV: 10/150 ns: 50 Pulse per s; both polarities: Duration 2 s: R_i = 80 Ω
	– Radiated Electromagnetic Interference ANSI/IEEE C37.90.2	35 V/m: 25 MHz to 1000 MHz amplitude and pulse modulated
	– Damped Oscillations similar to IEC 60694–4–12, IEC 61000–4–12	2.5 kV (Peak Value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, R_i = 200 Ω
EMC Tests For Noise Emission (type test)	Standard:	EN 50081–1 (Generic Standard)
	– Radio Noise Voltage to Lines, Only Power Supply Voltage IEC–CISPR 22	150 kHz to 30 MHz Limit Class B

	– Radio Noise Field Strength IEC–CISPR 22	30 MHz to 1000 MHz Limit Class B
	– Harmonic Currents on the Network Lead At 230 VAC IEC 61000–3–2	Device is to be assigned Class D (applies only for devices with >50VA power consumption)
	– Voltage Variations and Flicker on the Network Lead at 230 VAC IEC 61000–3–3	Limits are observed

10.1.6 Mechanical Stress Tests

Vibration and Shock Stress During Operation	Standards:	IEC 60255–21 and IEC 60068
	– Vibration IEC 60255–21–1, Class 2 IEC 60068–2–6	Sinusoidal 10 Hz to 60 Hz: ±0.075 mm Amplitude; 60 Hz to 150 Hz: 1 g acceleration frequency sweep rate 1 Octave/min 20 cycles in 3 orthogonal axes.
	– Shock IEC 60255–21–2, Class 1 IEC 60068–2–27	Half-sine shaped acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
	– Seismic Vibration IEC 60255–21–2, Class 1 IEC 60068–3–3	Sinusoidal 1 Hz to 8 Hz ± 3.5 mm Amplitude (horizontal axis) 1 Hz to 8 Hz: ± 1.5 mm Amplitude (Vertical axis) 8 Hz to 35 Hz: 1 g acceleration (horizontale axis) 8 Hz to 35 Hz: 0.5 g acceleration (Vertical axis) Frequency Sweep Rate1 Octave/min 1 cycle in 3 orthogonal axes
Vibration and Shock Stress During Transport	Standards:	IEC 60255–21 and IEC 60068–2
	– Vibration IEC 60255–21–1, Class 2 IEC 60068–2–6	Sinusoidal 5 Hz to 8 Hz: ±7.5 mm Amplitude; 8 Hz to 150 Hz: 2 g acceleration Frequency sweep rate1 Octave/min 20 cycles in 3 orthogonal axes.
	– Shock IEC 60255–21–2, Class1 IEC 60068–2–27	Half-sine shaped Acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes.
	– Continuous Shock IEC 60255–21–2, Class 1 IEC 60068–2–29	Half-sine shaped Acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes.

10.1.7 Climatic Stress Tests

Ambient Temperatures	Standards:	IEC 60255–6
	– Recommended operating temperature	+23°F to +131°F or –5 °C to +55 °C
		Visibility of display may be impaired at +131°F and above
	– Limiting, temporary (transient) operating temperatures	– 4°F to +158°F or –20 °C to +70 °C
	– Limiting temperatures for storage	–13°F to +131°F or –25 °C to +55 °C
	– Limiting temperatures for transport	–13°F to +158°F or –25 °C to +70 °C
	STORE AND TRANSPORT THE DEVICE WITH FACTORY PACKAGING.	
Humidity	Permissible Humidity	Mean value per year ≤75% relative humidity, on 56 days of the year up to 93% relative humidity.
		CONDENSATION MUST BE AVOIDED
	Siemens recommends that all devices be installed such that they are not exposed to direct sunlight, nor subject to large fluctuations in temperature that may cause condensation to occur.	

10.1.8 Service Conditions

The protective device is designed for use in an industrial environment and an electrical utility environment. Proper installation procedures should be followed to ensure electromagnetic compatibility (EMC). In addition, the following are recommended:

- All contactors and relays that operate in the same cubicle, cabinet, or relay panel as the numerical protective device should, as a rule, be equipped with suitable surge suppression components.

- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield grounded at both ends. The shield must be capable of carrying the fault currents that could occur. For substations with lower operating voltages, no special measures are normally required.

- Do not withdraw or insert individual modules while the protective device is energized. When handling the modules or the device outside of the case, standards for components sensitive to electrostatic discharge (ESD) must be observed. The modules and device are not endangered when inserted into the case.

10.1.9 Construction

Case	7XP20
Dimensions	see dimensional drawings, Section 10.15
Weight (mass) – In case for surface mounting – In case for flush mounting	 9.9 pounds (4.5 kg) 8.8 pounds (4.0 kg)
International Protection Under IEC 60529	
– in the surface mounted case	IP 51
– in the flush mounted case and in model with the detached operator interface	
Front	IP 51
Back	IP 50
– For human safety	IP 2x Terminals covered with protection cap

10.2　Definite-Time Overcurrent Protection (50 and 50N Elements)

Pickup and Time Delay Ranges/ Resolutions	Pickup Current	50–1 (phases)	0.50 A to 175.00 A[1])(increments 0.05 A)[1]) or ∞ (ineffective, no pickup)
	Pickup Current	50N–1 (ground)	0.25 A to 175.00 A[1])(increments 0.05 A)[1]) or ∞ (ineffective, no pickup)
	Pickup Current	50–2 (phases)	0.50 A to 175.00 A[1])(increments 0.05 A)[1]) or ∞ (ineffective, no pickup)
	Pickup Current	50N–2 (ground)	0.25 A to 175.00 A[1])(increments 0.05 A)[1]) or ∞ (ineffective, no pickup)
	Delay Times T	50–1, 50–2, 50N–1, 50N–2	0.00 s to 60.00 s　(increments 0.01 s) or ∞ (does not expire)
	The set times are pure delay times.		
Inherent Operating Times	Pickup times without delay (T) or inrush stabilization. With inrush stabilization add 10 ms		
	50–1, 50–2, 50N–1, 50N–2		
	– Current = 2 x Pickup Value – Current = 10x Pickup Value		approx. 30 ms approx. 20 ms
	Dropout Times		
	50–1, 50–2, 50N–1, 50N–2		approx. 40 ms
Dropout	Dropout/Pickup (ratio)		approx. 0.95 for $I/I_N \geq 0.3$
Tolerances	Pickup Current 50–1, 50–2, 50N–1, 50N–2 Delay Times T		2 % of setting value or 50 mA[1]) 1 % of setting value or 10 ms
Influencing Variables for Pickup	Power supply direct voltage in range $0.8 \leq V_{PS}/ V_{PS\ nominal} \leq 1.15$		1 %
	Temperatur in range 23° F $\leq \vartheta_{amb} \leq 131^\circ$ F		0.06% /10° F
	Frequency in range $0.95 \leq f/f_N \leq 1.05$		1 %
	Harmonic currents – Up to 10 % 3. Harmonic – Up to 10 % 5. Harmonic		1 % 1 %

[1]) For I_N = 1 A, divide all limits and increments by 5.

10.3   Inverse-Time Overcurrent Protection (51 and 51N Elements)

Pickup and Time Multiplier Ranges/ Resolutions	Pickup Current 51, 51N	0.50 A to 20.00 A[1] (Increments 0.05 A)[1]
	Time Multipliers for T_p, T_{Ep} I_p, I_{Ep}, IEC–Characteristics	0.05 s to 3.20 s (Increments 0.01 s) or ∞ (delay does not expire)
	Time Multiplier for 51, 51N D ANSI characteristics	0.05 s to 15.00 s (Increments 0.01 s) or ∞ (delay does not expire)
Trip Time Characteristics As Per IEC	As per IEC 60255-3, Section 3.5.2 or BS 142 (See also Figure 10-1)	
	NORMAL INVERSE (Type A)	$t = \dfrac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p$ [s]
	VERY INVERESE (Type B)	$t = \dfrac{13.5}{(I/I_p)^{1} - 1} \cdot T_p$ [s]
	EXTREMELY INV. (Type C)	$t = \dfrac{80}{(I/I_p)^{2} - 1} \cdot T_p$ [s]
	LONG INVERSE (Type B)	$t = \dfrac{120}{(I/I_p)^{1} - 1} \cdot T_p$ [s]
	For All Characteristics	
	t trip time in seconds T_p setting value of the time multiplier I fault current I_p setting value of the pickup current	
	The trip times for $I/I_p \geq 20$ are identical to those for $I/I_p = 20$.	
	Pickup threshold	approx. $1.10 \cdot I_p$
	Dropout threshold	approx. $1.05 \cdot I_p$ for $I_p/I_N \geq 0.3$
Tolerances	Pickup Currents I_p, I_{Ep}	2 % of setting value, or 50 mA[1]
	Trip Time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Influencing Variables for Pickup	Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PS\ nominal} \leq 1.15$	1 %
	Temperature in range 23° F $\leq \vartheta_{amb} \leq 131^\circ$ F	0.06% /10° F
	Frequency in range $0.95 \leq f/f_N \leq 1.05$	1 %
	Harmonic currents – Up to 10 % 3. Harmonic – Up to 10 % 5. Harmonic	1 % 1 %

[1] For I_N = 1 A, divide all limits and increments by 5.

Normal Inverse:
(Type A)

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p \quad [s]$$
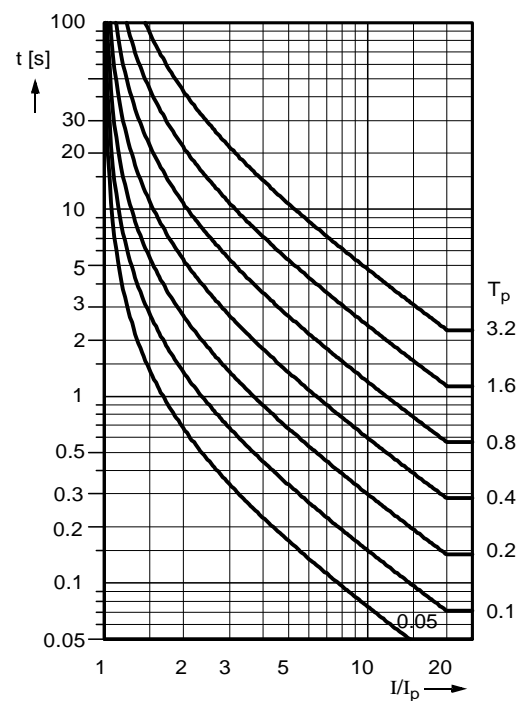
Very inverse:
(Type B)

$$t = \frac{13.5}{(I/I_p)^1 - 1} \cdot T_p \quad [s]$$
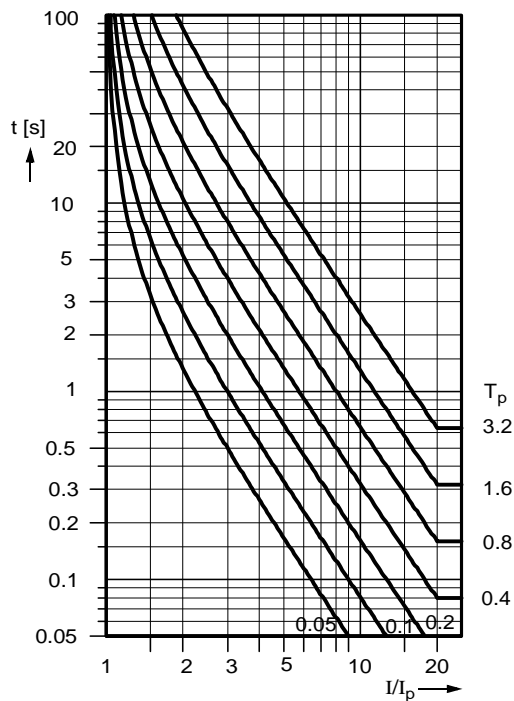
Extremely Inverse:
(Type C)

$$t = \frac{80}{(I/I_p)^2 - 1} \cdot T_p \quad [s]$$
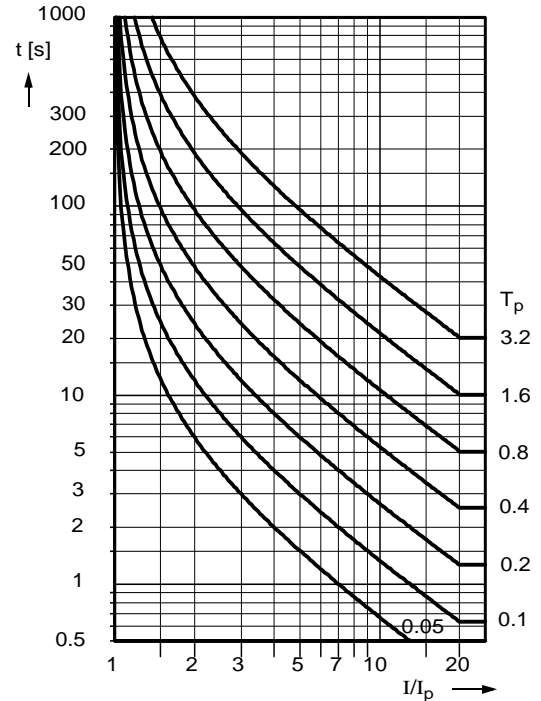
Long Inverse:

$$t = \frac{120}{(I/I_p)^1 - 1} \cdot T_p \quad [s]$$

t   trip time in seconds
T_p setting value of the time factor
I   fault current
I_p setting value of the pickup cur-

Note: For ground faults read I_{Ep} stead of I_p and T_{Ep} instead of T_p

Figure 10-1   Trip Characteristics of the Inverse-time Overcurrent Protection, as per IEC 60755–3 (phases and ground)

Trip Time Characteristics As Per ANSI	As per ANSI/IEEE (see also Figures 10-2 and 10-3)

INVERSE

$$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966 \right) \cdot D \ [s]$$

SHORT INVERSE

$$t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393 \right) \cdot D \ [s]$$

LONG INVERSE

$$t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592 \right) \cdot D \ [s]$$

MODERATELY INV.

$$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228 \right) \cdot D \ [s]$$

VERY INVERSE

$$t = \left(\frac{3.922}{(I/I_p)^2 - 1} + 0.0982 \right) \cdot D \ [s]$$

EXTREMELY INVERSE

$$t = \left(\frac{5.64}{(I/I_p)^2 - 1} + 0.02434 \right) \cdot D \ [s]$$

DEFINITE INVERSE

$$t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359 \right) \cdot D \ [s]$$

For all Characteristics

t	= Trip time in seconds
D	= Setting value of the time multiplier
I	= Fault Current
I_p	= Setting value of the pickup current

The trip times for $I/I_p \geq 20$ are identical to those for $I/I_p = 20$.

Pickup Threshold	approx. $1.10 \cdot I_p$

Reset Time Characteristic As Per ANSI

	ANSI INVERSE	$t_{Reset} = \left(\dfrac{8.8}{(I/I_p)^{2.0938} - 1} \right) \cdot D$ [s]
	ANSI SHORT INVERSE	$t_{Reset} = \left(\dfrac{0.831}{(I/I_p)^{1.2969} - 1} \right) \cdot D$ [s]
	ANSI LONG INVERSE	$t_{Reset} = \left(\dfrac{12.9}{(I/I_p)^{1} - 1} \right) \cdot D$ [s]
	ANSI MODERATELY INV.	$t_{Reset} = \left(\dfrac{0.97}{(I/I_p)^{2} - 1} \right) \cdot D$ [s]
	ANSI VERY INVERSE	$t_{Reset} = \left(\dfrac{4.32}{(I/I_p)^{2} - 1} \right) \cdot D$ [s]
	ANSI EXTREMELY INV.	$t_{Reset} = \left(\dfrac{5.82}{(I/I_p)^{2} - 1} \right) \cdot D$ [s]
	ANSI DEFINITE INV.	$t_{Reset} = \left(\dfrac{1.03940}{(I/I_p)^{1.5625} - 1} \right) \cdot D$ [s]

for $0.05 < (I/I_p) \leq 0.90$

For all Characteristics

t_{RESET} = Reset time in seconds
D = Setting value of the time multiplier
I = Fault Current
I_p = Setting value of the pickup current

Dropout	ANSI without Disk–Emulation Dropout/Pickup (ratio)	approx. [$1.05 \cdot I_p$ setting value] for $I_p/I_N > 0.3$, corresponds to approx. [$0.95 \cdot$ pickup threshold]
	ANSI with Disk Emulation Dropout/Pickup (ratio)	approx. [$0.90 \cdot I_p$ setting value]

Tolerances	Dropout Threshold I_p, I_{Ep}	2 % of setting value or 50 mA[1])
	Dropout Time for $0.05 \leq I/I_p \leq 0.90$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

Influencing Variables	Power Supply Direct Voltage in Range $0.8 \leq V_{PS}/V_{PS\ nominal} \leq 1.15$	1 %
	Temperature in Range 23° F $\leq \vartheta_{amb} \leq 131^o$ F	0.06% /10° F
	Frequency in Range $0.95 \leq f/f_N \leq 1.05$	1 %, referring to reference time

[1]) For I_N = 1 A, divide all limits and increments by 5.
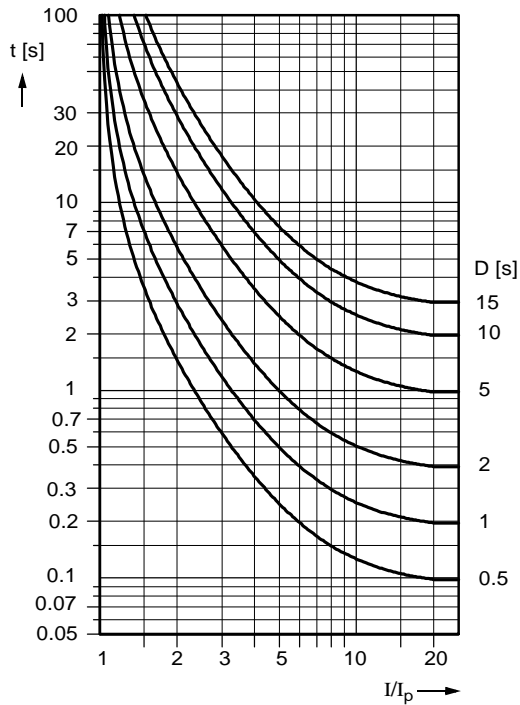
INVERSE
$$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966 \right) \cdot D \text{ [s]}$$
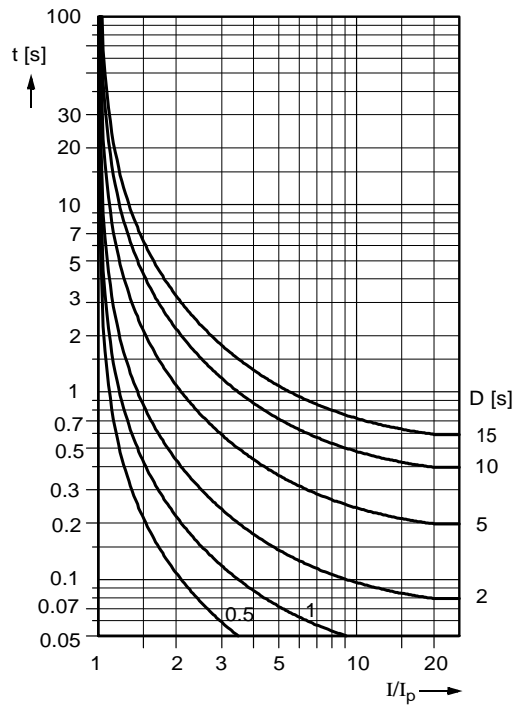
SHORT INVERSE
$$t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393 \right) \cdot D \text{ [s]}$$
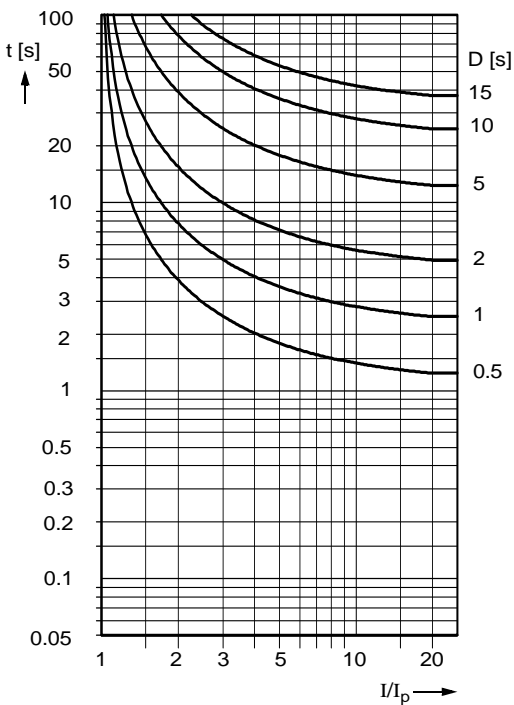
LONG INVERSE
$$t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592 \right) \cdot D \text{ [s]}$$
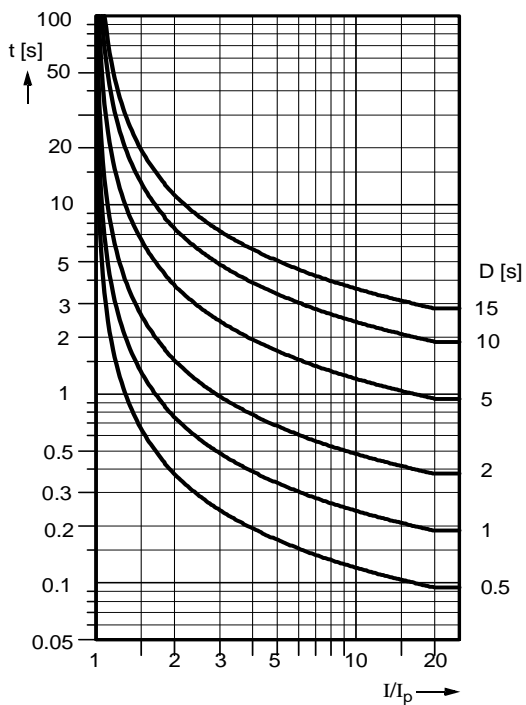
MODERATELY INVERSE
$$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228 \right) \cdot D \text{ [s]}$$

Figure 10-2   Trip Time Characteristics Of The Inverse-time Overcurrent Protection, As Per ANSI/IEEE (Phases, Ground)
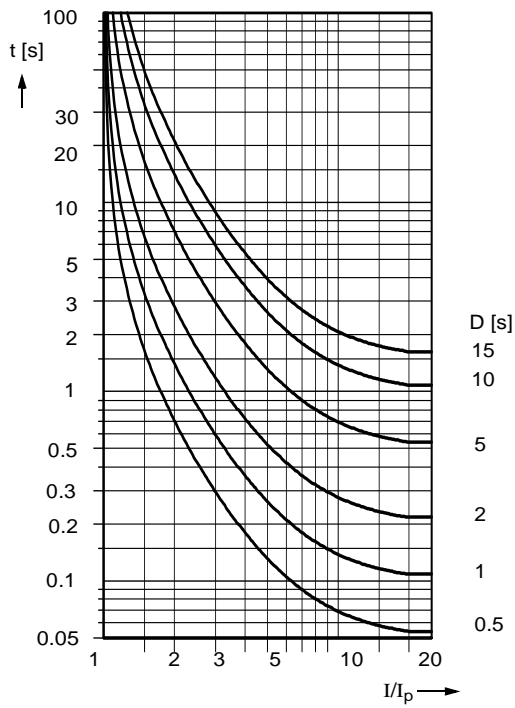
VERY INVERSE
$$t = \left(\frac{3.922}{\left(I/I_p\right)^2 - 1} + 0.0982 \right) \cdot D \ [s]$$
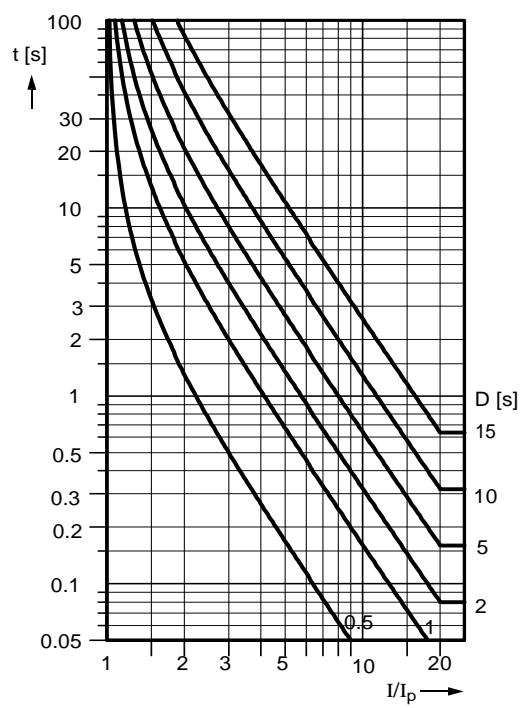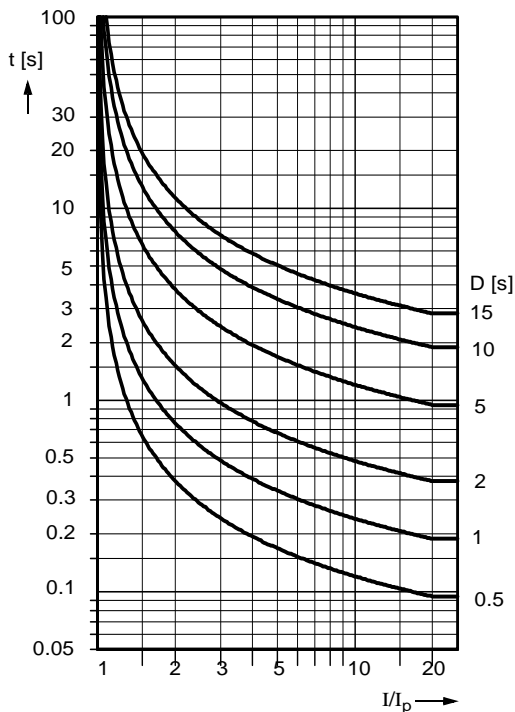
EXTREMELY INVERSE
$$t = \left(\frac{5.64}{\left(I/I_p\right)^2 - 1} + 0.02434 \right) \cdot D \ [s]$$

t = Trip time in seconds
D = Setting value of the time multiplier
I = Fault Current
I_p = Setting value of the pickup current

DEFINITE INVERSE
$$t = \left(\frac{0.4797}{\left(I/I_p\right)^{1.5625} - 1} + 0.21359 \right) \cdot D \ [s]$$

Figure 10-3 Trip Characteristics Of The Inverse-time Overcurrent Protection, As Per ANSI/IEEE (Phases And Ground)

10.4   Dynamic Cold Load Pick–up Function (50c, 50Nc, 51Nc)

Timed Changeover of Settings	Controlled Elements	Directional and non-directional time over-current protective elements (separate phase andground settings)
	Initiation Criteria	Current Criteria"BkrClosed I MIN" or Binary input controlled, for example, by 52/b contact
	Timing	3 time levels ($T_{CB\,Open}$, T_{Active}, T_{Stop})
	Current Control	Current threshold "BkrClosed I MIN" (reset on current falling below threshold: monitoring with timer)
Adjustment Ranges/ Resolution	Current Control"BkrClosed I MIN"	0.20 A to 5.00 A[1]) (Increments 0.05 A)[1])
	Time Until Changeover To Dynamic Settings — $T_{CB\,Open}$	0 s to 21600 s (= 6 h) (Increments 1 s)
	Period Dynamic Settings are Effective After a Reclosure — T_{Active}	4 s to 21600 s (= 6 h) (Increments 1 s)
	Fast Reset Time — T_{Stop}	1 s to 600 s (= 10 min) (Increments 1 s) or ∞ (fast reset inactive)
	Dynamic Settings of Pickup Currents and Time Delays or Time Multipliers	Adjustable within the same ranges [1]) and with the same increments [1]) as the directional and non-directional time overcurrent protection

[1]) For I_N = 1 A, divide all limits and increments by 5.

10.5   Inrush Restraint

	Controlled Elements	All 50, 50N, 51, 51N, 67, and 67N Elements
Adjustment Ranges/ Resolution	Stabilization Factor Second Harmonic — I_{2f}/I	10 % to 45 % (Increments 1 %)
Function Limits Crossblock	Lower Function Limit Upper Function Limit, Adjustable	at least one phase current $\geq$ 1.25 A[1]) 1.50 A to 125.00 A[1])(Increments 0.05 A)[1])
Crossblock	I_a, I_b, I_c	ON/OFF

[1]) For I_N = 1 A, divide all limits and increments by 5.

10.6   Sensitive Ground Fault Detection (50Ns, 51Ns)

Ground Fault Pick-up	Definite Time Characteristic		
for All Types of Ground Faults	Pickup Current	50-Ns-1	0.003 A to 1.500 A (increments 0.001 A)
	Delay Time	50-Ns-1	0.00 s to 320.00 s (increments 0.01 s) or ∞ (ineffective)
	Pickup Current	50-Ns-2	0.003 A to 1.500 A (increments 0.001 A)
	Delay Time	50-Ns-2	0.00 s to 320.00 s (increments 0.01 s) or ∞ (ineffective)
	Inherent Pickup Time		≤ 60 ms
	Dropout/Pickup (ratio)		approx. 0.95 for $I_{Ns} \geq 50$ mA
	Measurement Tolerance Operating Time Tolerance		2 % of setting value or 1 mA 1 % of setting value or 20 ms
	User-defined Characteristic		user-specified characteristic (defined by maximum of 20 pairs of current–trip time values)
	Pickup Current	51 Ns	0.003 A to 1.400 A (increments 0.001 A)
	Time multiplier	51 Ns	0.10 to 4.00 (increments 0.01) or ∞ (ineffective)
	Pickup Threshold		approx. $1.10 \cdot I_{Nsp}$
	Dropout Threshold		approx. $1.05 \cdot I_{Nsp}$ for $I_{Nsp} > 50$ mA
	Measurement Tolerance		2 % of setting value or 1 mA
	Operating Time Tolerance in the Linear Range		7% of reference value for $2 \leq I/I_{Nsp} \leq 20$ + 2% current tolerance, or 70 ms
Influencing Variables	Power supply direct voltage in range $0.8 \leq V_{PS}/ V_{PS\ nominal} \leq 1.15$		1 %
	Temperatur in range 23° F $\leq \vartheta_{amb} \leq 131^{o}$ F		0.06% /10° F
	Frequency in range $0.95 \leq f/f_N \leq 1.05$		1 %
	Harmonic currents – Up to 10 % 3rd Harmonic – Up to 10 % 5th Harmonic		1 % 1 %

Note: For the purpose of high sensitivity, the linear range of the measuring input for the sensitive ground fault acquisition is from 0.003 A to 1.6 A. For currents greater than 1.6 A, this function drops out!

The set times are pure delay times for the definite time characteristic.

10.7 Negative Sequence Protection (46)

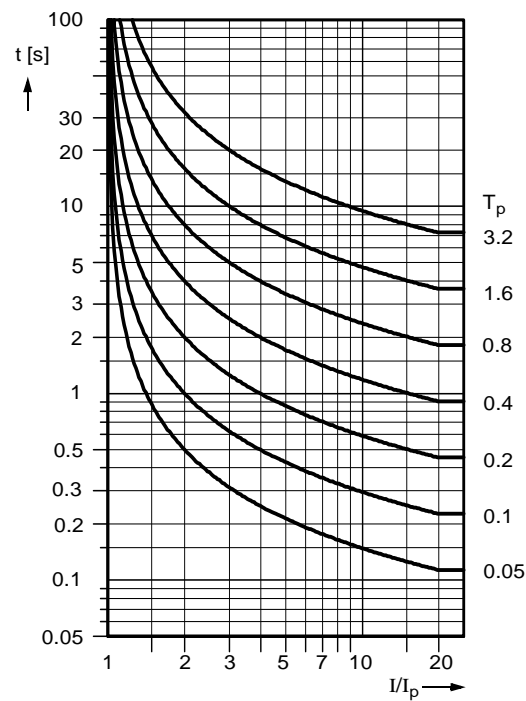### 10.7.1 Definite–Time Elements (46-1 and 46-2)

Pickup and Time Delay Ranges/ Resolutions	Pickup Current	46-1	0.50 A to 15.00 A [1](Increments 0.05 A) [1] or ∞ (ineffective, no pickup)
	Pickup Current	46-2	0.50 A to 15.00 A [1](Increments 0.05 A) [1] or ∞ (ineffective, no pickup)
	Time Delays	46-1, 46-2	0.00 s to 60.00 s (Increments 0.01 s) or ∞ (does not expire)
Functional Limits	Lower Functional Limit		at least one phase current $\geq$ 0.5 A[1]
	Upper Functional Limit		all phase currents $\leq$ 20 A[1]
Inherent Operating Times	Pickup Time		approx. 35 ms
	Dropout Time		approx. 35 ms
Dropout	Dropout/Pickup (ratio) 46-1, 46-2		approx. 0.95 for I_2/I_N > 0.3
Tolerances	Pickup Currents 46-1, 46-2 Time Delays		3% of set value or 50 mA[1] 1% or 10 ms
Influencing Variables for Pickup-Pickup Currents	Power Supply DC voltage in range $0.8 \leq V_{PS}/ V_{PS\ nominal} \leq 1.15$		1%
	Temperature in range 23° F $\leq \vartheta_{amb} \leq 131^\circ$ F		0.06% /10º F
	Frequency in range $0.95 \leq f/f_N \leq 1.05$		1%
	Harmonic currents – Up to 10 % 3rd Harmonic – Up to 10 % 5th Harmonic		1 % 1 %

[1]) For I_N = 1 A, divide all limits and increments by 5.

10.7.2 Inverse–Time Elements (46-TOC)

Pickup and Time Multiplier	Pickup Current	46–TOC	0.50 A to 10.00 A[1](Increments 0.05 A)[1]
	Time Multiplier (IEC)	T_{I2p}	0.05 s to 3.20 s (Increments 0.01 s) or ∞ (does not trip)
	Time Multiplier (ANSI)	D_{I2p}	0.50 s to 15.00 s (Increments 0.01 s) or ∞ (does not trip)
Functional Limits	Lower Functional Limit Upper Functional Limit		at least one phase current $\geq$ 0.5 A[1] all phase currents $\leq$ 20 A[1]

[1]) For I_N = 1 A, divide all limits and increments by 5.

Time Trip Characteristics As Per IEC 60255–3	See also Figure10-4	
	IEC NORMAL INVERSE	$t = \dfrac{0.14}{(I_2/I_{2p})^{0.02} - 1} \cdot T_{I2p}$ [s]
	IEC VERY INVERSE	$t = \dfrac{13.5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p}$ [s]
	IEC EXTREMELY INVERSE	$t = \dfrac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p}$ [s]

for $1.1 < (I_2/I_{2p}) \leq 20$

Where:

t	trip time in seconds
T_{I2p}	setting value of the time multiplier
I_2	negative sequence currents
I_{2p}	setting value of the pickup current

Trip Time Characteristics As Per ANSI	See Also Figure10-5	
	ANSI INVERSE	$t = \left(\dfrac{8.9341}{(I_2/I_{2p})^{2.0938} - 1} + 0.17966 \right) \cdot D_{I2p}$ [s]
	ANSI MODERATELY INVERSE	$t = \left(\dfrac{0.0103}{(I_2/I_{2p})^{0.02} - 1} + 0.0228 \right) \cdot D_{I2p}$ [s]
	ANSI VERY INVERSE	$t = \left(\dfrac{3.922}{(I_2/I_{2p})^{2} - 1} + 0.0982 \right) \cdot D_{I2p}$ [s]
	ANSI EXTREMELY INVERSE	$t = \left(\dfrac{5.64}{(I_2/I_{2p})^{2} - 1} + 0.02434 \right) \cdot D_{I2p}$ [s]

for $1.1 < (I_2/I_{2p}) \leq 20$

Where:

t	trip time in seconds
D_{I2p}	setting value of the time multiplier
I_2	negative sequence currents
I_{2p}	setting value of the pickup current

The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$.

Pickup Threshold	approx. $1.10 \cdot I_{2p}$

Tolerances	Pickup Current I_{2p}	3% of set value or 50 mA
	Time for $2 \leq I_2/I_{2p} \leq 20$	5% of reference (calculated) value + 2 % current tolerance, or 30 ms

[1]) For $I_N = 1$ A, divide all limits and increments by 5.

Reset Time Characteristics As Per ANSI	**ANSI INVERSE**	$t_{Reset} = \left(\dfrac{8.8}{(I_2/I_{2p})^{2.0938} - 1} \right) \cdot D_{I2p}$ [s]
	ANSI MODERATELY INVERSE	$t_{Reset} = \left(\dfrac{0.97}{(I_2/I_{2p})^2 - 1} \right) \cdot D_{I2p}$ [s]
	ANSI VERY INVERSE	$t_{Reset} = \left(\dfrac{4.32}{(I_2/I_{2p})^2 - 1} \right) \cdot D_{I2p}$ [s]
	ANSI EXTREMELY INVERSE	$t_{Reset} = \left(\dfrac{5.82}{(I_2/I_{2p})^2 - 1} \right) \cdot D_{I2p}$ [s]

for $0.05 < (I_2/I_{2p}) \le 0.90$

Where:

t_{Reset}	trip time in seconds
D_{I2p}	setting value of the time multiplier
I_2	negative sequence currents
I_{2p}	setting value of the pickup current

Dropout	IEC and ANSI (without Disk Emulation)	approx. $1.05 \cdot I_{2p}$ Setting Value, which is approx. [$0.95 \cdot$ pickup threshold]
	ANSI with Disk–Emulation	approx. $0.90 \cdot I_{2p}$ Setting Value
Tolerances	Reset Current I_{2p}	2% of set value or 50 mA[1])
	Time for $0.05 \le I_2/I_{2p} \le 0.90$	5% of reference (calculated) value + 2 % current tolerance, minimum 30 ms
Influencing Variables for Pickup Currents	Power supply DC voltage in range $0.8 \le V_{PS}/V_{PS\ nominal} \le 1.15$	1%
	Temperature in range 23° F $\le \vartheta_{amb} \le 131^\circ$ F	0.06% /10° F
	Frequency in range $0.95 \le f/f_N \le 1.05$	1%
	Harmonic currents – Up to 10 % 3rd Harmonic – Up to 10 % 5th Harmonic	 1 % 1 %

[1]) For $I_N = 1$ A, divide all limits and increments by 5.

IEC NORMAL INVERSE:
$$t = \frac{0.14}{(I_2/I_{2p})^{0.02} - 1} \cdot T_{I2p} \ [s]$$
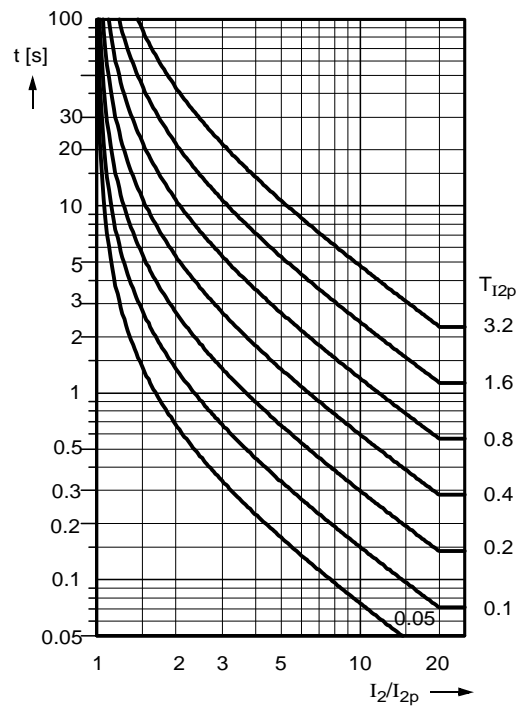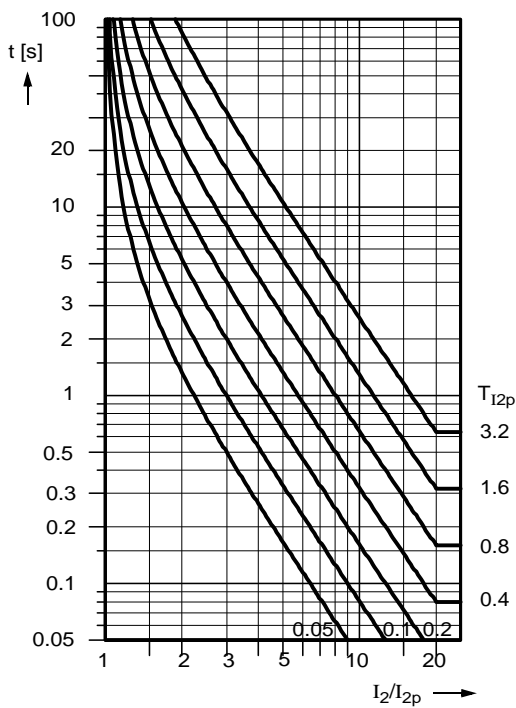
IEC VERY INVERSE:
$$t = \frac{13.5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p} \ [s]$$

t = Trip time in seconds

T_{I2p} = Setting value of the time multiplier

I_2 = Negative Sequence Current

I_{2p} = Setting value of the pickup current

IEC EXTREMELY INVERSE:
$$t = \frac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p} \ [s]$$

Figure 10-4   Trip Time Characteristic Curves Of The Inverse-time Negative Sequence Element 46-TOC, per IEC 60255–3
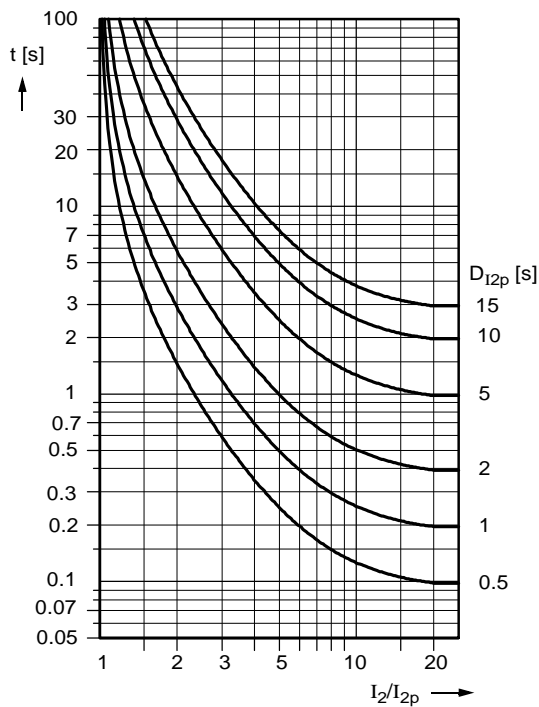
ANSI INVERSE: $t = \left(\dfrac{8.9341}{(I_2/I_{2p})^{2.0938} - 1} + 0.17966 \right) \cdot D_{I2p}$ [s]
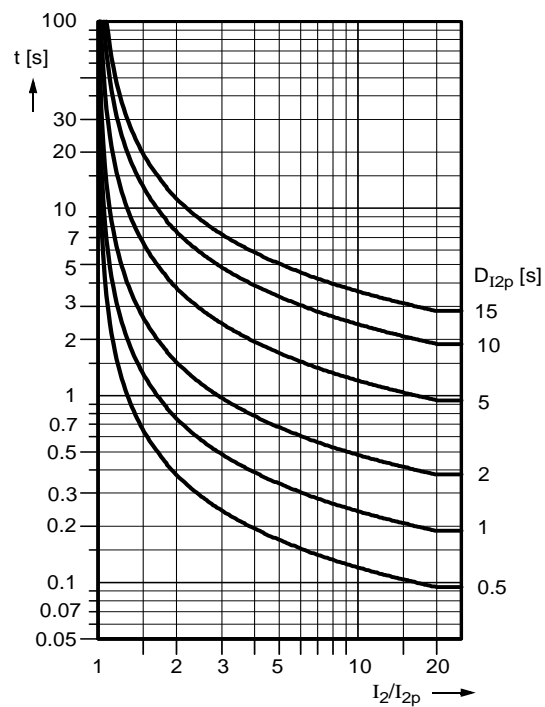
ANSI MODERATELY INV.: $t = \left(\dfrac{0.0103}{(I_2/I_{2p})^{0.02} - 1} + 0.0228 \right) \cdot D_{I2p}$ [s]
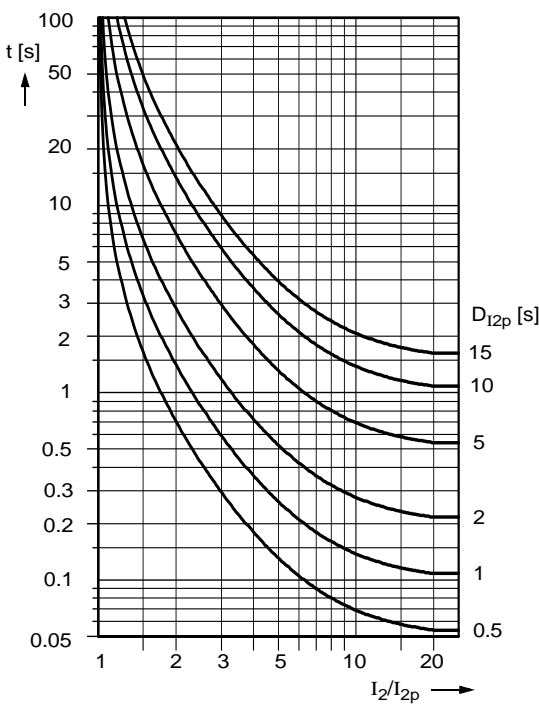
ANSI VERY INVERSE: $t = \left(\dfrac{3.922}{(I_2/I_{2p})^{2} - 1} + 0.0982 \right) \cdot D_{I2p}$ [s]
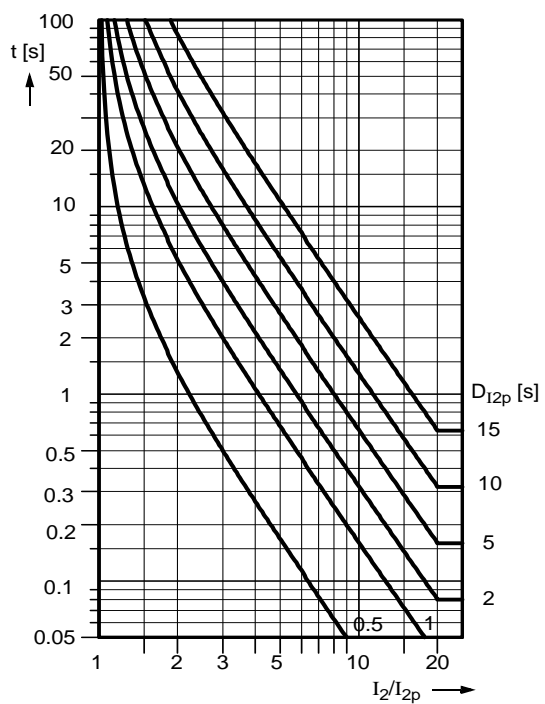
ANSI EXTREMELY INV.: $t = \left(\dfrac{5.64}{(I_2/I_{2p})^{2} - 1} + 0.02434 \right) \cdot D_{I2p}$ [s]

Figure 10-5 Trip Time Characteristic Curves Of The Inverse-time Negative Sequence Element, 46-TOC, per ANSI

10.8 Motor Starting Protection (48)

Setting Ranges/Increments	Motor Starting Current $I_{STARTUP}$	5.00 A to 80.00 A[1]) (Increments 0.05 A)[1]
	Pickup Threshold $I_{MOTOR\ START}$	3.00 A to 50.00 A[1])(Increments 0.05 A)[1]
	Permissible Starting Time $T_{STARTUP}$	1.0 to 180.0 s (Increments 0.1 s)
	Permissible Locked Rotor Time $T_{LOCKED\text{-}ROTOR}$	0.5 s to 120.0 s (Increments 0.1 s) or ∞ (step is ineffective)

Trip Time Characteristic	Trip Time Characteristics for $I_{rms\ >}\ I_{MOTOR\ START}$		$t = \left(\dfrac{I_{STARTUP}}{I_{rms}}\right)^2 \cdot T_{STARTUP}$
	Where:	$I_{STARTUP}$	Motor starting current setting.
		I_{rms}	Actual current flowing.
		$I_{MOTOR\ START}$	Pickup threshold setting, used to detect motor startup.
		t	Trip time in seconds.

Dropout Ratio	$I_{rms}/I_{MOTOR\ START}$	approx. 0.95
Tolerance	Pickup Threshold	2 % of set value, or 50 mA[1])
	Time Delay	5 % or 30 ms
Influencing Values for Pickup Threshold	Power supply DC voltage (V_{DC}) in range $0.8 \leq V_{PS}/V_{PS\ nominal} \leq 1.15$	1%
	Temperature in range $23^o\ F \leq \vartheta_{amb} \leq 131^o\ F$	0.3% /10° F
	Frequency in range $0.95 \leq f/f_N \leq 1.05$	1%
	Harmonics - Up to 10% 3rd harmonic - Up to 10% 5th harmonic	1% 1%

[1]) for I_N= 1 A, divide all limits by 5.

10.9   Thermal Overload Protection (49)

Setting Ranges/ Resolutions	K-Factor per IEC 60255-8		0.10 to 4.00 (Increments 0.01)
	Time Constant	τ	1.0 min to 999.9 min (Increments 0.1 min)
	Thermal Alarm (Θ ALARM)	$\Theta_{Alarm}/\Theta_{Trip}$	50% to 100% of the trip temperature rise (Increments 1%)
	Current Overload Alarm (I ALARM)	I_{Alarm}	0.50 A to 20.00 A[1] (Increments 0.05 A)[1]
	Extension K-Factor when Machine Stopped	k_t - Factor	1.0 to 10.0 relative to the time constant for the machine running(Increments 0.1)
	Emergency Time		10 s to 15000 s (Increments 1 s)
Trip Characteristic Curve			See also Figure 10-6
	Trip Characteristic Curve for $(I/\ k \cdot I_N) \le 8$		$t = \tau \cdot ln \dfrac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$ [min]
	Where:		t trip time in minutes
			τ Temperature rise time constant
			I Load current
			I_{pre} Pre-load current
			k Setting factor per VDE 0435 Part 3011 and IEC 60255–8, (see also Figure 10-6)
			I_N Nominal current of the device
Dropout Relations	Θ/Θ_{trip}		Drops out with Θ_{Alarm}
	Θ/Θ_{Alarm}		approx. 0.99
	I/I_{Alarm}		approx. 0.97
Tolerances	Referring to $k \cdot I_N$		2 % or 50 mA[1]; 2 % class per IEC 60255–8
	Thermal trip and alarm times		3 % or 1 s for $I/(k \cdot I_N) > 1.25$;
			3 % class per IEC 60255–8
Influencing Variables Referring to [$k \cdot I_N$]	Power supply DC voltage (V_{DC}) in range $0.8 \le V_{PS}/\ V_{PS\ nominal} \le 1.15$		1 %
	Temperature in range $23\ °F \le \vartheta_{amb} \le 131\ °F$		0.3% /10° F
	Frequency in range $0.95 \le f/f_N \le 1.05$		1 %

[1]) For $I_N = 1$ A, divide all limits and increments by 5.
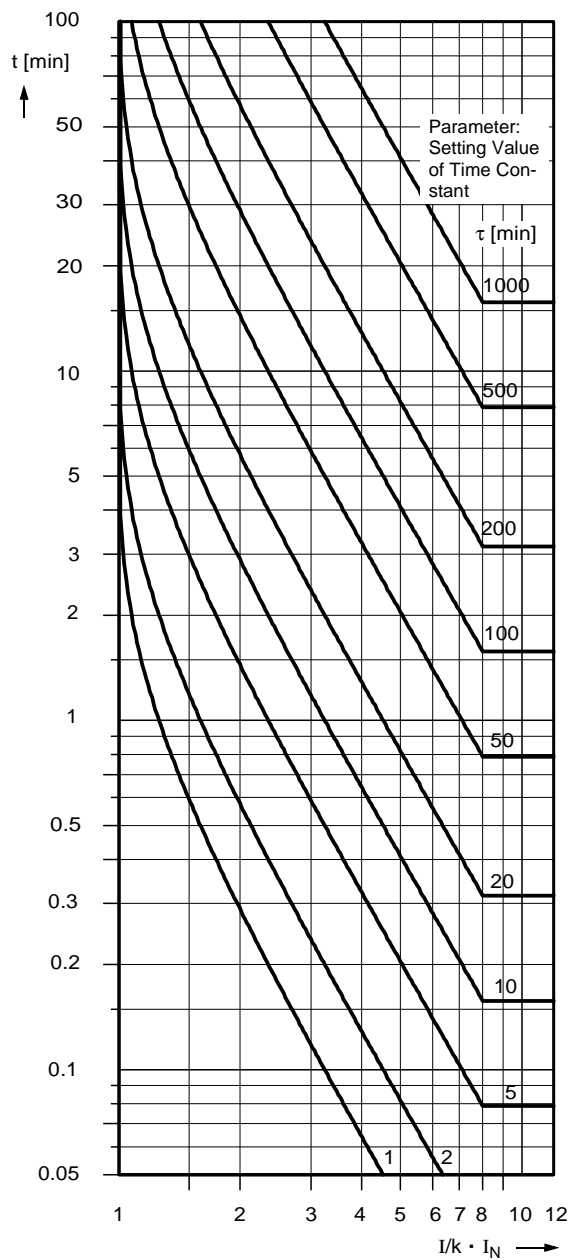
without pre-load:

with 90 % pre-load:

$$t = \tau \cdot \ln \frac{\left(\dfrac{I}{k \cdot I_N}\right)^2}{\left(\dfrac{I}{k \cdot I_N}\right)^2 - 1} \quad [\text{min}]$$

$$t = \tau \cdot \ln \frac{\left(\dfrac{I}{k \cdot I_N}\right)^2 - \left(\dfrac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\dfrac{I}{k \cdot I_N}\right)^2 - 1} \quad [\text{min}]$$

Figure 10-6   Trip Time Characteristic Curves For The Thermal Overload Protection (49)

10.10 Start Inhibit for Motors (66/68)

Setting Ranges / Resolutions				
	Starting Current Relative to Nominal Motor Current	$I_{Start}/I_{Motor\ nom}$	3.0 to 10.0	(Increments 0.1)
	Nominal Motor Current	$I_{Motor\ nom}$	1.0 A to 6.0 A[1])	(Increments 0.5 A)[1])
	Maximum Permissible Starting Time	$T_{Start\ Max}$	3 s to 120 s	(Increments 1 s)
	Temperature Equalization Time	T_{Equal}	0.0 min to 60.0 min	(Increments 0.1 min)
	Maximum Permissible Number of Warm Starts	n_{warm}	1 to 4	(Increments 1)
	Difference between Cold and Warm Starts	$n_{cold} - n_{warm}$	1 to 2	(Increments 1)
	Extension K-Factor for Cooling Simulations of Rotor at Rest	$k\tau$-Factor	1 to 10	(Increments 1)

Restarting Limit

$$\Theta_{RESTART} = \Theta_{Rot.max.perm} \cdot \frac{n_{COLD} - 1}{n_{COLD}}$$

Where:

$\Theta_{Restart}$	Temperature limit below which restarting is possible
$\Theta_{Rot.max.perm}$	maximum permissible motor over-temperature (= 100 % in operating measured value $\Theta_{Rot}/\Theta_{Rot\ trip}$)
n_{Cold}	Number of permissible restarts from cold state

[1]) For I_N = 1 A, divide all limits by 5.

10.11 Breaker Failure Protection (50BF)

Pickup and Time Delay Ranges/ Resolutions	Pickup of 50 Element BkrClosed I MIN		0.20 A to 5.00 A [1] (Increments 0.05 A)[1]
	Time Delay	TRIP-Timer	0.06 s to 60.00 s (Increments 0.01 s) or ∞ (no trip)
Initiating Time	Pickup Times (protection initiates)		
	- For Internal Start		included in time delay
	- Using Controls		included in time delay
	- For External Start		included in time delay
	Reset Time		approx. 25 ms
Tolerances	Pickup Current	BkrClosed I MIN	3% of set value, or 50 mA[1]
	Time Delay	TRIP-Timer	1% or 20 ms
Influencing Variables	Power supply DC voltage (V_{DC}) in range $0.8 \leq V_{PS}/ V_{PS\ nominal} \leq 1.15$		1%
	Temperature in range 23° F $\leq \vartheta_{amb} \leq 131^\circ$ F		0.3 % /10° F
	Frequency in range $0.95 \leq f/f_N \leq 1.05$		1%
	Harmonics - Up to 10% 3rd harmonic - Up to 10% 5th harmonic		1% 1%

[1]) For I_N = 1A, divide all limits by 5.

10.12 Automatic Reclosing System (79M)

Number of Reclosures	0 to 9 (for both phase and ground) Shots 1 to 4 individually adjustable
For Phase Faults-Processing 79 Initiates: Selectable	50-1, 50-2, 51, 46-1, 46-2, 46-TOC, Binary Inputs
For Ground Faults-Processing 79 Initiates: Selectable	50-1, 50-2, 51, 50N-1, 50N-2, 51N, Sensitive Ground Fault 50Ns, 51Ns Binary Inputs
Blocking of 79	Trip of protective elements for which 79 blocking is set.
	Three-phase fault detected by a protective element.
	Last trip command after the reclosing cycle is complete (unsuccessful reclosing).
	Trip command from the breaker failure protection.
	Opening the circuit breaker without 79 initiation.
	External CLOSE Command
Safety Time until 79 Ready	0.01 s to 300.00 s (Increments 0.01 s)
Dead Times (Separate for phase and ground, and individual for shots 1 to 4)	0.01 s to 320.00 s (Increments 0.01 s)
Extension of Dead Time	Using binary input with time monitoring
Maximum Inhibit Time (Binary Input)	0.01 s to 320.00 s (Increments 0.01 s)
Reset Time (Reclaim or Time Restraint)	0.50 s to 320.00 s (Increments 0.01 s)
Close Command Duration	0.01 s to 32.00 s (Increments 0.01 s)
Delay Time	0.01 s to 320.00 s (Increments 0.01 s)
Additional Functions	Definitive Trip.
	Coordination with other protective and control devices.
	Circuit breaker monitoring using, breaker auxiliary contacts.

10.13 Breaker Control

Number of Controlled Switching Device (e.g. Circuit Breakers)	Depends on the number of binary Devices inputs and outputs available
Interlocking	Freely programmable interlocking
Messages (Feedback)	Feedback messages; closed, open, intermediate position
Control Commands	Single command, double command
Operating Command to Switching Device	1, 1 plus 1 common, or 2 contacts
Programmable Logic Controller	PLC logic, graphic input tool
Local Control	Control via menu control, assignment of function keys
Remote Control	Using communication interfaces SCADA DIGSI$^®$ 4 (e.g. via modem)

10.14 Additional Functions

Operational Measured Values	Operating Measured Values for Currents – Ia, Ib, Ic	in A or kA primary; in A secondary, or in % of I_{Nom}
	- Range - Tolerance	10% to 200% I_{Nom} 1% of measure value or 0.5 % of I_{Nom}
	– I_G and $3I_0$	in A or kA primary; in A and in % of I_{Nom} secondary
	– Positive sequence current I_1	in A or kA primary; in A secondary, or in % of I_{Nom}
	– Negative sequence current I_2	in A or kA primary; in A and in % of I_{Nom} secondary

	Operating Measured Values for
	Thermal Overload Protection and
	Motor Restart Blocking
	  - Range
	  - Tolerance
		$\Theta_S/\Theta_{S\ Trip}$
		$\Theta_L/\Theta_{L\ Trip}$
		
		0% to 400%
		5% class accuracy per IEC 60255-8

	Operating Measured Values for
	Sensitive Ground Fault Protection
	– I_{Ns}
	  - Range
	  - Tolerance
		
		in A or kA primary and in mA secondary
		0 mA to 1600 mA
		2% of measure value or 1 mA

Long-Term Mean Value	Time Window	15, 30 or 60 minutes
	Frequency of Updates	adjustable
	Long-Term Means of – Currents Ia $_{dmd}$, Ib $_{dmd}$, Ic $_{dmd}$, I$_{1\ dmd}$	in A (kA)
Min/Max Report	Report of Measured Values	with date and time
	Reset – Automatic	Time of day adjustable (in minutes). Time frame and starting time adjustable (in days, 1 to 365 days, and ∞).
	Reset – Manual	Using binary input Using keypad Using communication
	Min/Max Values for Current	I_a, I_b, I_c, I_1 (positive sequence)
Measured Values Supervision	Current Asymmetry	$I_{max}/I_{min} > I$ - balance factor, for $I > I$ - balance limit. Factor and limit are adjustable.
	Current Sum	$\mid i_a+i_b+i_c+[k_n \cdot i_n] \mid > I$ - sum threshold value, adjustable. $k_n = CT_n$ ratio / CT_{phase} ratio
	Current Phase Sequence	Clockwise (ABC)/ counter-clockwise (ACB)
	Limit Value Monitor	$I_a >$ Limit value $I_{A\ dmd}>$ $I_b >$ Limit value $I_{B\ dmd}>$ $I_c >$ Limit value $I_{C\ dmd}>$

		I_1 > Limit value $I_{1\,dmd}$> I_L < Limit value 37-1
Trip Log)	Recording of indication of the last 8 power system faults Recording of indication of the last 3 power system ground faults	
Time Stamping	Resolution for Event Log (Operational Messages)	1 ms
	Resolution for Trip Log (Fault Records)	1 ms
	Time Deviation (Internal Clock)	Maximum 0.01%
	Buffer Battery	Lithium Battery, 3 V / 1 Ah, type CR 1/2 AA Self-discharging time > 5 years Message "Fail Battery" if battery charge is low
Waveform Capture		Maximum 8 fault records saved Memory maintained by buffer battery in case of loss of power supply
	Recording Time	Total of 5 s Pre-event and post-event recording and memory time adjustable
	Sampling Rate for 50 Hz Sampling Rate for 60 Hz	1 sample/1.25 ms (16 sam/cyc) 1 sample/1.04 ms (16 sam/cyc)
Statistics (Circuit Breaker)	Saved Number of Trips	Up to 9 digits
	Accumulated Interrupted Current	Up to 4 digits (kA) per pole
Operating Hours Counter	Operating Hours Range Criterion to Count	Up to 7 digits Current exceeds an adjustable current threshold (BkrClosed I MIN)
Trip Circuit Monitor (74TC)		With one or two binary inputs.
Commissioning Start-up Aids	Phase Rotation Field Check Operating Measured Values Circuit Breaker / Switching Device Test Creation of a Test Measurement Report	
Clock	Time Synchronization	IRIG-B/DCF77-signal Binary signal Communication

10.15 Dimensions

**Panel and Cubical
Installation**

Side view (with threaded terminals)   Side view (with plug-in terminals)   Rear view

Panal cut out

Dimensions in inches
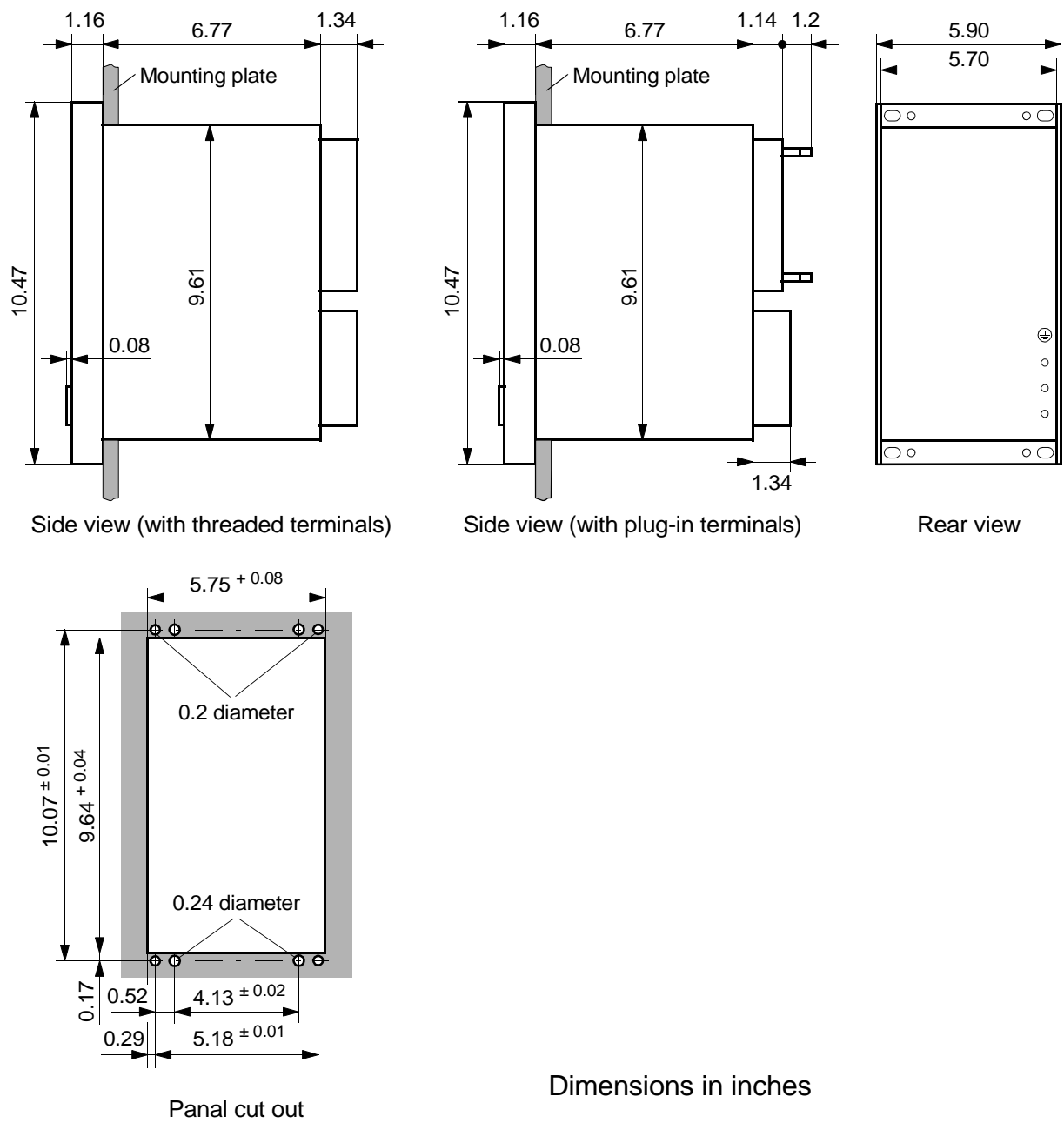
Figure 10-7   Dimensional Drawing Of A 7SJ61 For Panel Flush Mounting Or Cubicle Mounting (Housing Style 7XP2030-2)

Panel Mounting

Front view

Side view

Dimensions in inches

Figure 10-8   Dimensional Drawing Of A 7SJ61 For Panel Mounting

■

Appendix

<div style="text-align: right; font-size: 2em;">**A**</div>

This appendix is primarily a reference for the experienced user. This section provides ordering information for the models of 7SJ61. General diagrams indicating the terminal connections of the 7SJ61 models are included. Following the general diagrams are diagrams that show the proper connections of the device to primary equipment in many typical power system configurations. Tables with all settings and all information available in a 7SJ61 equipped with all options are provided. Default settings are also given.

A.1   Ordering Information and Accessories

	6 7	8 9 10 11 12	13 14 15 16
SIPROTEC 4 Time-Overcurrent Protection With Controls Order No. **7SJ61**	□□ −	□□□□□ −	□□□□

Number of Binary Inputs and Outputs

3 Binary Inputs, 4 Binary outputs, 1 Live Status Contact	0
8 Binary Inputs, 8 Binary Outputs, 1 Live Status Contact	1
11 Binary Inputs, 6 Binary Outputs, 1 Live Status Contact	2

Nominal Current

I_N = 1 A	1
I_N = 5 A	5

Power Supply, Binary Inputs Pickup Threshold Setting

24 to 48 VDC, Binary Input Threshold17 VDC	2
60 to 125 VDC, Binary Input Threshold17 VDC	4
110 to 250 VDC, 115 VAC, Binary Input Threshold 73 VDC	5
220 to 250 VDC, 230 VAC, Binary Input Threshold 73 VDC	6

Construction

Surface-mounting case for panel, 2 tier terminals top/bottom	B
Flush-mounting case for panel/cubicle, plug-in terminals (2/3 pin connector)	D
Flush-mounting case for panel/cubicle, screw-type terminals (ring lugs)	E

Region-Specific Default/Language Setting and Function Versions

Region DE, 50 Hz, IEC, Language German (Language can be changed)	A
Region World, 50/60 Hz, IEC/ANSI, Language English (Language can be changed)	B
Region US, 60 Hz, ANSI, Language American English (Language can be changed)	C
Region DE, 50 Hz, IEC, Language German (Language cannot be changed))	M
Region World, 50/60 Hz, IEC/ANSI, Language English (Language cannot be changed)	N
Region US, 60 Hz, ANSI, Language Americal English (Language cannot be changed)	P

System Interfaces - Rear Ports

No system interface	0
IEC-Protocol, RS232 (EIA-232)	1
IEC-Protocol, RS485 (EIA-485)	2
IEC-Protocol, Optical, 820 nm, ST-Connector	3
Profibus FMS Slave, RS485	4
Profibus FMS Slave, Optical, Single Ring, ST-Connector[1]	5[1]
Profibus FMS Slave, Optical, Double Ring, ST-Connector[1]	6[1]

DIGSI 4/Modem Interface-Rear Port

No rear DIGSI V4 Interface	0
RS232	1
RS485	2
Optical 820 nm, ST-Connector	3

Fault Recording/Mean and Min/Max Metering

Fault Recording	1
Fault Recording, mean values, min/max values	3

[1] not available if "B" is in position 9.

SIPROTEC 4 Time-Overcurrent Protection with Controls   **Order No.**   **7SJ61**☐☐ – ☐☐☐☐☐ – ☐☐☐☐

6   7   8   9   10 11 12   13 14 15 16

Functionality/Accessories

Time-overcurrent protection phase 50-1, 50-2, 51 and	B A
Time-overcurrent protection ground 50N-1, 50N-2, 51N	

Controls	F A
Time-overcurrent protection phase 50-1, 50-2, 51 and	
Time-overcurrent protection ground 50N-1, 50N-2, 51N,	
Overload protection (with 2 time constants) 49,	
Negative sequence protection 46-1, 46-2, 46-TOC,	
Circuit breaker failure protection,	
Trip circuit monitoring 74	
Inrush stabilization	
Cold-load pickup (Dynamic setting changes) 50c-1, 50c-2, 50Nc-1, 50Nc-2, 51Nc	
Lockout 86	

Controls	F B
Time-overcurrent protection phase 50-1, 50-2, 51,	
Sensitive ground fault protection 64, 50Ns, 51Ns	
Overload protection (with 2 time constants) 49,	
Negative sequence protection 46-1, 46-2, 46-TOC,	
Circuit breaker failure protection,	
Trip circuit monitoring 74	
Inrush stabilization	
Cold-load pickup (Dynamic setting changes) 50c-1, 50c-2, 50Nc-1, 50Nc-2, 51Nc	
Lockout 86	

Controls	H A
Time-overcurrent protection phase 50-1, 50-2, 51 and	
Time-overcurrent protection ground 50N-1, 50N-2, 51N,	
Overload protection (with 2 time constants) 49,	
Negative sequence protection 46-1, 46-2, 46-TOC,	
Circuit breaker failure protection,	
Trip circuit monitoring 74	
Inrush stabilization	
Cold-load pickup (Dynamic setting changes) 50c-1, 50c-2, 50Nc-1, 50Nc-2, 51Nc	
Lockout 86	
Undercurrent monitoring 37-1	
Motor starting time supervision 48	
Motor start inhibit (66/68)	

Automatic Reclosing (79)

No 79	0
With 79	1

A.1.1 Accessories

Terminal Block Covering Caps

Covering cap for terminal block type	Order No.
18 terminal voltage, 12 terminal current block	C73334-A1-C31-1
12 terminal voltage, 8 terminal current block	C73334-A1-C32-1

Short Circuit Links

Short circuit links for terminal type	Order No.
Voltage terminal, 18 terminal, or 12 terminal	C73334-A1-C34-1
Current terminal,12 terminal, or 8 terminal	C73334-A1-C33-1

Femal Plug

Connector Type	Order No.
2 pin	C73334-A1-C35-1
3 pin	C73334-A1-C36-1

Mounting Rail for 19"-Racks

Name	Order No.
Angle Strip (Mounting Rail)	C73165-A63-C200-2

Battery

Lithium-Battery 3 V/1 Ah, Type CR 1/2 AA	Order No
VARTA	6127 501 501
SONNENSCHEIN	1110 150 301

Interface Cable

An interface cable is necessary for communication between the SIPROTEC device and a PC. Requirements for the computer are Windows 95 or Windows NT4 and the operating software DIGSI® 4.

Interface cable between PC or SIPROTEC device	Order No.
Cable with 9-pin male/female connections	7XV5100-4

Operating Software DIGSI® 4

Software for setting and operating SIPROTEC® 4 devices

Operating Software DIGSI® 4	Order No.
DIGSI® 4, basic version with license for 10 computers	7XS5400-0AA00
DIGSI® 4, complete version with all option packages	7XS5402-0AA0

Graphical Analysis Program DIGRA   Software for graphical visualization, analysis, and evaluation of fault data. Option package of the complete version of DIGSI® 4

Graphical analysis program DIGRA®	Order No.
Full version with license for 10 PCs	7XS5410-0AA0

Display Editor   Software for creating basic and power system control pictures. Option package of the complete version of DIGSI® 4

Display Editor 4	Order No.
Full version with license for 10 PCs	7XS5420-0AA0

Graphic Tools   Graphical Software to aid in the setting of characteristic curves and provide zone diagrams for overcurrent and distance protective devices. Option package of the complete version of DIGSI® 4.

Graphic Tools 4	Order No.
Full version with license for 10 PCs	7XS5430-0AA0

DIGSI REMOTE 4   Software for remotely operating protective devices via a modem (and possibly a star connector) using DIGSI® 4. (Option package of the complete version of DIGSI® 4.

DIGSI REMOTE 4	Order No.
Full version with license for 10 PCs	7XS5440-2AA0

SIMATIC CFC 4   Graphical based software for configuration of control interlocking conditions or creating additional logic functions in SIPROTEC 4 devices. Option package for the complete version of DIGSI® 4.

SIMATIC CFC 4	Order No.
Full version with license for 10 PCs	7XS5450-0AA0

A.2 Elementary Diagrams

A.2.1 Panel Flush Mounting or Cubicle Mounting

7SJ610∗−∗D/E
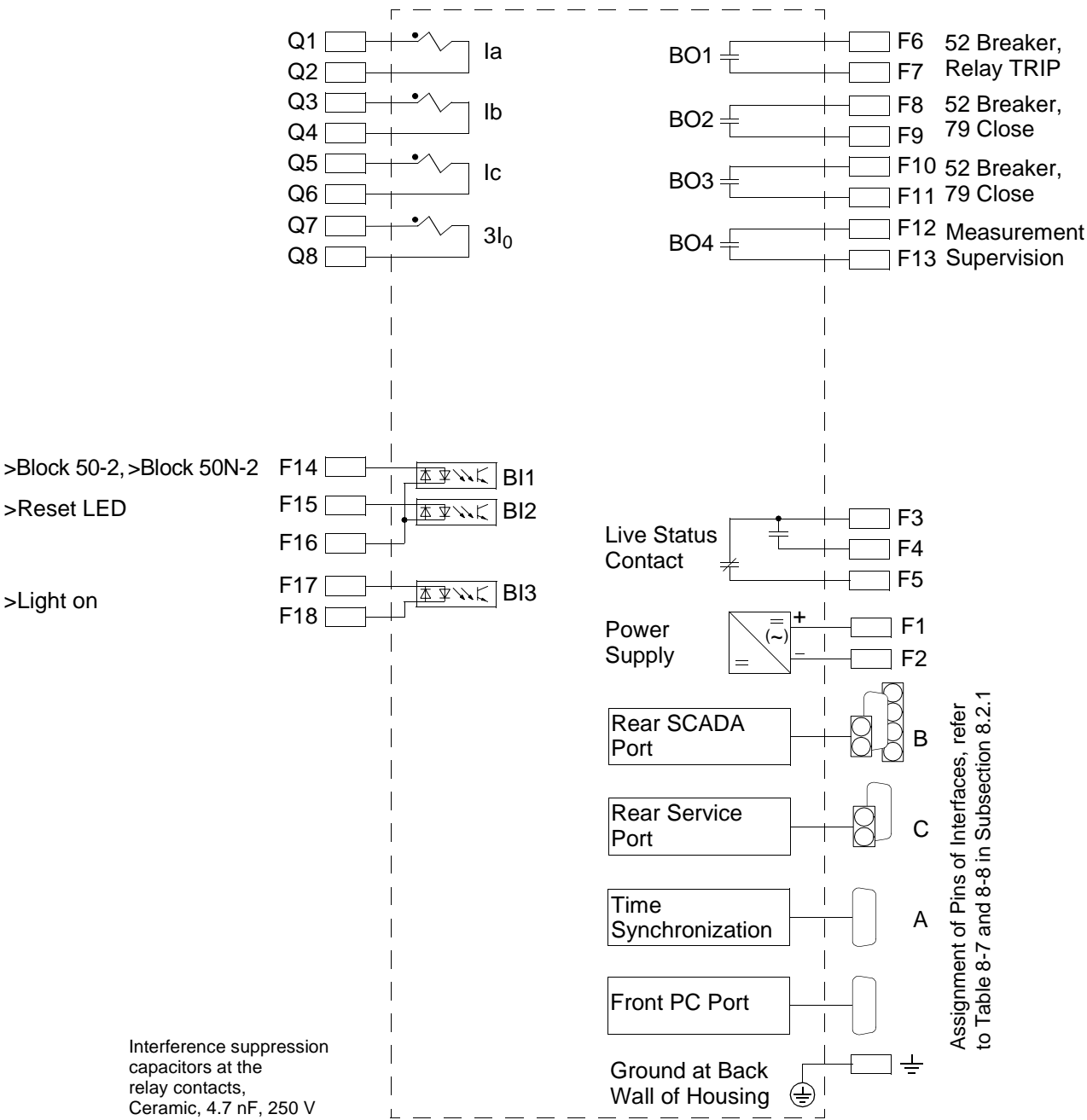
Figure A-1 Connection Diagram For 7SJ610∗−∗D/E (Panel Flush Mounted or Cubicle Mounted)

7SJ611∗−∗D/E
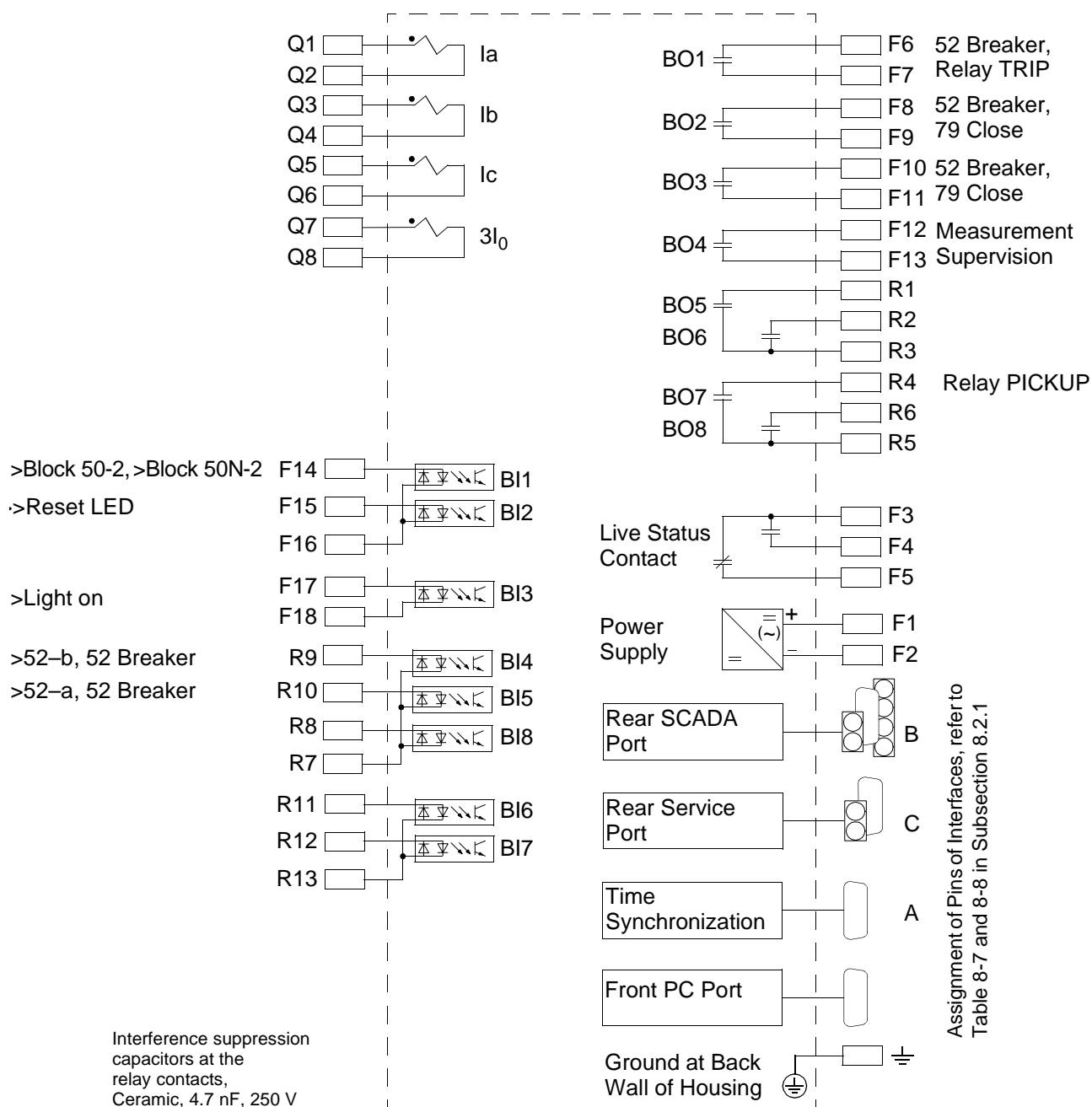
Figure A-2 Connection Diagram For 7SJ611∗−∗D/E (Panel Flush Mounted or Cubicle Mounted)

7SJ612∗−∗D/E
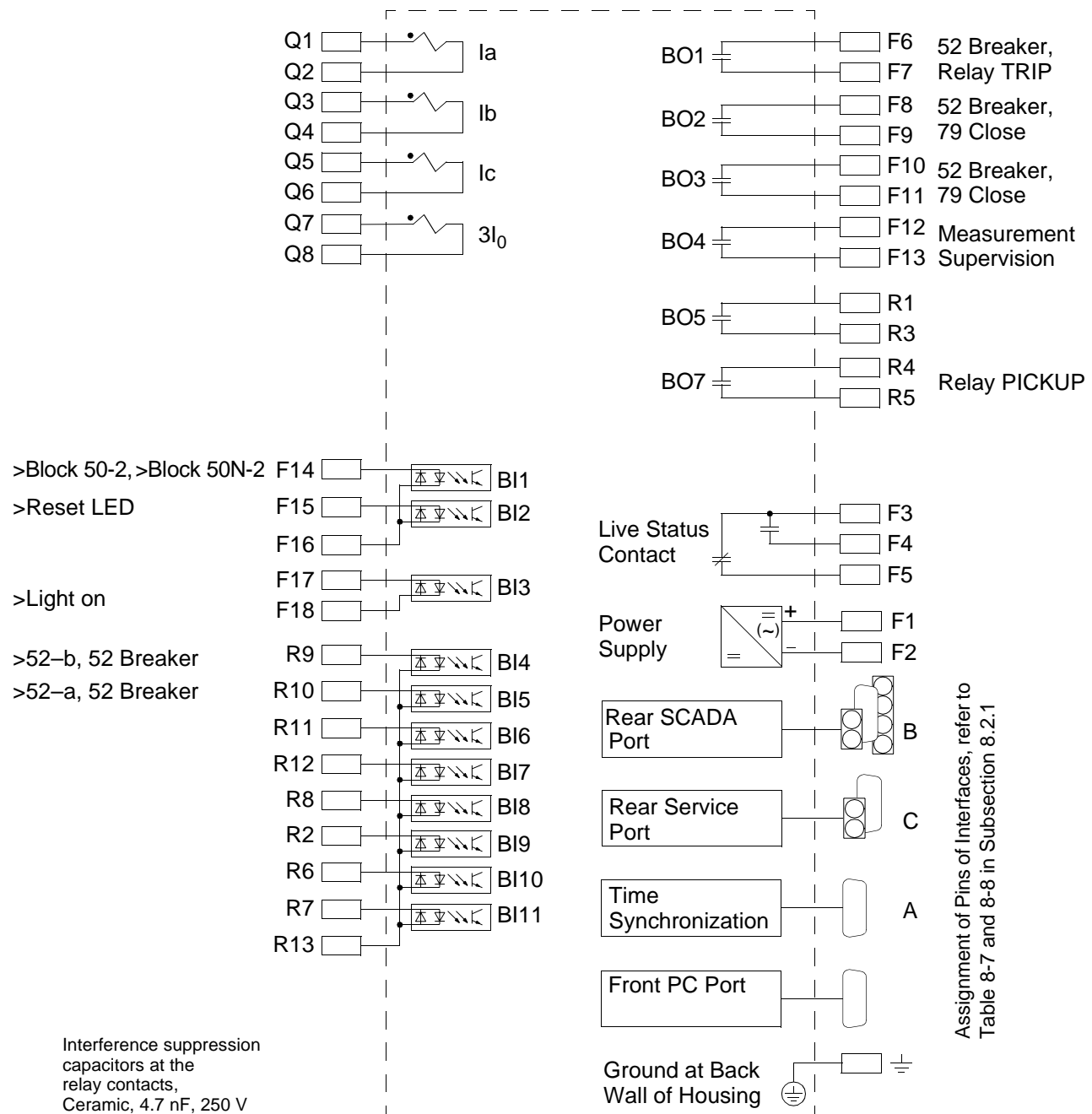
Figure A-3 Connection Diagram For 7SJ612∗−∗D/E (Panel Flush Mounted or Cubicle Mounted)

A.2.2 Panel Surface Mounting

7SJ610∗−∗B
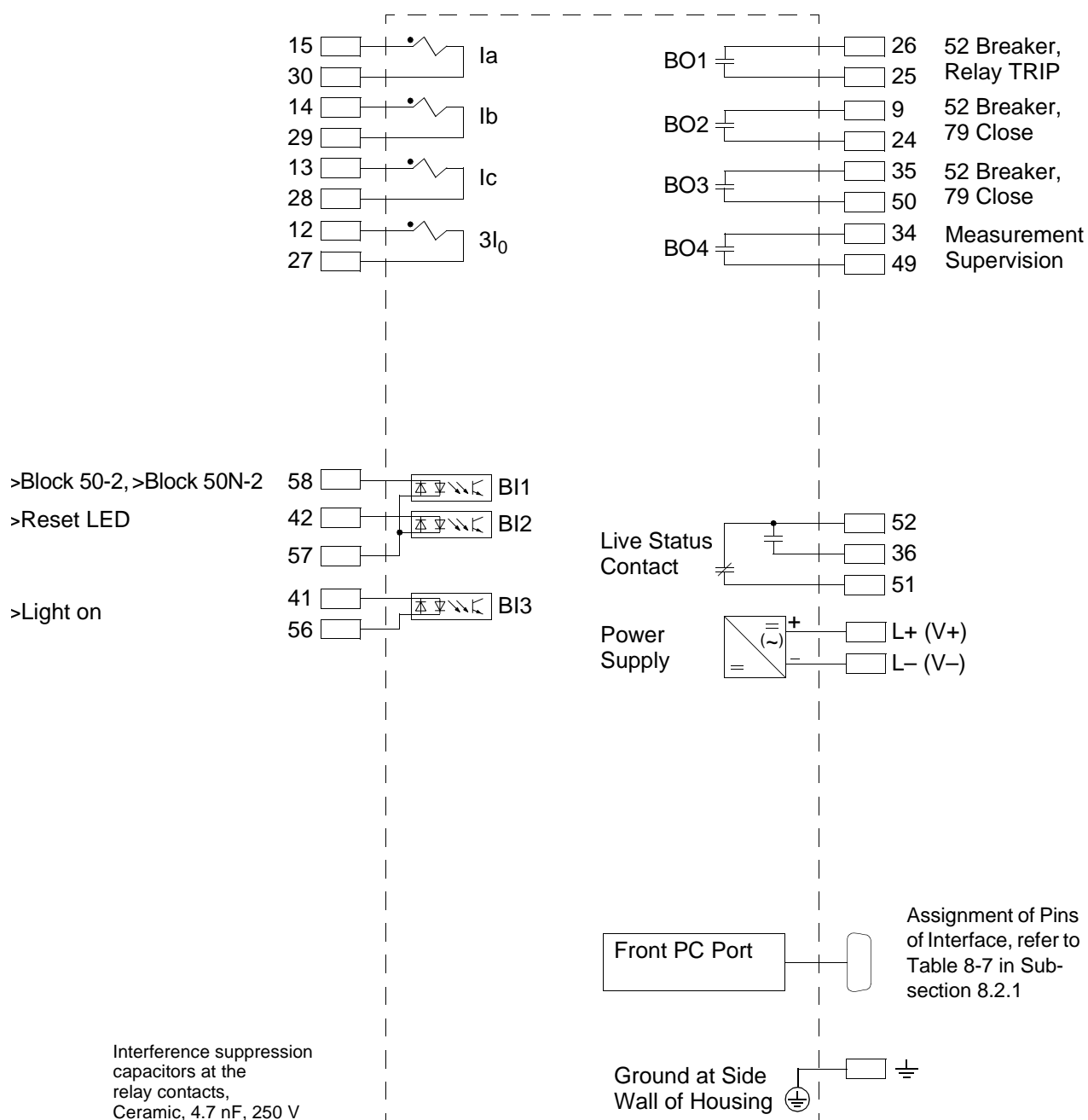
Figure A-4 Connection Diagram For 7SJ610∗−∗B (Panel Surface Mounted)

The connections for additional serial interfaces are taken from Figure A-7.

7SJ611∗−∗B
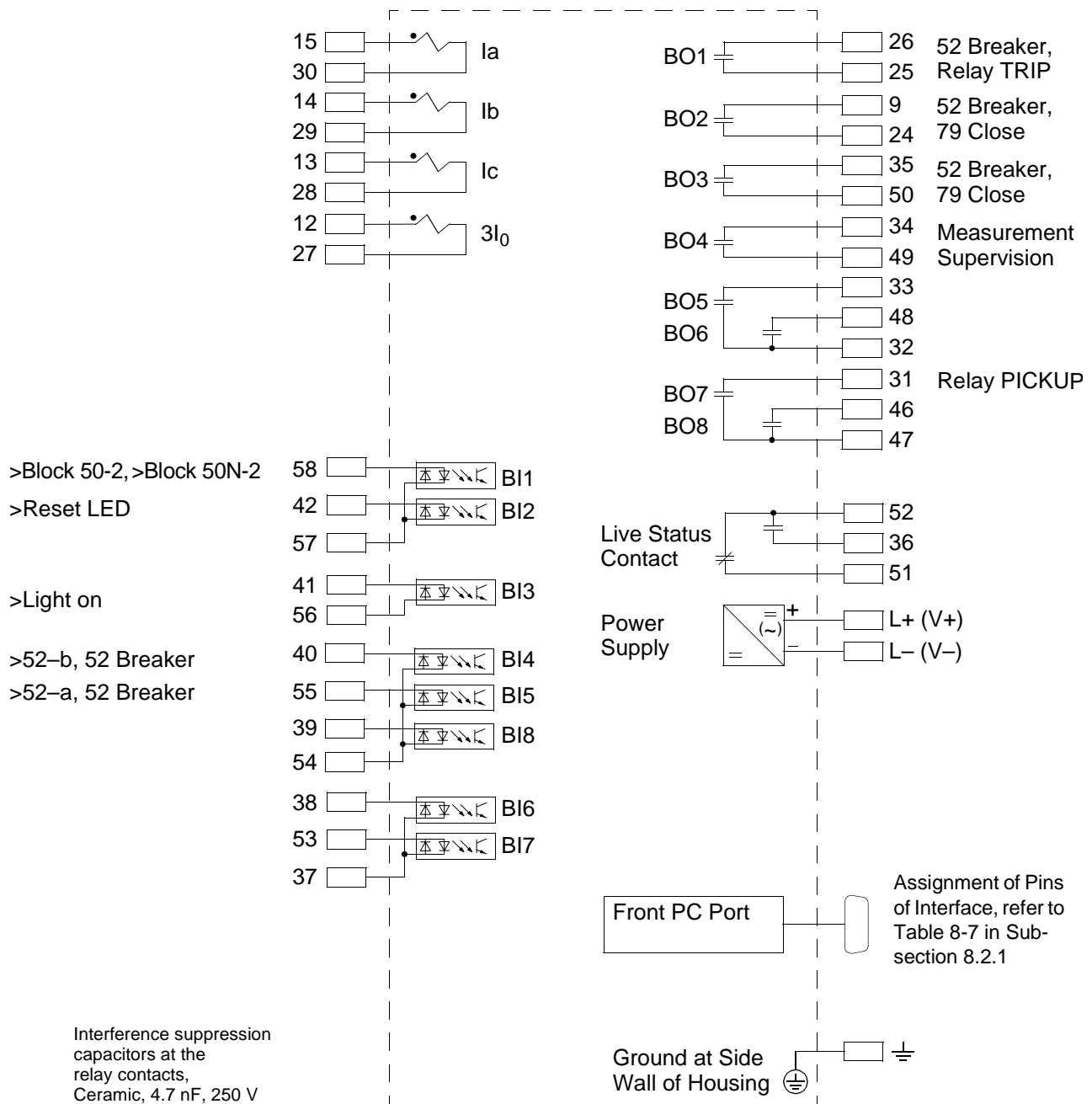
Figure A-5 Connection Diagram For 7SJ611∗−∗B (Panel Surface Mounted)

The connections for additional serial interfaces are taken from Figure A-7.

7SJ612∗−∗B
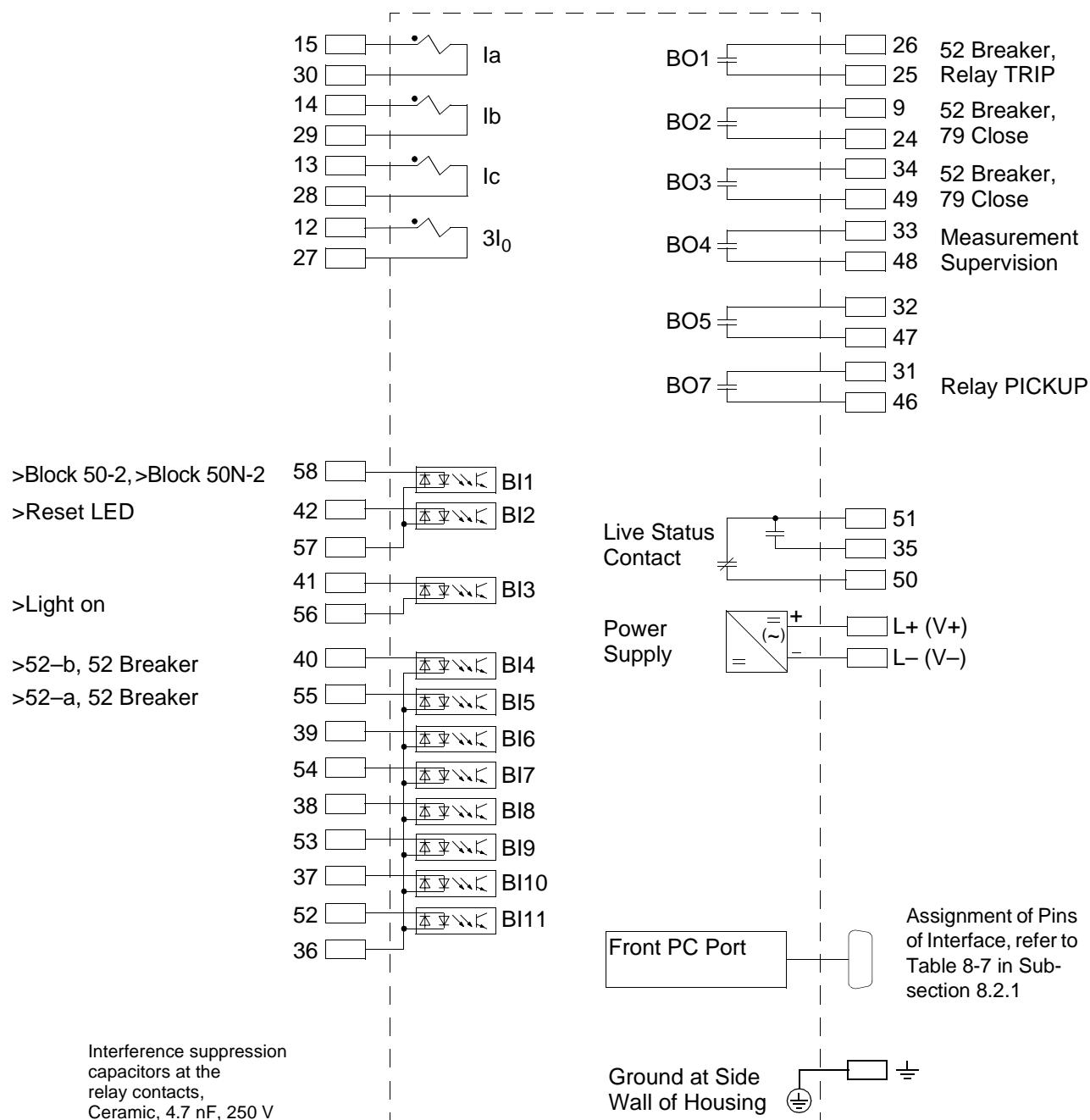
Figure A-6 Connection Diagram For 7SJ612∗−∗B (Panel Surface Mounted)

The connections for additional serial interfaces are taken from Figure A-7.

7SJ610/1/2∗−∗B
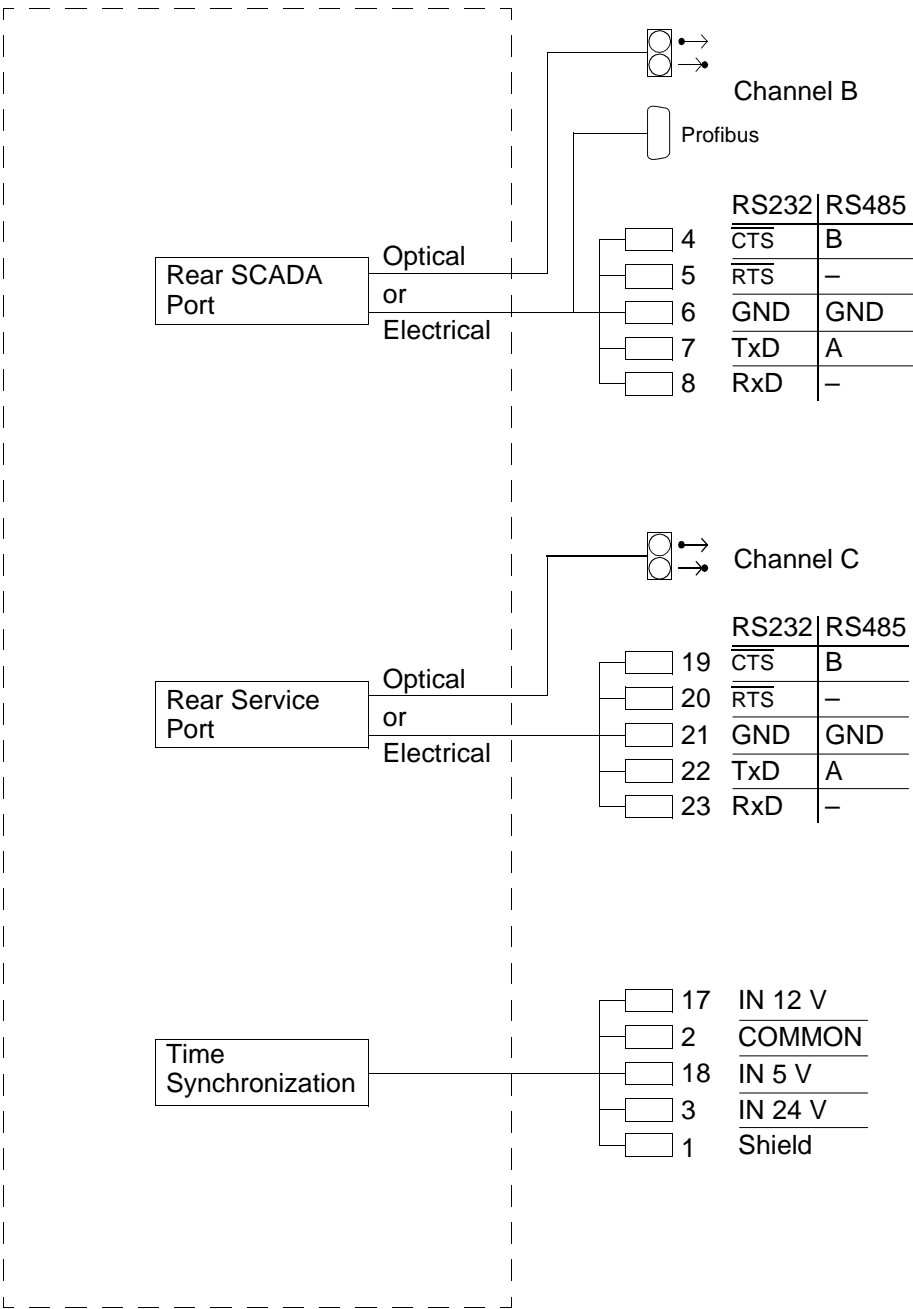
Figure A-7   Connection Diagram For 7SJ610/1/2∗−∗B (Panel Surface Mounted)

A.3 Connection Examples
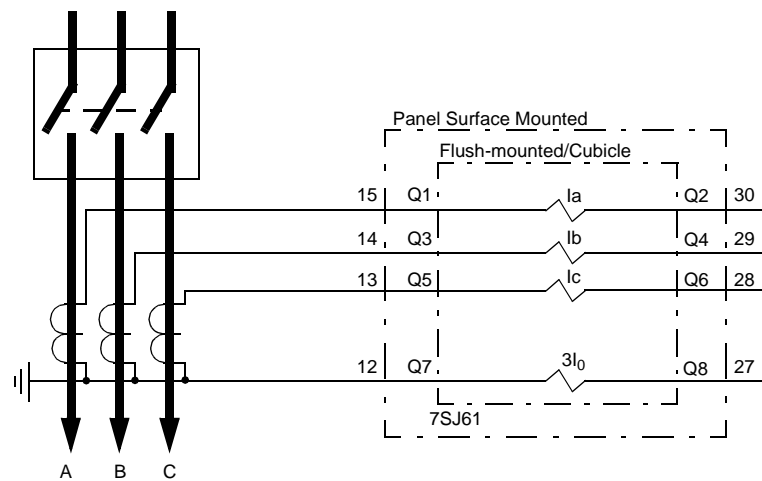
Figure A-8   Current connections to three current transformers with a starpoint connection for ground current(Grounded-Wye Connection with residual $3I_0$ Neutral Current), normal circuit layout – appropriate for all networks.
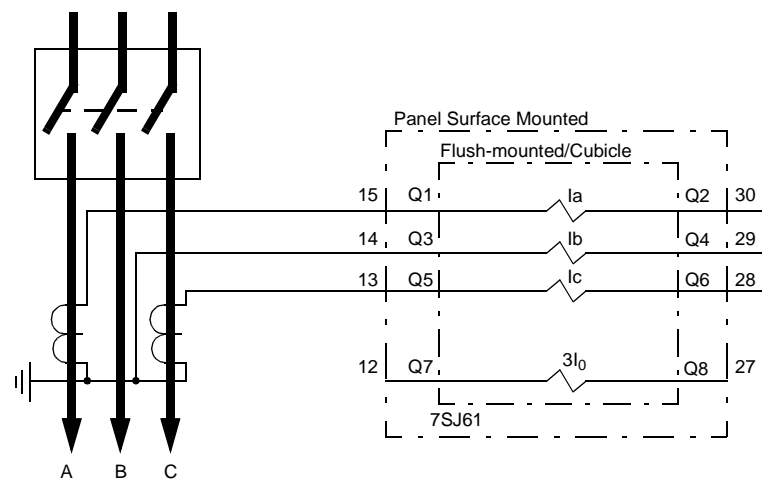
Figure A-9   Current connections to two current transformers - only for ungrounded or compensated networks.

Important! Cable shield grounding must be done on the cable side!

Note: Change of Address 0201 setting changes polarity of $3I_0$ Current Input !
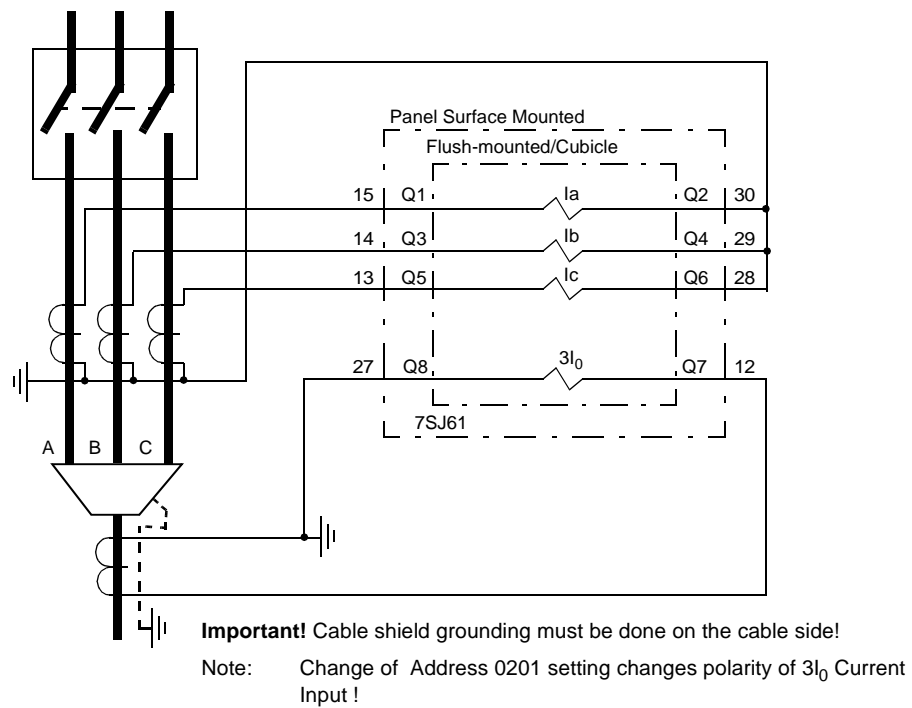
Figure A-10 Current connections to three current transformers and a core balance neutral current transformer for ground current - preferred for effectively or low-resistive grounded networks

Important! Cable shield grounding must be done on the cable side!

Note: Change of Address 0201 setting changes polarity of I_{NS} Current Input !
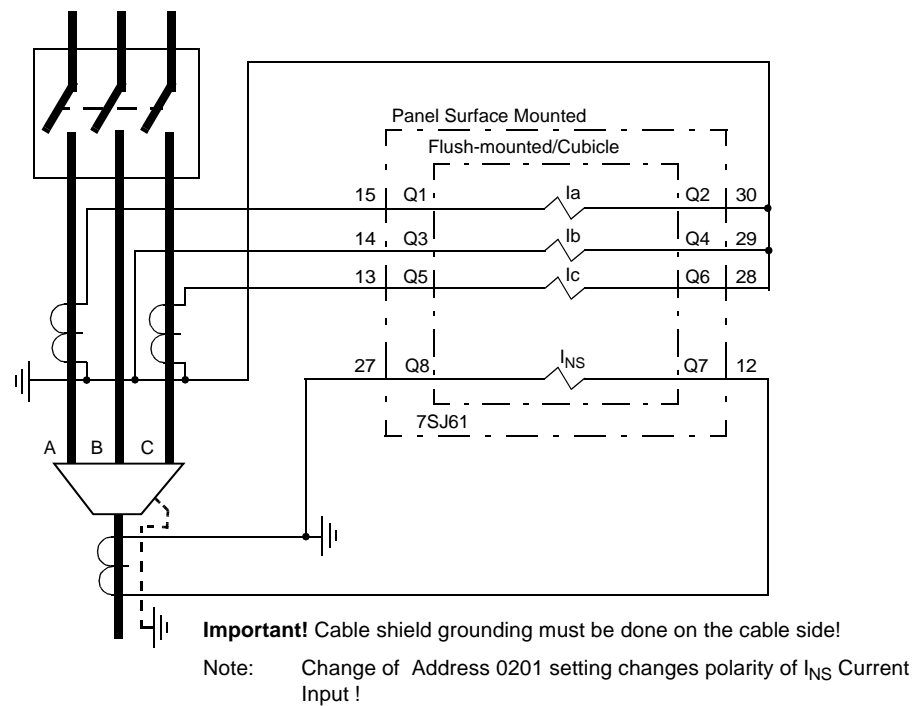
Figure A-11 Current connections to two current transformers and a core balance neutral current transformer for sensitive ground fault detection - only for ungrounded or compensated networks

Figure A-12   Current connections to three current transformers - core balance neutral current transformers for sensitive ground fault detection.

A.4   Settings

NOTE: The following table lists all data which are available in the maximum complement of the device. Dependent on the ordered model, only those data may be present which are valid for the individual version.

Addr.	Setting Title	Setting Options	Default Setting	Comments
201	CT Starpoint	towards Line towards Busbar	towards Line	CT Starpoint
204	CT PRIMARY	10..50000 A	100 A	CT Rated Primary Current
205	CT SECONDARY	1A 5A	5A	CT Rated Secondary Current
207	CT N / CT Ph	0.010..1.000	1.000	Neutral CT over Phase CT Ratio
208	CT Ns / CT Ph	0.001..5.000	1.000	Neutral CT(sens.) over Phase CT Ratio
209	PHASE SEQ.	A B C A C B	A B C	Phase Sequence
210	TMin TRIP CMD	0.01..32.00 sec	0.15 sec	Minimum TRIP Command Duration
211	TMax CLOSE CMD	0.01..32.00 sec	1.00 sec	Maximum Close Command Duration
212	BkrClosed I MIN	020..5.00 A	0.20 A	Closed Breaker Min. Current Threshold
214	Rated Frequency	50 Hz 60 Hz	60 Hz	Rated Frequency
302	CHANGE	Group A Group B Group C Group D Binary Input IEC60870-5-103	Group A	Change to Another Setting Group
401	WAVEFORMTRIGGER	Save with Pickup Save with TRIP Start with TRIP	Save with Pickup	Waveform Capture
402	WAVEFORM DATA	Fault event Power System fault	Fault event	Scope of Waveform Data
403	MAX. LENGTH	0.30..5.00 sec	1.00 sec	Max. length of a Waveform Capture Record
404	PRE. TRIG. TIME	0.05..0.50 sec	0.10 sec	Captured Waveform Prior to Trigger
405	POST REC. TIME	0.05..0.50 sec	0.10 sec	Captured Waveform after Event
406	BinIn CAPT.TIME	0.10..5.00 sec	0.50 sec	Capture Time via Binary Input
1102	I PRIMARY OP.	10..50000 A	100 A	Primary Operating Current
1107	I MOTOR START	3.00..50.00 A	12.50 A	Motor Start Current (Block 49, Start 48)
1201	FCT 50/51	ON OFF	ON	50, 51 Phase Time Overcurrent
1202	50-2 PICKUP	0.50..175.00 A	10.00 A	50-2 Pickup
1203	50-2 DELAY	0.00..60.00 sec	0.00 sec	50-2 Time Delay
1204	50-1 PICKUP	0.50..175.00 A	5.00 A	50-1 Pickup

Addr.	Setting Title	Setting Options	Default Setting	Comments
1205	50-1 DELAY	0.00..60.00 sec	0.50 sec	50-1 Time Delay
1207	51 PICKUP	0.50..20.00 A	5.00 A	51 Pickup
1208	51 TIME DIAL	0.05..3.20 sec	0.50 sec	51 Time Dial (IEC)
1209	51 TIME DIAL	0.50..15.00	5.00	51 Time Dial (ANSI)
1210	51 Drop-out	Instantaneous Disk Emulation	Disk Emulation	Drop-out characteristic
1211	51 IEC CURVE	Normal Inverse Very Inverse Extremely Inverse Long Inverse	Normal Inverse	IEC Curve
1212	51 ANSI CURVE	Very Inverse Inverse Short Inverse Long Inverse Moderately Inverse Extremely Inverse Definite Inverse	Very Inverse	ANSI Curve
1213	MANUAL CLOSE	50-2 instantaneously 50 -1 instantaneously 51 instantaneously Inactive	50-2 instantane-ously	Manual Close Mode
1214	50-2 active	Always with 79 active	Always	50-2 active
1230	51/51N			51/51N
1231	MofPU Res T/Tp			Multiple of Pickup <-> T/Tp
1301	FCT 50N/51N	ON OFF	ON	50N, 51N Ground Time Overcurrent
1302	50N-2 PICKUP	0.25..175.00 A	2.50 A	50N-2 Pickup
1303	50N-2 DELAY	0.00..60.00 sec	0.10 sec	50N-2 Time Delay
1304	50N-1 PICKUP	0.25..175.00 A	1.00 A	50N-1 Pickup
1305	50N-1 DELAY	0.00..60.00 sec	0.50 sec	50N-1 Time Delay
1307	51N PICKUP	0.50..20.00 A	1.00 A	51N Pickup
1308	51N TIME DIAL	0.05..3.20 sec	0.20 sec	51N Time Dial (IEC)
1309	51N TIME DIAL	0.50..15.00	5.00	51N Time Dial (ANSI)
1310	51N RESET	Instantaneous Disk Emulation	Disk Emulation	Drop-Out Characteristic
1311	51N IEC CURVE	Normal Inverse Very Inverse Extremely Inverse Long Inverse	Normal Inverse	IEC Curve
1312	51N ANSI CURVE	Very Inverse Inverse Short Inverse Long Inverse Moderately Inverse Extremely Inverse Definite Inverse	Very Inverse	ANSI Curve

Addr.	Setting Title	Setting Options	Default Setting	Comments
1313	MANUALCLOSE-MODE	50N-2 instantane-ously 50N-1 instantane-ously 51N instantaneously Inactive	50N-2 instantane-ously	Manual Close Mode
1314	50N-2 active	Always with 79 Active	Always	50N-2 active
1330	50N/51N			50N/51N
1331	MofPU Res T/TEp			Multiple of Pickup <-> T/TEp
1701	COLDLOAD PICKUP	OFF ON	OFF	Cold-Load-Pickup Function
1702	Start Condition	No Current Breaker Contact	No Current	Start Condition
1703	CB Open Time	0..21600 sec	3600 sec	Circuit Breaker OPEN Time
1704	Active Time	1..21600 sec	3600 sec	Active Time
1705	Stop Time	1..600 sec	600 sec	Stop Time
1801	50c-2 PICKUP	0.50..175.00 A	50.00 A	50c-2 Pickup
1802	50c-2 DELAY	0.00..60.00 sec	0.00 sec	50c-2 Time Delay
1803	50c-1 PICKUP	0.50..175.00 A	10.00 A	50c-1 Pickup
1804	50c-1 DELAY	0.00..60.00 sec	0.30 sec	50c-1 Time Delay
1805	51c PICKUP	0.50..20.00 A	7.50 A	51c Pickup
1806	51c TIME DIAL	0.05..3.20 sec	0.50 sec	51c Time dial (IEC)
1807	51c TIME DIAL	0.50..15.00	5.00	51c Time dial (ANSI)
1901	50Nc-2 PICKUP	0.25..175.00 A	35.00 A	50Nc-2 Pickup
1902	50Nc-2 DELAY	0.00..60.00 sec	0.00 sec	50Nc-2 Time Delay
1903	50Nc-1 PICKUP	0.25..175.00 A	7.50 A	50Nc-1 Pickup
1904	50Nc-1 DELAY	0.00..60.00 sec	0.30 sec	50Nc-1 Time Delay
1905	51Nc PICKUP	0.50..20.00 A	5.00 A	51Nc Pickup
1906	51Nc T-DIAL	0.05..3.20 sec	0.50 sec	51Nc Time Dial (IEC)
1907	51Nc T-DIAL	0.50..15.00	5.00	51Nc Time Dial (ANSI)
2201	INRUSH REST.	OFF ON	OFF	Inrush Restraint
2202	2nd HARMONIC	10..45 %	15 %	2nd. harmonic in % of fundamental
2203	CROSS BLOCK	NO YES	NO	Cross Block
2204	CROSS BLK TIMER	0.00..180.00 sec	0.00 sec	Cross Block Time
2205	I Max	1.50..125.00 A	37.50 A	Maximum Current for Inrush Restraint
3101	Sens. Gnd Fault	OFF ON Alarm Only	OFF	Sensitive Ground Fault
3102	CT Err. I1	0.003..1.600 A	0.050 A	Current I1 for CT Angle Error

Addr.	Setting Title	Setting Options	Default Setting	Comments
3103	CT Err. F1	0.0..5.0 °	0.0 °	CT Angle Error at I1
3104	CT Err. I2	0.003..1.600 A	1.000 A	Current I2 for CT Angle Error
3105	CT Err. F2	0.0..5.0 °	0.0 °	CT Angle Error at I2
3113	50Ns-2 PICKUP	0.003..1.500 A	0.300 A	50Ns-2 Pickup
3114	50Ns-2 DELAY	0.00..320.00 sec	1.00 sec	50Ns-2 Time Delay
3117	50Ns-1 PICKUP	0.003..1.500 A	0.100 A	50Ns-1 Pickup
3118	50Ns-1 DELAY	0.00..320.00 sec	2.00 sec	50Ns-1 Time delay
3119	51Ns PICKUP	0.003..1.400 A	0.100 A	51Ns Pickup
3120	51Ns TIME DIAL	0.10..4.00 sec	1.00 sec	51Ns Time Dial
3131	M.of PU TD			Multiples of PU Time-Dial
4001	FCT 46	OFF ON	OFF	46 Negative Sequence Protection
4002	46-1 PICKUP	0.50..15.00 A	0.50 A	46-1 Pickup
4003	46-1 DELAY	0.00..60.00 sec	1.50 sec	46-1 Time Delay
4004	46-2 PICKUP	0.50.15.00 A	2.50 A	46-2 Pickup
4005	46-2 DELAY	0.00..60.00 sec	1.50 sec	46-2 Time Delay
4006	46 IEC CURVE	Normal Inverse Very Inverse Extremely Inverse	Extremely Inverse	IEC Curve
4007	46 ANSI CURVE	Extremely Inverse Inverse Moderately Inverse Very Inverse	Extremely Inverse	ANSI Curve
4008	46-TOC PICKUP	0.50..10.00 A	4.50 A	46-TOC Pickup
4009	46-TOC TIMEDIAL	0.50..15.00	5.00	46-TOC Time Dial
4010	46-TOC TIMEDIAL	0.05..3.20 sec	0.50 sec	46-TOC Time Dial
4011	46-TOC RESET	Instantaneous Disk Emulation	Instantaneous	46-TOC Drop Out
4101	FCT 48/66	OFF ON	OFF	48 / 66 Motor (Startup Monitor/Counter)
4102	STARTUP CURRENT	5.00..80.00 A	25.00 A	Startup Current
4103	STARTUP TIME	1.0..180.0 sec	10.0 sec	Startup Time
4104	LOCK ROTOR TIME	0.5..120.0 sec	2.0 sec	Permissible Locked Rotor Time
4201	FCT 49	OFF ON Alarm Only	OFF	49 Thermal overload protection
4202	49 K-FACTOR	0.10..4.00	1.10	49 K-Factor
4203	TIME CONSTANT	1.0..999.9 min	100.0 min	Time Constant
4204	49 Θ ALARM	50..100 %	90 %	49 Thermal Alarm Stage
4205	I ALARM	0.50..20.00 A	5.00 A	Current Overload Alarm Setpoint
4207	Kτ-FACTOR	1.0..10.0	1.0	Kt-FACTOR when motor stops
4208	T EMERGENCY	10..15000 sec	100 sec	Emergency time

Addr.	Setting Title	Setting Options	Default Setting	Comments
4301	FCT 66	OFF ON	OFF	66 Startup Counter for Motors
4302	IStart/IMOTnom	3.0..10.0	4.5	I Start / I Motor nominal
4303	T START MAX	3..120 sec	10 sec	Maximum Permissible Starting Time
4304	T Equal	0.0..60.0 min	1.0 min	Temperature Equalizaton Time
4305	I MOTOR NOMINAL	1.0..6.0 A	5.0 A	Rated Motor Current
4306	MAX.WARM STARTS	1..4	2	Maximum Number of Warm Starts
4307	#COLD-#WARM	1..2	1	Number of Cold Starts - Warm Starts
4308	kτ-FACTOR	1..10	2	Kt-Factor at Stop
7001	FCT 50BF	OFF ON	OFF	50BF Breaker Failure Protection
7004	Chk BRK CONTACT	OFF ON	OFF	Check Breaker contacts
7005	TRIP-Timer	0.06..60.00 sec	0.25 sec	TRIP-Timer
7101	FCT 79	OFF ON	OFF	79 Auto-Reclose Function
7103	BLK MAN. CLOSE	NO YES	NO	Block Manual close
7105	TIME RESTRAINT	0.50..320.00 sec	3.00 sec	79 Auto Reclosing reset time
7108	SAFETY 79 ready	0.01..300.00 sec	15.00 sec	Safety Time until 79 is ready
7110	FltDisp.LED/LCD	Display Targets on every Pickup Display Targets on TRIP only	Display Targets on every Pickup	Fault Display on LED / LCD
7113	CHECK CB?	No check Check each cycle	No check	Check circuit breaker before AR?
7115	CB TIME OUT	0.10..320.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
7116	MAX.InhibitTIME	0.01..320.00 sec	15.00 sec	Maximum Inhibit Time allowed for ext. BI
7127	DEADTIME 1: PH	0.01..320.00 sec	0.50 sec	Dead Time 1: Phase Fault
7128	DEADTIME 1: G	0.01..320.00 sec	0.50 sec	Dead Time 1: Ground Fault
7129	DEADTIME 2: PH	0.01..320.00 sec	0.50 sec	Dead Time 2: Phase Fault
7130	DEADTIME 2: G	0.01..320.00 sec	0.50 sec	Dead Time 2: Ground Fault
7131	DEADTIME 3: PH	0.01..320.00 sec	0.50 sec	Dead Time 3: Phase Fault
7132	DEADTIME 3: G	0.01..320.00 sec	0.50 sec	Dead Time 3: Ground Fault
7133	DEADTIME 4: PH	0.01..320.00 sec	0.50 sec	Dead Time 4: Phase Fault
7134	DEADTIME 4: G	0.01..320.00 sec	0.50 sec	Dead Time 4: Ground Fault
7135	# OF RECL. GND	0..9	1	Number of Reclosing Cycles Ground
7136	# OF RECL. PH	0..9	1	Number of Reclosing Cycles Phase
7140	ZONE SEQ.COORD.	OFF ON	OFF	ZSC - Zone sequence coordination

Addr.	Setting Title	Setting Options	Default Setting	Comments
7150	50-1/50N-1	No influence Starts 79 Stops 79	No influence	50-1, 50N-1
7151	50-2/50N-2	No influence Starts 79 Stops 79	No influence	50-2, 50N-2
7152	51/51N	No influence Starts 79 Stops 79	No influence	51, 51N
7156	sens Ground Flt	No influence Starts 79 Stops 79	No influence	Sensitive Ground Fault
7157	46	No influence Starts 79 Stops 79	No influence	46
7158	BINARY INPUT	No influence Starts 79 Stops 79	No influence	Binary Input
7159	3Pol.PICKUP BLK	YES NO	NO	3 Pole Pickup blocks 79
7170	1.Cy: 50(N)-1	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	1. Cycle: 50-1, 50N-1
7171	1.Cy: 50(N)-2	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	1. Cycle: 50-2, 50N-2
7174	2.Cy: 50(N)-1	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	2. Cycle: 50-1, 50N-1
7175	2.Cy: 50(N)-2	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	2. Cycle: 50-2, 50N-2
7178	3.Cy: 50(N)-1	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	3. Cycle: 50-1, 50N-1
7179	3.Cy: 50(N)-2	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	3. Cycle: 50-2, 50N-2
7182	4.Cy: 50(N)-1	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	4. Cycle: 50-1, 50N-1
7183	4.Cy: 50(N)-2	Not Blocked Blocked Via 79 Auto Recl.	Not Blocked	4. Cycle: 50-2, 50N-2
8101	MEASURE. SUPERV	OFF ON	ON	Measurement Supervision
8104	BALANCE I LIMIT	0.50..5.00 A	2.50 A	Current Threshold for Balance Monitoring
8105	BAL. FACTOR I	0.10..0.90	0.50	Balance Factor for Current Monitor
8106	Σ I THRESHOLD	0.25..10.00 A	0.50 A	Summated Current Monitoring Threshold

Addr.	Setting Title	Setting Options	Default Setting	Comments
8107	Σ I FACTOR	0.00..0.95	0.10	Summated Current Monitoring Factor
8201	FCT 74TC	ON OFF	ON	74TC TRIP Circuit Supervision
8311	MinMax cycRESET	NO YES	YES	Automatic Cyclic Reset Function
8312	MiMa RESET TIME	0..1439 min	0 min	MinMax Reset Timer
8313	MiMa RESETCYCLE	1..365 day(s)	7 day(s)	MinMax Reset Cycle Period
8314	MinMaxRES.START	1..365 Days	1 Days	MinMax Start Reset Cycle in

A.5   Interoperability List

1.   Physical layer

1.1   Electrical interface
☒   EIA RS-485   ☒   Number of loads for one equipment: 32

1.2   Optical interface
☒   Glass fibre   ☐   F-SMA type connector
☒   Plastic fibre   ☒   BFOC/2,5 type connector

1.3   Transmission speed
☒   9600 bit/s   ☒   19200 bit/s

2.   Link layer

There are no choices for the link layer

3.   Application layer

3.1   Transmission mode for application data Mode 1 (least significant octet first) as defined in 4.10 of
        IEC 60870-5-4

3.2   Common address of ASDU
☒   One common address of ADSU   ☐   More than one common address of ASDU
      (identical with station address)

3.3   Selection of standard information numbers in monitor direction
3.3.1   System functions in monitor direction
☒   0   End of general interrogation   ☒   0   Time synchronization
☒   2   Reset FCB   ☒   3   Reset CU
☒   4   Start/restart   ☒   5   Power on

3.3.2 ⎫
3.3.3 ⎪
3.3.4 ⎬ see separate table in the device manual (Information List in the following section)
3.3.5 ⎪
3.3.6 ⎭

3.3.7   Measurands in monitor direction
☒   144   Measurand I   ☒   145   Measurands I, V
☐   146   Measurand I, V, P, Q   ☐   147   Measurands I_N, V_{EN}
☐   148   Measurands $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, f

3.3.8   Generic functions in monitor direction
☐   240   Read headings of all defined groups   ☐   241   Read values of all entries of one group
☐   243   Read directory of a single entry   ☐   244   Read value of a single entry
☐   245   End of general interrogation generic   ☐   249   Write entry with confirmation
                data
☒   250   Write entry with execution   ☐   251   Write entry aborted

3.4   Selection of standard information numbers in control direction
3.4.1   System functions in control direction
☒   0   Initiation of general interrogation   ☒   0   Time synchronization
3.4.2   General commands in control direction
☒   16   Auto-recloser on / off   ☐   17   Teleprotection on / off
☒   18   Protection on / off   ☒   19   LED reset
☒   23   Activate characteristic 1   ☒   24   Activate characteristic 2
☒   25   Activate characteristic 3   ☒   26   Activate characteristic 4

3.4.3 Generic functions in control direction

☐	240	Read headings of all defined groups	☐	241	Read values of all entries of one group
☐	243	Read directory of a single entry	☐	244	Read value of a single entry
☐	245	General interrogation of generic data	☐	248	Write entry
☐	249	Write entry with confirmation	☐	250	Write entry with execution
☐	251	Write entry abort			

3.5 Basic application functions

☒	Test mode	☒	Blocking of monitor direction
☒	Disturbance data	☐	Generic services
☒	Private data		

3.6 Miscellaneous

Measurand	max. value = rated value x	
	1.2	2.4
Current L_1	☐	☐
Current L_2	☐	☒
Current L_3	☐	☐
Voltage L_{1-E}	☐	☐
Voltage L_{2-E}	☐	☐
Voltage L_{3-E}	☐	☐
Voltage L_1-L_2	☐	☒
Active power P	☐	☐
Reactive power Q	☐	☐
Frequency f	☐	☐

A.6 Information List

NOTE: The following table lists all data which are available in the maximum complement of the device. Dependent on the ordered model, only those data may be present which are valid for the individual version.

The symbol ' **>** ' indicates that the source of the indication is a binary input.

O/O	–	ON/OFF	DP	– Double Point Indication
OUT	–	Output Indication	C	– Command without Feedback
SP	–	Single Point Indication	CF	– Command with Feedback
IntSP	–	Internal Single Point Indication	MV	– Measured Value
SP_Ev	–	Spontaneous Event	LV	– Limit Value

F#	Description	Type of Informa-tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
3	>Synchronize Internal Real Time Clock (>Time Synch)	SP_Ev				O/O	LED	BI		REL					O/O	GI	135	48	1	GI
5	>Reset LED (>Reset LED)	SP					LED	BI		REL					O/O	GI	135	50	1	GI
	>Back Light on (>Light on)	SP	O/O				LED	BI		REL	OM	FM			O/O	GI				
51	Device is Operational and Protecting (Device OK)	OUT	O/O				LED			REL					O/O	GI	135	81	1	GI

F#	Description	Type of Informa-tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
																General	IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
52	At Least 1 Protection Funct. is Active (ProtActive)	IntSP	O/O				LED			REL					O/O	GI	160	18	1	GI
55	Reset Device (Reset Device)	OUT	ON ON				LED			REL					O/O	GI				
56	Initial Start of Device (Initial Start)	OUT	ON				LED			REL					O/O	GI	160	5	1	
60	Reset LED (Reset LED)	OUT	ON				LED			REL					O/O	GI	160	19	1	
67	Resume (Resume)	OUT	ON				LED			REL	OM	FM			O/O	GI				
68	Clock Synchronization Error (Clock Syn-cError)	OUT	O/O				LED			REL					O/O	GI				
69	Daylight Saving Time (DayLightSav-Time)	OUT	O/O				LED			REL					O/O	GI				
110	Event lost (Event Lost)	OUT	ON				LED			REL					O/O	GI	135	130	1	
113	Flag Lost (Flag Lost)	OUT	ON			M	LED			REL					O/O	GI	135	136	1	GI
125	Chatter ON (Chatter ON)	OUT	O/O				LED			REL					O/O	GI	135	145	1	GI
140	Error with a summary alarm (Error Sum Alarm)	OUT	O/O				LED			REL					O/O	GI	160	47	1	GI
160	Alarm Summary Event (Alarm Sum Event)	OUT	O/O				LED			REL					O/O	GI	160	46	1	GI
178	I/O-Board Error (I/O-Board error)	OUT	O/O				LED			REL					O/O	GI				
144	Error 5V (Error 5V)	OUT	O/O				LED			REL					O/O	GI				
145	Error 0V (Error 0V)	OUT	O/O				LED			REL					O/O	GI				

F#	Description	Type of Information	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
146	Error -5V (Error -5V)	OUT	O/O				LED			REL					O/O	GI				
147	Error Power Supply (Error PwrSupply)	OUT	O/O				LED			REL					O/O	GI				
177	Failure: Battery empty (Fail Battery)	OUT	O/O				LED			REL					O/O	GI				
70	Setting calculation is running (Settings Calc.)	OUT	O/O				LED			REL					O/O	GI	160	22	1	GI
71	Settings Check (Settings Check)	OUT					LED			REL					O/O	GI				
72	Level-2 change (Level-2 change)	OUT	O/O				LED			REL					O/O	GI				
73	Local setting change (Local change)	OUT													O/O	GI				
301	Power System fault (Pow.Sys.Flt.)	OUT	O/O	O/O											O/O	GI	135	231	2	GI
302	Fault Event (Fault Event)	OUT		ON											O/O	GI	135	232	2	GI
303	sensitive Ground fault (sens Gnd flt)	OUT	O/O		ON										O/O	GI	135	233	1	GI
	Stop data transmission (DataStop)	IntSP	O/O				LED			REL					O/O	GI	160	20	1	GI
16	>Stop data transmission (>DataStop)	SP					LED	BI		REL					O/O	GI	135	54	1	GI
	Test mode (Test mode)	IntSP	O/O				LED			REL					O/O	GI	160	21	1	GI
15	>Test mode (>Test mode)	SP					LED	BI		REL					O/O	GI	135	53	1	GI
	Feeder GROUNDED (Feeder gnd)	IntSP					LED			REL	OM	FM			O/O	GI				
	Breaker OPENED (Brk OPENED)	IntSP					LED			REL	OM	FM FM			O/O	GI				
	Hardware Test Mode (HWTestMod)	IntSP	O/O				LED			REL					O/O	GI				

Appendix

F#	Description	Type of Informa-tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
	Clock Synchronization (SynchClock)	IntSP_Ev													O/O	GI				
5145	>Reverse Phase Rotation (>Reverse Rot.)	SP	O/O				LED	BI		REL					O/O	GI				
5147	Phase rotation ABC (Rotation ABC)	OUT	O/O				LED			REL					O/O	GI	70	128	1	GI
5148	Phase rotation ACB (Rotation ACB)	OUT	O/O				LED			REL					O/O	GI	70	129	1	GI
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	SP				M	LED	BI		REL					O/O	GI	135	49	1	GI
203	Waveform data deleted (Wave. deleted)	OUT	ON ON				LED			REL					O/O	GI	135	203	1	
	Fault Recording Start (FltRecSta)	IntSP	O/O				LED			REL					O/O	GI				
7	>Setting Group Select Bit 0 (>Set Group Bit0)	SP					LED	BI		REL					O/O	GI	135	51	1	GI
8	>Setting Group Select Bit 1 (>Set Group Bit1)	SP					LED	BI		REL					O/O	GI	135	52	1	GI
	Group A (Group A)	IntSP	O/O				LED			REL					O/O	GI	160	23	1	GI
	Group B (Group B)	IntSP	O/O				LED			REL					O/O	GI	160	24	1	GI
	Group C (Group C)	IntSP	O/O				LED			REL					O/O	GI	160	25	1	GI
	Group D (Group D)	IntSP	O/O				LED			REL					O/O	GI	160	26	1	GI
356	>Manual close signal (>Manual Close)	SP					LED	BI		REL					O/O	GI	150	6	1	GI
2720	>Enable 50/67-(N)-2 (override 79 blk) (>Enable ANSI#-2)	SP	O/O				LED	BI		REL					O/O	GI	40	20	1	GI

F#	Description	Type of Information	Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
			Log-Buffers				Configurable in Matrix								SCADA Interface — General		IEC 60870-5-103			
888	Pulsed Energy Wp (active)	PMV															133	55	205	
889	Pulsed Energy Wq (reactive)	PMV															133	56	205	
533	Primary fault current Ia (Ia =)	OUT		O/O											O/O	GI	150	177	4	
534	Primary fault current Ib (Ib =)	OUT		O/O											O/O	GI	150	178	4	
535	Primary fault current Ic (Ic =)	OUT		O/O											O/O	GI	150	179	4	
501	Relay PICKUP (Relay PICKUP)	OUT		ON		M	LED			REL					O/O	GI	150	151	2	GI
511	Relay GENERAL TRIP command (Relay TRIP)	OUT		ON		M	LED			REL					O/O	GI	150	161	2	GI
561	Manual close signal detected (Man.Clos.Detect)	OUT	O/O				LED			REL					O/O	GI				
4601	>52-a contact (OPEN, if bkr is open) (>52-a)	SP					LED	BI		REL					O/O	GI				
4602	>52-b contact (OPEN, if bkr is closed) (>52-b)	SP					LED	BI		REL					O/O	GI				
126	Protection ON/OFF (via system port) (ProtON/OFF)	IntSP	O/O				LED			REL					O/O	GI				
1761	50(N)/51(N) O/C PICKUP (50(N)/51(N) PU)	OUT		O/O		M	LED			REL					O/O	GI	160	84	2	GI
1791	50(N)/51(N) TRIP (50(N)/51(N)TRIP)	OUT		ON		M	LED			REL					O/O	GI	160	68	2	
1704	>BLOCK 50/51 (>BLK 50/51)	SP					LED	BI		REL					O/O	GI				
1721	>BLOCK 50-2 (>BLOCK 50-2)	SP					LED	BI		REL					O/O	GI	60	1	1	GI

Appendix

F#	Description	Type of Information	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
1722	>BLOCK 50-1 (>BLOCK 50-1)	SP					LED	BI		REL					O/O	GI	60	2	1	GI
1723	>BLOCK 51 (>BLOCK 51)	SP					LED	BI		REL					O/O	GI	60	3	1	GI
1751	50/51 O/C switched OFF (50/51 PH OFF)	OUT	O/O				LED			REL					O/O	GI	60	21	1	GI
1752	50/51 O/C is BLOCKED (50/51 PH BLK)	OUT	O/O	O/O			LED			REL					O/O	GI	60	22	1	GI
1753	50/51 O/C is ACTIVE (50/51 PH ACT)	OUT	O/O				LED			REL					O/O	GI	60	23	1	GI
1762	50/51 Phase A picked up (50/51 Ph A PU)	OUT		O/O		M	LED			REL					O/O	GI	160	64	2	GI
1763	50/51 Phase B picked up (50/51 Ph B PU)	OUT		O/O		M	LED			REL					O/O	GI	160	65	2	GI
1764	50/51 Phase C picked up (50/51 Ph C PU)	OUT		O/O		M	LED			REL					O/O	GI	160	66	2	GI
1800	50-2 picked up (50-2 picked up)	OUT		O/O			LED			REL					O/O	GI	60	75	2	GI
1805	50-2 TRIP (50-2 TRIP)	OUT		ON		M	LED			REL					O/O	GI	160	91	2	
1810	50-1 picked up (50-1 picked up)	OUT		O/O			LED			REL					O/O	GI	60	76	2	GI
1815	50-1 TRIP (50-1 TRIP)	OUT		ON		M	LED			REL					O/O	GI	160	90	2	
1820	51 picked up (51 picked up)	OUT		O/O			LED			REL					O/O	GI	60	77	2	GI
1825	51 TRIP (51 TRIP)	OUT		ON		M	LED			REL					O/O	GI	60	58	2	GI
1866	51 Disk emulation Pickup (51 Disk Pik-kup)	OUT													O/O	GI				

F#	Description	Type of Informa-tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking		General		IEC 60870-5-103		
															Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
1804	50-2 Time Out (50-2 TimeOut)	OUT					LED			REL					O/O	GI	60	49	2	GI
1814	50-1 Time Out (50-1 TimeOut)	OUT					LED			REL					O/O	GI	60	53	2	GI
1824	51 Time Out (51 Time Out)	OUT					LED			REL					O/O	GI	60	57	2	GI
1852	50-2 BLOCKED (50-2 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	106	1	GI
1851	50-1 BLOCKED (50-1 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	105	1	GI
1855	51 BLOCKED (51 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	109	1	GI
1714	>BLOCK 50N/51N (>BLK 50N/51N)	SP					LED	BI		REL					O/O	GI				
1724	>BLOCK 50N-2 (>BLOCK 50N-2)	SP					LED	BI		REL					O/O	GI	60	4	1	GI
1725	>BLOCK 50N-1 (>BLOCK 50N-1)	SP					LED	BI		REL					O/O	GI	60	5	1	GI
1726	>BLOCK 51N (>BLOCK 51N)	SP					LED	BI		REL					O/O	GI	60	6	1	GI
1756	50N/51N is OFF (50N/51N OFF)	OUT	O/O				LED			REL					O/O	GI	60	26	1	GI
1757	50N/51N is BLOCKED (50N/51N BLK)	OUT	O/O	O/O			LED			REL					O/O	GI	60	27	1	GI
1758	50N/51N is ACTIVE (50N/51N ACT)	OUT	O/O				LED			REL					O/O	GI	60	28	1	GI
1765	50N/51N picked up (50N/51NPickedup)	OUT		O/O		M	LED			REL					O/O	GI	160	67	2	GI
1831	50N-2 picked up (50N-2 picked up)	OUT		O/O			LED			REL					O/O	GI	60	59	2	GI
1833	50N-2 TRIP (50N-2 TRIP)	OUT		ON		M	LED			REL					O/O	GI	160	93	2	
1834	50N-1 picked up (50N-1 picked up)	OUT		O/O			LED			REL					O/O	GI	60	62	2	GI
1836	50N-1 TRIP (50N-1 TRIP)	OUT		ON		M	LED			REL					O/O	GI	160	92	2	
1837	51N picked up (51N picked up)	OUT		O/O			LED			REL					O/O	GI	60	64	2	GI

F#	Description	Type of Informa-tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
																General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
1839	51N TRIP (51N TRIP)	OUT		ON		M	LED			REL					O/O	GI	60	66	2	GI
1867	51N Disk emulation picked up (51N Disk Pickup)	OUT													O/O	GI				
1832	50N-2 Time Out (50N-2 TimeOut)	OUT					LED			REL					O/O	GI	60	60	2	GI
1835	50N-1 Time Out (50N-1 TimeOut)	OUT					LED			REL					O/O	GI	60	63	2	GI
1838	51N Time Out (51N TimeOut)	OUT					LED			REL					O/O	GI	60	65	2	GI
1854	50N-2 BLOCKED (50N-2 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	108	1	GI
1853	50N-1 BLOCKED (50N-1 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	107	1	GI
1856	51N BLOCKED (51N BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	110	1	GI
7563	>BLOCK InRush Phase (>BLOCK InRushPh)	SP					LED	BI		REL					O/O	GI				
1840	Phase A trip blocked by inrush detection (PhA InrushBlk)	OUT		O/O			LED			REL					O/O	GI	60	101	2	GI
1841	Phase B trip blocked by inrush detection (PhB InrushBlk)	OUT		O/O			LED			REL					O/O	GI	60	102	2	GI
1842	Phase C trip blocked by inrush detection (PhC InrushBlk)	OUT		O/O			LED			REL					O/O	GI	60	103	2	GI
1843	Cross blk: PhX blocked PhY (INRUSH X-BLK)	OUT		O/O			LED			REL					O/O	GI	60	104	2	GI
7551	50-1 InRush picked up (50-1 InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	80	2	GI

F#	Description	Type of Information	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
7552	50N-1 InRush picked up (50N-1 InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	81	2	GI
7553	51 InRush picked up (51 InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	82	2	GI
7554	51N InRush picked up (51N InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	83	2	GI
7556	InRush OFF (InRush OFF)	OUT	O/O				LED			REL					O/O	GI	60	92	1	GI
7557	InRush Phase BLOCKED (InRushPh-BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	93	1	GI
7558	InRush Ground BLOCKED (InRush Gnd BLK)	OUT		O/O			LED			REL					O/O	GI	60	94	1	GI
7559	67-1 InRush picked up (67-1 InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	84	2	GI
7560	67N-1 InRush picked up (67N-1 InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	85	2	GI
7561	67-TOC InRush picked up (67-TOC InRushPU)	OUT		O/O			LED			REL					O/O	GI	60	86	2	GI
7562	67N-TOC InRush picked up (67N-TOCInRushPU)	OUT		O/O			LED			REL					O/O	GI	60	87	2	GI
7565	Phase A InRush picked up (Ia InRush PU)	OUT		O/O			LED			REL					O/O	GI	60	89	2	GI
7566	Phase B InRush picked up (Ib InRush PU)	OUT		O/O			LED			REL					O/O	GI	60	90	2	GI
7567	Phase C InRush picked up (Ic InRush PU)	OUT		O/O			LED			REL					O/O	GI	60	91	2	GI

F#	Description	Type of Information	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
7564	Ground InRush picked up (Gnd InRush PU)	OUT		O/O			LED			REL					O/O	GI	60	88	2	GI
1730	>BLOCK Cold-Load-Pickup (>BLOCK CLP)	SP					LED	BI		REL					O/O	GI				
1731	>BLOCK Cold-Load-Pickup stop timer (>BLK CLP stpTim)	SP	O/O				LED	BI		REL					O/O	GI	60	243	1	GI
1994	Cold-Load-Pickup switched OFF (CLP OFF)	OUT	O/O				LED			REL					O/O	GI	60	244	1	GI
1995	Cold-Load-Pickup is BLOCKED (CLP BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	60	245	1	GI
1996	Cold-Load-Pickup is RUNNING (CLP running)	OUT	O/O				LED			REL					O/O	GI	60	246	1	GI
1997	Dynamic settings are ACTIVE (Dyn set. ACTIVE)	OUT	O/O				LED			REL					O/O	GI	60	247	1	GI
5143	>BLOCK 46 (>BLOCK 46)	SP					LED	BI		REL					O/O	GI	70	126	1	GI
5151	46 switched OFF (46 OFF)	OUT	O/O				LED			REL					O/O	GI	70	131	1	GI
5152	46 is BLOCKED (46 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	70	132	1	GI
5153	46 is ACTIVE (46 ACTIVE)	OUT	O/O				LED			REL					O/O	GI	70	133	1	GI
5159	46-2 picked up (46-2 picked up)	OUT		O/O			LED			REL					O/O	GI	70	138	2	GI
5165	46-1 picked up (46-1 picked up)	OUT		O/O			LED			REL					O/O	GI	70	150	2	GI
5166	46-TOC picked up (46-TOC pickedup)	OUT		O/O			LED			REL					O/O	GI	70	141	2	GI

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															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
5170	46 TRIP (46 TRIP)	OUT		ON		M	LED			REL					O/O	GI	70	149	2	GI
5171	46 Disk emulation picked up (46 Dsk pickedup)	OUT					LED			REL					O/O	GI				
6801	>BLOCK Startup Supervision (>BLK START-SUP)	SP					LED	BI		REL					O/O	GI				
6805	>Rotor locked (>Rotor locked)	SP					LED	BI		REL					O/O	GI				
6811	Startup supervision OFF (START-SUP OFF)	OUT	O/O				LED			REL					O/O	GI	169	51	1	GI
6812	Startup supervision is BLOCKED (START-SUP BLK)	OUT	O/O	O/O			LED			REL					O/O	GI	169	52	1	GI
6813	Startup supervision is ACTIVE (START-SUP ACT)	OUT	O/O				LED			REL					O/O	GI	169	53	1	GI
6821	Startup supervision TRIP (START-SUP TRIP)	OUT		ON		M	LED			REL					O/O	GI	169	54	2	GI
6822	Rotor locked (Rotor locked)	OUT		ON			LED			REL					O/O	GI	169	55	2	GI
6823	Startup supervision Pickup (START-SUP pu)	OUT	O/O				LED			REL					O/O	GI	169	56	1	GI
4822	>BLOCK Motor Startup counter (>BLOCK 66)	SP					LED	BI		REL					O/O	GI				
4823	>Emergency start (>66 emer.start)	SP	O/O				LED	BI		REL					O/O	GI	168	51	1	GI
4824	66 Motor start protection OFF (66 OFF)	OUT	O/O				LED			REL					O/O	GI	168	52	1	GI

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															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
4825	66 Motor start protection BLOCKED (66 BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	168	53	1	GI
4826	66 Motor start protection ACTIVE (66 ACTIVE)	OUT	O/O				LED			REL					O/O	GI	168	54	1	GI
4827	66 Motor start protection TRIP (66 TRIP)	OUT	O/O				LED			REL					O/O	GI	168	55	1	GI
1503	>BLOCK 49 Overload Protection (>BLOCK 49 O/L)	SP					LED	BI		REL					O/O	GI	167	3	1	GI
1507	>Emergency start of motors (>Emer-gencyStart)	SP	O/O				LED	BI		REL					O/O	GI	167	7	1	GI
1511	49 Overload Protection is OFF (49 O / L OFF)	OUT	O/O				LED			REL					O/O	GI	167	11	1	GI
1512	49 Overload Protection is BLOCKED (49 O/L BLOCK)	OUT	O/O	O/O			LED			REL					O/O	GI	167	12	1	GI
1513	49 Overload Protection is ACTIVE (49 O/L ACTIVE)	OUT	O/O				LED			REL					O/O	GI	167	13	1	GI
1515	49 Overload Current Alarm (I alarm) (49 O/L I Alarm)	OUT	O/O				LED			REL					O/O	GI	167	15	1	GI
1516	49 Overload Alarm! Near Thermal Trip (49 O/L Θ Alarm)	OUT	O/O				LED			REL					O/O	GI	167	16	1	GI
1517	49 Winding Overload (49 Winding O/L)	OUT	O/O				LED			REL					O/O	GI	167	17	1	GI

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																General	IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
1521	49 Thermal Overload TRIP (49 Th O/L TRIP)	OUT		ON		M	LED			REL					O/O	GI	167	21	2	GI
162	Failure: Current Summation (Failure Σ I)	OUT	O/O				LED			REL					O/O	GI	135	182	1	GI
163	Failure: Current Balance (Fail I balance)	OUT	O/O				LED			REL					O/O	GI	135	183	1	GI
161	Failure: general Current Supervision (Fail I Superv.)	OUT	O/O				LED			REL					O/O	GI	160	32	1	GI
171	Failure: Phase Sequence (Fail Ph. Seq.)	OUT	O/O				LED			REL					O/O	GI	160	35	1	GI
175	Failure: Phase Sequence Current (Fail Ph. Seq. I)	OUT	O/O				LED			REL					O/O	GI	135	191	1	GI
197	Measurement Supervision is switched OFF (MeasSup OFF)	OUT	O/O				LED			REL					O/O	GI	135	197	1	GI
6851	>BLOCK 74TC (>BLOCK 74TC)	SP					LED	BI		REL					O/O	GI				
6853	>74TC Trip circuit superv.: bkr relay (>74TC brk rel.)	SP	O/O				LED	BI		REL					O/O	GI	170	52	1	GI
6852	>74TC Trip circuit superv.: trip relay (>74TC trip rel.)	SP	O/O				LED	BI		REL					O/O	GI	170	51	1	GI
6861	74TC Trip circuit supervision OFF (74TC OFF)	OUT	O/O				LED			REL					O/O	GI	170	53	1	GI
6862	74TC Trip circuit supervision is BLOK-KED (74TC BLOCKED)	OUT	O/O	O/O			LED			REL					O/O	GI	153	16	1	GI

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																General	IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
6863	74TC Trip circuit supervision is ACTIVE (74TC ACTIVE)	OUT	O/O				LED			REL					O/O	GI	153	17	1	GI
6864	74TC blocked. Bin. input is not set (74TC ProgFail)	OUT	O/O				LED			REL					O/O	GI	170	54	1	GI
6865	74TC Failure Trip Circuit (FAIL: Trip cir.)	OUT	O/O				LED			REL					O/O	GI	170	55	1	GI
1202	>BLOCK 50Ns-2 (>BLOCK 50Ns-2)	SP	O/O				LED	BI		REL					O/O	GI	151	102	1	GI
1203	>BLOCK 50Ns-1 (>BLOCK 50Ns-1)	SP	O/O				LED	BI		REL					O/O	GI	151	103	1	GI
1204	>BLOCK 51Ns (>BLOCK 51Ns)	SP	O/O				LED	BI		REL					O/O	GI	151	104	1	GI
1207	>BLOCK 50Ns/67Ns (>BLK 50Ns/67Ns)	SP	O/O				LED	BI		REL					O/O	GI	151	107	1	GI
1211	50Ns/67Ns is OFF (50Ns/67Ns OFF)	OUT	O/O				LED			REL					O/O	GI	151	111	1	GI
1212	50Ns/67Ns is ACTIVE (50Ns/67Ns ACT)	OUT	O/O				LED			REL					O/O	GI	151	112	1	GI
1221	50Ns-2 Pickup (50Ns-2 Pickup)	OUT		O/O			LED			REL					O/O	GI	151	121	2	GI
1223	50Ns-2 TRIP (50Ns-2 TRIP)	OUT		ON		M	LED			REL					O/O	GI	151	123	2	GI
1224	50Ns-1 Pickup (50Ns-1 Pickup)	OUT		O/O			LED			REL					O/O	GI	151	124	2	GI
1226	50Ns-1 TRIP (50Ns-1 TRIP)	OUT		ON		M	LED			REL					O/O	GI	151	126	2	GI
1227	51Ns picked up (51Ns Pickup)	OUT		O/O			LED			REL					O/O	GI	151	127	2	GI
1229	51Ns TRIP (51Ns TRIP)	OUT		ON		M	LED			REL					O/O	GI	151	129	2	GI

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															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
1230	Sensitive ground fault detection BLOK-KED (Sens. Gnd block)	OUT	O/O	O/O			LED			REL					O/O	GI	151	130	1	GI
2701	>79 ON (>79 ON)	SP					LED	BI		REL					O/O	GI	40	1	1	GI
2702	>79 OFF (>79 OFF)	SP					LED	BI		REL					O/O	GI	40	2	1	GI
2703	>BLOCK 79 (>BLOCK 79)	SP	O/O				LED	BI		REL					O/O	GI	40	3	1	GI
2705	>79 T Wait (coordination control) (>79 T WAIT)	SP	O/O				LED	BI		REL					O/O	GI	40	10	1	GI
2730	>Circuit breaker READY for reclosing (>CB Ready)	SP	O/O				LED	BI		REL					O/O	GI	40	30	1	GI
2715	>79 Ext. 1pole TRIP for internal A/R (>79 TRIP 1p)	SP					LED	BI		REL					O/O	GI	40	15	1	GI
2716	>79 Ext. 3pole TRIP for internal A/R (>79 TRIP 3p)	SP					LED	BI		REL					O/O	GI	40	16	1	GI
2722	>Switch zone sequence coordination ON (>ZSC ON)	SP					LED	BI		REL					O/O	GI				
2723	>Switch zone sequence coordination OFF (>ZSC OFF)	SP					LED	BI		REL					O/O	GI				
2781	79 Auto recloser is switched OFF (79 OFF)	OUT	O/O				LED			REL					O/O	GI	40	81	1	GI
2782	79 Auto recloser is switched ON (79 ON)	IntSP					LED			REL					O/O	GI	160	16	1	GI

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			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
2784	Circuit breaker is NOT ready (CB is NOT ready)	OUT	O/O	O/O			LED			REL					O/O	GI	160	130	1	GI
2785	79 - Auto-reclose is dynamically BLOK-KED (79 DynBlock)	OUT	O/O	O/O			LED			REL					O/O	GI	40	85	1	GI
2801	79 - in progress (79 in progress)	OUT	ON				LED			REL					O/O	GI	40	101	1	GI
2851	79 - Close command (79 Close)	OUT		ON		M	LED			REL					O/O	GI	160	128	1	
2862	79 - cycle successful (79 Successful)	OUT	ON				LED			REL					O/O	GI	40	162	1	GI
2863	79 - Lockout (79 Lockout)	OUT					LED			REL					O/O	GI	40	163	2	GI
2869	TRIP Ground Fault (TRIP Gnd Fault)	OUT		O/O			LED			REL					O/O	GI				
2870	TRIP Phase Fault (TRIP Ph Fault)	OUT		O/O			LED			REL					O/O	GI				
2876	79-A/R attempt step (79 STEP)	OUT		O/O											O/O	GI	40	182	2	GI
2878	79-A/R single phase reclosing sequence (79 L-N Sequence)	OUT		ON			LED			REL					O/O	GI	40	180	2	GI
2879	79-A/R multi-phase reclosing sequence (79 L-L Sequence)	OUT		ON			LED			REL					O/O	GI	40	181	2	GI
2883	Zone Sequencing is active (ZSC active)	OUT	ON				LED			REL					O/O	GI				
2884	Zone sequence coordination switched ON (ZSC ON)	OUT					LED			REL					O/O	GI				
2885	Zone sequence coordination switched OFF (ZSC OFF)	OUT	O/O				LED			REL					O/O	GI				

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			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
127	79 ON/OFF (via system port) (79 ON/OFF)	IntSP	O/O				LED			REL					O/O	GI				
1403	>BLOCK 50BF (>BLOCK 50BF)	SP	O/O				LED	BI		REL					O/O	GI	166	103	1	GI
1431	>50BF initiated externally (>50BF ext SRC)	SP	O/O				LED	BI		REL					O/O	GI	166	104	1	GI
1451	50BF is switched OFF (50BF OFF)	OUT	O/O				LED			REL					O/O	GI	166	151	1	GI
1452	50BF is BLOCKED (50BF BLOCK)	OUT	O/O	O/O			LED			REL					O/O	GI	166	152	1	GI
1453	50BF is ACTIVE (50BF ACTIVE)	OUT	O/O				LED			REL					O/O	GI	166	153	1	GI
1456	50BF (internal) PICKUP (50BF int Pik-kup)	OUT		O/O			LED			REL					O/O	GI	166	156	2	GI
1457	50BF (external) PICKUP (50BF ext Pik-kup)	OUT		O/O			LED			REL					O/O	GI	166	157	2	GI
1471	50BF TRIP (50BF TRIP)	OUT		ON		M	LED			REL					O/O	GI	160	85	2	
1480	50BF (internal) TRIP (50BF int TRIP)	OUT		ON			LED			REL					O/O	GI	166	180	2	GI
1481	50BF (external) TRIP (50BF ext TRIP)	OUT		ON			LED			REL					O/O	GI	166	181	2	GI
	Controlmode REMOTE (ModeRE-MOTE)	IntSP	O/O				LED								O/O	GI				
	Control DIGSI (CntrlDIGSI)	LV	O/O												O/O	GI				
	Control Authority (Cntrl Auth)	IntSP	O/O				LED								O/O	GI	101	85	1	GI
	Controlmode LOCAL (ModeLOCAL)	IntSP	O/O				LED								O/O	GI	101	86	1	GI

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																General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
	52 Breaker (52Breaker)	CF_D12	O/O							REL	OM				O/O	GI	240	160	1	GI
	52 Breaker (52Breaker)	DP	O/O					BI			OM			CB	O/O	GI	240	160	1	GI
	Disconnect Switch (Disc.Swit.)	CF_D2	O/O							REL	OM				O/O	GI	240	161	1	GI
	Disconnect Switch (Disc.Swit.)	DP	O/O					BI			OM			CB	O/O	GI	240	161	1	GI
	Ground Switch (GndSwit.)	CF_D2	O/O							REL	OM				O/O	GI	240	164	1	GI
	Ground Switch (GndSwit.)	DP	O/O					BI			OM			CB	O/O	GI	240	164	1	GI
	Interlocking: 52 Open (52 Open)	IntSP													O/O					
	Interlocking: 52 Close (52 Close)	IntSP													O/O					
	Interlocking: Disconnect switch Open (Disc.Open)	IntSP													O/O					
	Interlocking: Disconnect switch Close (Disc.Close)	IntSP													O/O					
	Interlocking: Ground switch Open (GndSw Open)	IntSP													O/O					
	Interlocking: Ground switch Close (GndSw Cl.)	IntSP													O/O					
	Block Data Transmission to SCADA (Block Data)	IntSP													O/O					
	Q2 Open/Close (Q2 Op/Cl)	CF_D2	O/O							REL	OM				O/O	GI	240	162	1	GI
	Q2 Open/Close (Q2 Op/Cl)	DP	O/O					BI			OM			CB	O/O	GI	240	162	1	GI

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															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
	Q9 Open/Close (Q9 Op/Cl)	CF_D2	O/O							REL	OM				O/O	GI	240	163	1	GI
	Q9 Open/Close (Q9 Op/Cl)	DP	O/O					BI			OM			CB	O/O	GI	240	163	1	GI
	Fan ON/OFF (Fan ON/OFF)	CF_D2	O/O							REL	OM				O/O	GI	240	175	1	GI
	Fan ON/OFF (Fan ON/OFF)	DP	O/O					BI			OM			CB	O/O	GI	240	175	1	GI
	>CB ready Spring is charged (>CB ready)	SP					LED	BI		REL	OM			CB	O/O	GI				
	>Door closed (>DoorClose)	SP					LED	BI		REL	OM			CB	O/O	GI				
	>Cabinet door open (>Door open)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	101	1	1	GI
	>CB waiting for Spring charged (>CB wait)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	101	2	1	GI
	>No Voltage (Fuse blown) (>No Volt.)	SP	O/O				LED	BI		REL				CB	O/O	GI	160	38	1	GI
	>Error Motor Voltage (>Err Mot V)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	240	181	1	GI
	>Error Control Voltage (>ErrCntrlV)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	240	182	1	GI
	>SF6-Loss (>SF6-Loss)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	240	183	1	GI
	>Error Meter (>Err Meter)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	240	184	1	GI
	>Transformer Temperature (>Tx Temp.)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	240	185	1	GI
	>Transformer Danger (>Tx Danger)	SP	O/O				LED	BI		REL	OM			CB	O/O	GI	240	186	1	GI
601	Ia (Ia =)	MV													O/O	GI	134	137	9	
602	Ib (Ib =)	MV													O/O	GI	160 134	145 137	3 9	

Appendix

F#	Description	Type of Informa-tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
603	Ic (Ic =)	MV													O/O	GI	134	137	9	
604	In (In =)	MV													O/O	GI	134	137	9	
605	I1 (positive sequence) (I1 =)	MV													O/O	GI				
606	I2 (negative sequence) (I2 =)	MV													O/O	GI				
831	3Io (zero sequence) (3Io =)	MV													O/O	GI				
830	INs Senstive Ground Fault Current (INs =)	MV													O/O	GI				
806	Temperature of Stator (Θ Stator)	MV													O/O	GI				
805	Temperature of Rotor (Θ Rotor)	MV													O/O	GI				
963	I A demand (Ia dmd=)	MV													O/O	GI				
964	I B demand (Ib dmd=)	MV													O/O	GI				
965	I C demand (Ic dmd=)	MV													O/O	GI				
833	I1 (positive sequence) Demand (I1 dmd=)	MV													O/O	GI				
	Reset Minimum and Maximum counter (ResMinMax)	IntSP_Ev	ON												O/O	GI				
395	>I MIN/MAX Buffer Reset (>I MinMax Reset)	SP	ON					BI		REL					O/O	GI				
396	>I1 MIN/MAX Buffer Reset (>I1 MiMa-Reset)	SP	ON					BI		REL					O/O	GI				

F#	Description	Type of Information	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
403	>Idmd MIN/MAX Buffer Reset (>Idmd MiMaReset)	SP	ON					BI		REL					O/O	GI				
851	Ia Min (Ia Min=)	MVT													O/O	GI				
852	Ia Max (Ia Max=)	MVT													O/O	GI				
853	Ib Min (Ib Min=)	MVT													O/O	GI				
854	Ib Max (Ib Max=)	MVT													O/O	GI				
855	Ic Min (Ic Min=)	MVT													O/O	GI				
856	Ic Max (Ic Max=)	MVT													O/O	GI				
857	I1 (positive sequence) Minimum (I1 Min=)	MVT													O/O	GI				
858	I1 (positive sequence) Maximum (I1 Max=)	MVT													O/O	GI				
837	I A Demand Minimum (IAdmdMin)	MVT													O/O	GI				
838	I A Demand Maximum (IAdmdMax)	MVT													O/O	GI				
839	I B Demand Minimum (IBdmdMin)	MVT													O/O	GI				
840	I B Demand Maximum (IBdmdMax)	MVT													O/O	GI				
841	I C Demand Minimum (ICdmdMin)	MVT													O/O	GI				
842	I C Demand Maximum (ICdmdMax)	MVT													O/O	GI				
843	I1 (positive sequence) Demand Minimum (I1dmdMin)	MVT													O/O	GI				

F#	Description	Type of Information	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
844	I1 (positive sequence) Demand Maximum (I1dmdMax)	MVT													O/O	GI				
	I A dmd> (I Admd>)	LV													O/O					
	I B dmd> (I Bdmd>)	LV													O/O					
	I C dmd> (I Cdmd>)	LV													O/O					
	I1dmd> (I1dmd>)	LV													O/O					
273	Set Point Phase A dmd> (SP. I A dmd>)	OUT	O/O				LED			REL	OM				O/O	GI	135	230	1	GI
274	Set Point Phase B dmd> (SP. I B dmd>)	OUT	O/O				LED			REL	OM				O/O	GI	135	234	1	GI
275	Set Point Phase C dmd> (SP. I C dmd>)	OUT	O/O				LED			REL	OM				O/O	GI	135	235	1	GI
276	Set Point positive sequence I1dmd> (SP. I1dmd>)	OUT	O/O				LED			REL	OM				O/O	GI	135	236	1	GI
284	Set Point 37-1 Undercurrent alarm (SP. 37-1 alarm)	OUT	O/O				LED			REL	OM				O/O	GI	135	244	1	GI
	37-1 under current (37-1)	LV													O/O					
	Reset meter (Meter res)	IntSP_Ev	ON					BI							O/O	GI				
1020	Counter of operating hours (Op.Hours=)	OUT													O/O	GI				
409	>BLOCK Op Counter (>BLOCK Op Count)	SP	O/O				LED	BI		REL	OM				O/O	GI				
1021	Accumulation of interrupted current Ph A (Σ Ia =)	OUT													O/O	GI				

F#	Description	Type of Informa- tion	Log-Buffers				Configurable in Matrix								SCADA Interface					
															General		IEC 60870-5-103			
			Event Log	Trip Log	Sensitive E Log	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Event Log	Trip Log	Sensitive E Log	Chatter Blocking	Status ON/OFF	General Interrogation	Type	Information-No.	Data Unit (ASDU)	General Interrogation
1022	Accumulation of interrupted current Ph B (Σ Ib =)	OUT													O/O	GI				
1023	Accumulation of interrupted current Ph C (Σ Ic =)	OUT													O/O	GI				
	Operating hours greater than (OpH-our>)	LV													O/O	GI				
272	Set Point Operating Hours (SP. Op Hours>)	OUT	O/O				LED			REL	OM				O/O	GI	135	229	1	GI

A.7 Overview of the masking features of the user defined informations

Type of Information		Source			Destination			CFC Task level			
		Binary Inputs	Function Keys	CFC	Binary Outputs	LED	CFC	Measurement	PLC1 (slow)	PLC (fast)	Interlocking
• **Annunciation:**											
Single Point											
– SP_Ev	Single Point Indication Event	–	–	–	–	–	–	–	–	–	–
– SP	Single Point Indication ON/OFF	X	–	X	X	X	X	–	X	X	–
– SP	Single Point Indication Open/Close	X	–	X	X	X	X	–	X	X	–
Double Point											
– DP	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	X	–	X	–	–	X	X[1]	X	X	X[2]
– DP_I	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	X	–	X	–	–	X	X[1]	X	X	X[2]
Output Slow											
– OUT	Output Indication Event	–	–	–	–	–	–	–	–	–	–
– OUT	Output Indication ON/OFF	–	–	X	X	X	X	X[1]	X	X	X[2]
– OUT	Output Indication Open/Close	–	–	X	X	X	X	X[1]	X	X	X[2]
Output Fast											
– OUT	Protection ON/OFF	–	–	X	X	X	X	–	X	X	X[2]
– OUT	Protection Open/Close	–	–	X	X	X	X	–	X	X	X[2]
Tagging											
– IntSP_ Ev	Internal Single Point Indication Event	–	–	–	–	–	–	–	–	–	–
– IntSP	Internal Single Point Indication ON/OFF	–	X	X	X	X	X	X[1]	X	X	X[2]
– IntSP	Internal Single Point Indication Open/Close	–	X	X	X	X	X	X[1]	X	X	X[2]
– IntDP	Internal Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	–	–	X	–	–	X	X[1]	X	X	X[2]
– IntDP_I	Internal Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	–	–	X	–	–	X	X[1]	X	X	X[2]
Tap Changer											
– TxTap	Transformer Tap Changer	X	–	–	–	–	–	–	–	–	–
• **Control Commands without feedback:**											
Single Controls											
– C_S	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_S	Open/Close	–	–	X	X	–	X	–	X	X	X
Single Controls negated											

[1] Only for measurement setpoints (is processed cyclically every 600 ms); do not use for binary inputs.
[2] Only for commands (is triggered by commands only).

Type of Information		Source			Destination			CFC Task level			
		Binary Inputs	Function Keys	CFC	Binary Outputs	LED	CFC	Measurement	PLC1 (slow)	PLC (fast)	Interlocking
– C_SN	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_SN	Open/Close	–	–	X	X	–	X	–	X	X	X
Double Controls 1 Trip 1 Close											
– C_D2	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_D2	Open/Close	–	–	X	X	–	X	–	X	X	X
– C_D2	Transformer Tap Changer	–	–	X	X	–	X	–	X	X	X
Double Controls 1 Trip 1 Close 1 Common											
– C_D3	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_D3	Open/Close	–	–	X	X	–	X	–	X	X	X
– C_D3	Transformer Tap Changer	–	–	X	X	–	X	–	X	X	X
Double Controls 2 Trip 2 Close											
– C_D4	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_D4	Open/Close	–	–	X	X	–	X	–	X	X	X
– C_D4	Transformer Tap Changer	–	–	X	X	–	X	–	X	X	X
Double Controls 1 Trip 2 Close											
– C_D12	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_D12	Open/Close	–	–	X	X	–	X	–	X	X	X
– C_D12	Transformer Tap Changer	–	–	X	X	–	X	–	X	X	X
Double Controls negated											
– C_D2N	ON/OFF	–	–	X	X	–	X	–	X	X	X
– C_D2N	Open/Close	–	–	X	X	–	X	–	X	X	X
– C_D2N	Transformer Tap Changer	–	–	X	X	–	X	–	X	X	X

[1]) Only for measurement setpoints (is processed cyclically every 600 ms); do not use for binary inputs.
[2]) Only for commands (is triggered by commands only).

Type of Information			Source			Destination			CFC Task level			
			Binary Inputs	Function Keys	CFC	Binary Outputs	LED	CFC	Measurement	PLC1 (slow)	PLC (fast)	Interlocking
• Control Commands with feedback:												
Single Controls												
– CF_S	Single Point Indication ON/OFF	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_S	Single Point Indication Open/Close	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_S	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	Control	–	–	X	X	–	X	–	X	X	X
– DP		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_S	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	Control	–	–	X	X	–	X	–	X	X	X
– DP_I		Feedback	X	–	X	–	–	X	–	X	X	X
Double Controls 1 Trip 1 Close												
– CF_D2	Single Point Indication ON/OFF	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D2	Single Point Indication Open/Close	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D2	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	Control	–	–	X	X	–	X	–	X	X	X
– DP		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D2	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	Control	–	–	X	X	–	X	–	X	X	X
– DP_I		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D2	Transformer Tap Changer	Control	–	–	X	X	–	X	–	X	X	X
– TxTap		Feedback	–	–	–	–	–	–	–	–	–	–
Double Controls 1 Trip 1 Close 1 Common												
– CF_D3	Single Point Indication ON/OFF	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D3	Single Point Indication Open/Close	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D3	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	Control	–	–	X	X	–	X	–	X	X	X
– DP		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D3	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	Control	–	–	X	X	–	X	–	X	X	X
– DP_I		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D3	Transformer Tap Changer	Control	–	–	X	X	–	X	–	X	X	X
– TxTap		Feedback	–	–	–	–	–	–	–	–	–	–
Double Controls 2 Trip 2 Close												
– CF_D4	Single Point Indication ON/OFF	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D4	Single Point Indication Open/Close	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D4	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	Control	–	–	X	X	–	X	–	X	X	X
– DP		Feedback	X	–	X	–	–	X	–	X	X	X

Type of Information			Source			Destination			CFC Task level			
			Binary Inputs	Function Keys	CFC	Binary Outputs	LED	CFC	Measurement	PLC1 (slow)	PLC (fast)	Interlocking
– CF_D4	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	Control	–	–	X	X	–	X	–	X	X	X
– DP_I		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D4	Transformer Tap Changer	Control	–	–	X	X	–	X	–	X	X	X
– TxTap		Feedback	–	–	–	–	–	–	–	–	–	–
Double Controls 1 Trip 2 Close												
– CF_D12	Single Point Indication ON/OFF	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D12	Single Point Indication Open/Close	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D12	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	Control	–	–	X	X	–	X	–	X	X	X
– DP		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D12	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	Control	–	–	X	X	–	X	–	X	X	X
– DP_I		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D12	Transformer Tap Changer	Control	–	–	X	X	–	X	–	X	X	X
– TxTap		Feedback	–	–	–	–	–	–	–	–	–	–
Double Controls 1 Trip 1 Close negated												
– CF_D2N	Single Point Indication ON/OFF	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D2N	Single Point Indication Open/Close	Control	–	–	X	X	–	X	–	X	X	X
– SP		Feedback	X	–	X	X	X	X	–	X	X	X
– CF_D2N	Double Point Indication (Breaker indication "00" = not valid/transmitted as "3")	Control	–	–	X	X	–	X	–	X	X	X
– DP		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D2N	Double Point Indication (Breaker indication "00" = intermediate/transmitted as "0")	Control	–	–	X	X	–	X	–	X	X	X
– DP_I		Feedback	X	–	X	–	–	X	–	X	X	X
– CF_D2N	Transformer Tap Changer	Control	–	–	X	X	–	X	–	X	X	X
– TxTap		Feedback	–	–	–	–	–	–	–	–	–	–
• **Measured Values:**												
– MV	Measured Value		–	–	–	–	–	X	X	–	–	–
– MVU	Measured Value, User Defined		–	–	X	–	–	–	X	–	–	–
– LV	Limit Value		–	–	–	–	–	X	X	–	–	–
– LVU	Limit Value, User Defined		–	–	–	–	–	X	X	–	–	–
• **Metered Values:**												
– MVMV	Metered Value of Measured Values		–	–	–	–	–	–	–	–	–	–
– PMV	Pulse Metered Values		X	–	–	–	–	–	–	–	–	–

A.8 Default Settings

A.8.1 Pre-Defined CFC Charts

Some CFC Charts are already supplied with the SIPROTEC® device:

**Device and System
Logic**
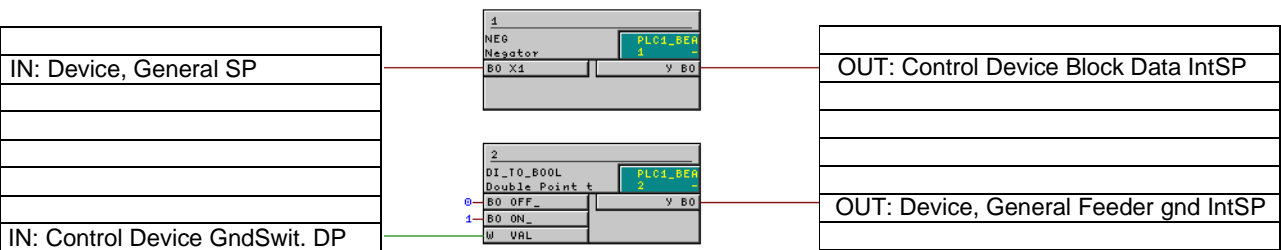
Figure A-13 Device and System Logic

Set points

Using modules on the running sequence "measured value processing", a low current monitor for the three phase currents is implemented. The output message is set high as soon as one of the three phase currents falls below the set threshold:
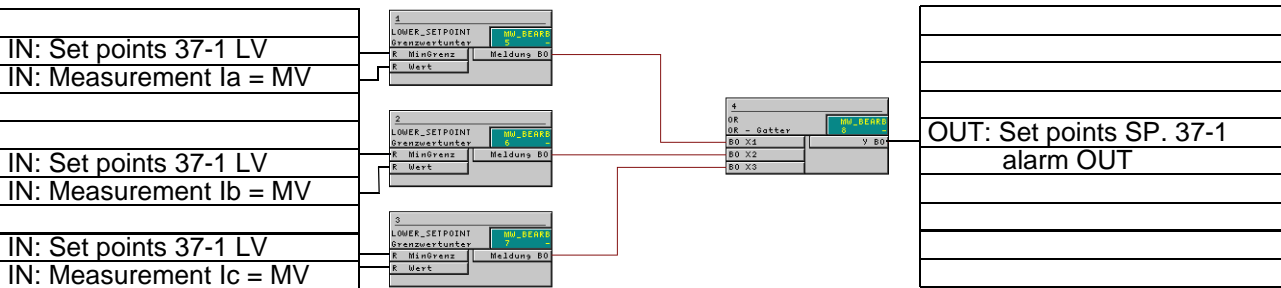
Figure A-14   Undercurrent monitoring 37-1

| IN: Set points I Admd> LV |
| IN: Demand meter Ia dmd= MV |

| 5 |
| UPPER_SETPOINT |
| Upper limit |
| R Limit |
| R Val |

MW_BEARB
3

Annunc BO

| OUT: Set points SP. I A dmd> OUT |

| IN: Set points I Bdmd> LV |
| IN: Demand meter Ib dmd= MV |

| 6 |
| UPPER_SETPOINT |
| Upper limit |
| R Limit |
| R Val |

MW_BEARB
10

Annunc BO

| OUT: Set points SP. I B dmd> OUT |

| IN: Set points I Cdmd> LV |
| IN: Demand meter Ic dmd= MV |

| 7 |
| UPPER_SETPOINT |
| Upper limit |
| R Limit |
| R Val |

MW_BEARB
11

Annunc BO

| OUT: Set points SP. I C dmd> OUT |

| IN: Set points I1dmd> LV |
| IN: Demand meter I1 dmd= MV |

| 8 |
| UPPER_SETPOINT |
| Upper limit |
| R Limit |
| R Val |

MW_BEARB
12

Annunc BO

| OUT: Set points SP. I1 dmd> OUT |

Figure A-15   Overcurrent monitoring

■

Index

U

V

W

Z