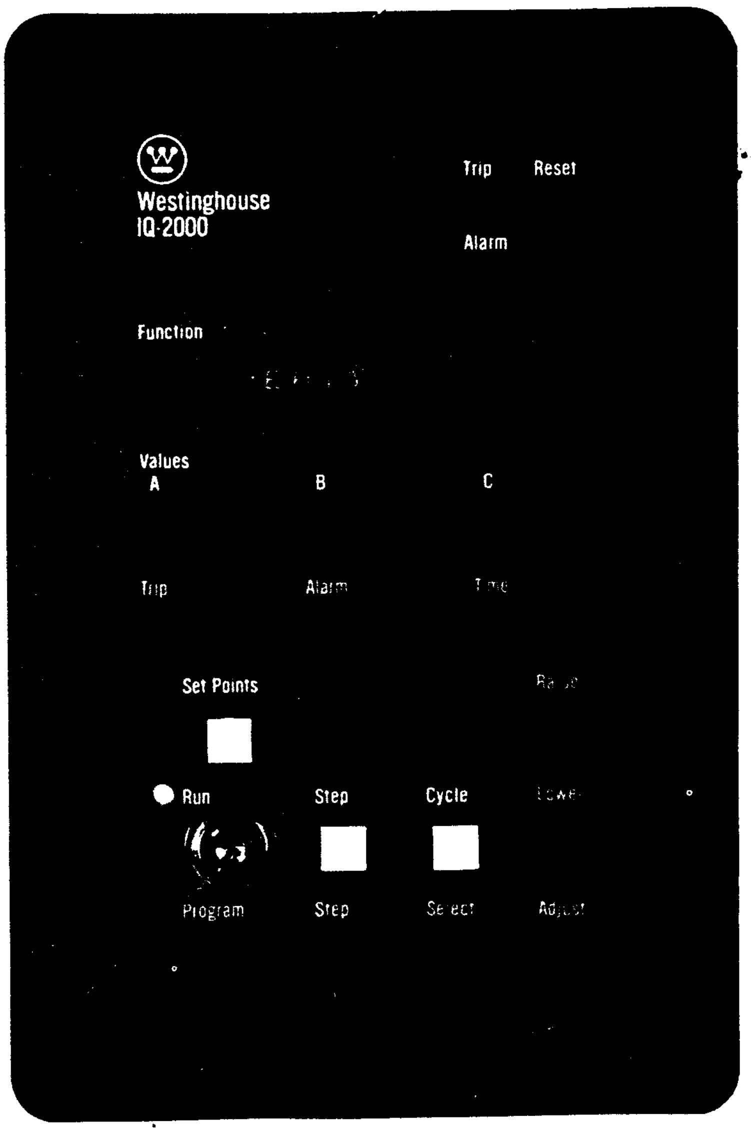
# IQ-2000™

Model B

# MOTOR COMMAND SYSTEM USER'S MANUAL




Westinghouse

CONTROL DIVISION

Effective April, 1985

*NOTE*

*All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.*

**Effective April, 1985**



**Westinghouse Electric Corporation**
Control Division
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# Section 1

# DESCRIPTION

**1.0 General** — The IQ-2000™ is a microprocessor-controlled, motor command system that is made available in a single, integrated package. It is designed for use with the Ampgard® Motor Control Assembly, and other types of starters. (See Figure 1.1.)

This manual describes the Model B version of the IQ-2000, as described more fully in Paragraph 1.4.

With respect to motors, the IQ-2000 has 3 primary functions:

- Protection
- Monitoring
- Control

A unique **protection** algorithm utilizes 3-phase motor current information and stator winding temperature data to protect both the stator and rotor from damage due to thermal overloads. The protection scheme utilizes the concept of positive and negative unbalance sequence currents, coupled with digital thermal modeling, to predict rotor temperature and remove motor power before the thermal limits are exceeded. The various protection schemes result in the maximum utilization of the motor.

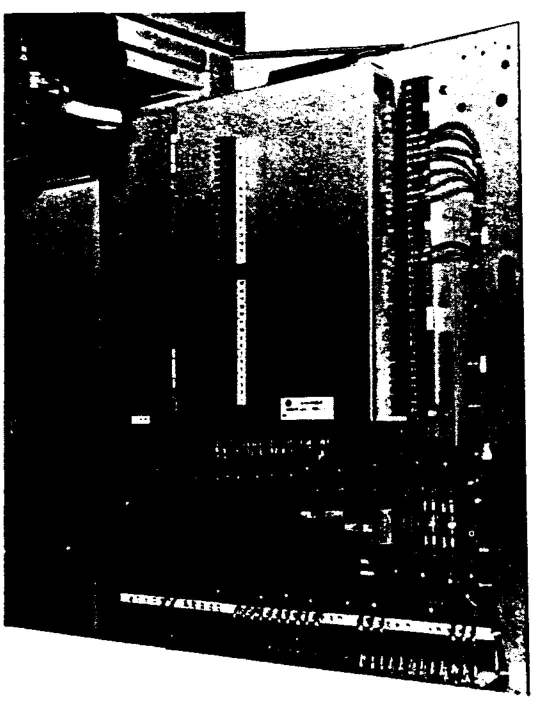


**Figure 1.1 — IQ-2000, Model B, Installed in Ampgard Enclosure**

The **monitoring** features include extensive instrumentation, including current, voltage, watts, frequency, power factor, elapsed time, and number of operations.

The **control** feature replaces the discrete relay logic for pre-start, post-start, pre-stop and post-stop timing functions and various enabling signals. Now programmable logic, under the control of the microprocessor, can perform these operations. This permits a single IQ-2000 to be easily programmed for a simple across-the-line starter or a complex starter such as a reduced-voltage start, reversing style, by means of simple pushbutton "user friendly" programming techniques.

Also included are numerous adjustable alarm and trip parameters. Extensive self-diagnostics are provided, including contactor report-back status signals which enhance system reliability. In instances when motor conditions exceed the programmed setpoint values, an alarm and/or trip condition is automatically initiated. The alarm condition causes a red LED on the Operator Panel to light. (See Table 7.B.) It also closes the internal Alarm Relay. Contacts from it are user-accessible for connection with external signaling devices, if desired.

The trip condition causes the main contactor(s) to open, thereby stopping the motor. (See Table 7.C.)

The 3 primary functions are actually composed of 28 separate functions, all of which are supplied as standard software and resident in permanent memory. A complete listing of these is given in Table 6.A. More detailed explanations are contained in Table 6.B. These functions were chosen to cover most features required by a wide variety of motor starters.

In instances where a particular function is not required by the application, it can be easily "programmed out," yet it remains passively resident in the software should it be required later.

Since the IQ-2000 is a basic-model product with very few options, individualizing for an application is performed in the field by the user/OEM by means of a simplified programming technique. Users enter the setpoint values for each function through the Operator Panel. (See the cover of this manual.) A simple grouping of pushbuttons allows the setpoints to be quickly entered. (There is no need to learn a specialized language.) An interactive alphanumeric display screen shows the entries and clearly indicates the function being specified. Once the fixed "menu" of functions is worked through, the setpoints are "permanently" loaded into the IQ-2000. They

**Table 1.A**
**IQ-2000 FEATURES AND BENEFITS**

| Feature | Benefit |
|---|---|
| • Micro-processor based control | • Reliable service without need for numerous discrete components |
| • All 28 setpoint functions available in all units | • Allows for wide-spread standardization of control types regardless of parameters or starter types |
| • Undesired functions are simply programmed out | • No extra costs for unwanted features<br>• In-field removal or reactivation of functions |
| • Single model unit | • Low inventory of spares possible<br>• Quick, inexpensive interchangeability during maintenance |
| • Nonvolatile memory | • No lost programs nor special back-up batteries |
| • Man-readable programming | • No special language to be learned<br>• Setpoint values easily written with everyday numbers |
| • Setpoints easily determined | • Motor manufacturer's data and a knowledge of the application are sufficient |
| • Simplified Operator Panel | • No elaborate, complex keyboard<br>• Functions and diagnostic messages displayed in man-readable format |
| • Display window shows a number of diagnostic conditions | • Install and maintain without extra and special test equipment |
| • Ease of startup | • Low time-to-assemble factor<br>• Fast program entry |
| • Auxiliary contacts | • Allow for additional process operations beyond the basic motor starting/stopping<br>• Allow for external warning devices when approaching setpoint thresholds |
| • Keylock mode switch | • Provides protection against program tampering while allowing the monitoring of programmed setpoints<br>• Minimizes shut-downs for noncritical reasons |
| • Communication data port | • All metering data, trip data, status annunciation, setpoints and diagnostic data is available for remote analysis |

**Table 1.B**
**COMMUNICATION ARRANGEMENTS**

| Communication Type | Description |
|---|---|
| Single Device RS-232C | A direct connection to an RS-232C compatible device where the IQ-2000 acts as a slave. A COM 21 Communication Card plugs directly onto the Processor Module. |
| Communication to any computer | A Local Area Network, INCOM® is formed by 2 or more IQ-2000s connecting to a Translator Box. The Translator Box is a slave to the main computer. In this arrangement the COM 22 Communication Card is plugged into the Processor Module of each IQ-2000. These cards are wired together using a shared non-shielded twisted pair to form a local area network. The twisted pair is wired to a Translator Box containing a COM 23 Communication Card which provides an RS-232C port. |
| Communication to an IBM-compatible personal computer | A Local Area Network, INCOM is formed by 2 or more IQ-2000s connecting to a personal computer via a shared non-shielded twisted pair of wires. The personal computer acts as a master. In this arrangement the COM 22 Communication Card plugs into each Processor Module. A COM 25 Communication Card is used in an expansion slot of the personal computer. |

remain stored through power outages, or until new programming entries change the values.

The IQ-2000 is factory-shipped in any of the following ways:

- Mounted in the low-voltage compartment of the Ampgard® enclosure
- For installation by an original equipment manufacturer in a new motor command system
- For installation by the Westinghouse Engineering Services Department into an existing motor starter
- For installation by an end user in a motor starter

**1.1 Features and Options** — A list of features and benefits is given in Table 1.A. Since the IQ-2000 is a standardized package, there are very few options. Those currently available are:

- **RTD Module** option, which is required if resistance temperature devices are used to monitor motor and load or motor bearing temperatures. The RTD Module is offered for 10-ohm, 100-ohm, and 120-ohm applications.
- **Ground Fault Transformer** option, which provides input current signals. (Its ratio is always 50:5.)
- **Potential Transformers** option, which provides incoming AC line phase and level information.
- **Communication** options, which provide communication of motor data to a remote device such as a computer or programmable controller. The communication options are described in more detail in publication number TD-11-730. In all cases a Communication Card will be installed inside the IQ-2000. Table 1.B lists and describes the 3 types of communication arrangements available.

**1.2 Specifications** — The specifications for the IQ-2000 motor command system are listed in Table 1.C.

**1.3 Hardware Familiarization** — The purpose of this Paragraph is to familiarize the user with the main hardware features of the IQ-2000. A complete description of the Operator Panel and the functions of each pushbutton is given in Chapter 4.

The IQ-2000 mounts in an optional enclosure, as shown in the typical installation of Figure 1.2. Observe the Figure and note the following explanation keyed to the callouts of the Figure:

1. The enclosure is a Type 1.
2. Cable connecting the Processor Chassis to the Operator Panel
3. Terminal block TB-A
4. Terminal block TB-B
5. Terminal block TB-R for connections to optional RTD Module
6. AC line fuse
7. Terminal block TB-P for the P1, P2, and P3 AC line connections
8. Additional terminal block. When the IQ-2000 is installed by Westinghouse, this is assigned the designation TB. The TB terminal block is not part of the IQ-2000 hardware.

The various components of the IQ-2000's Processor Chassis are shown in Figure 1-3. Observe the Figure and note the following:

- The front cover of the IQ-2000 consists of a hinged access door. (A screw secures it to the Chassis.)

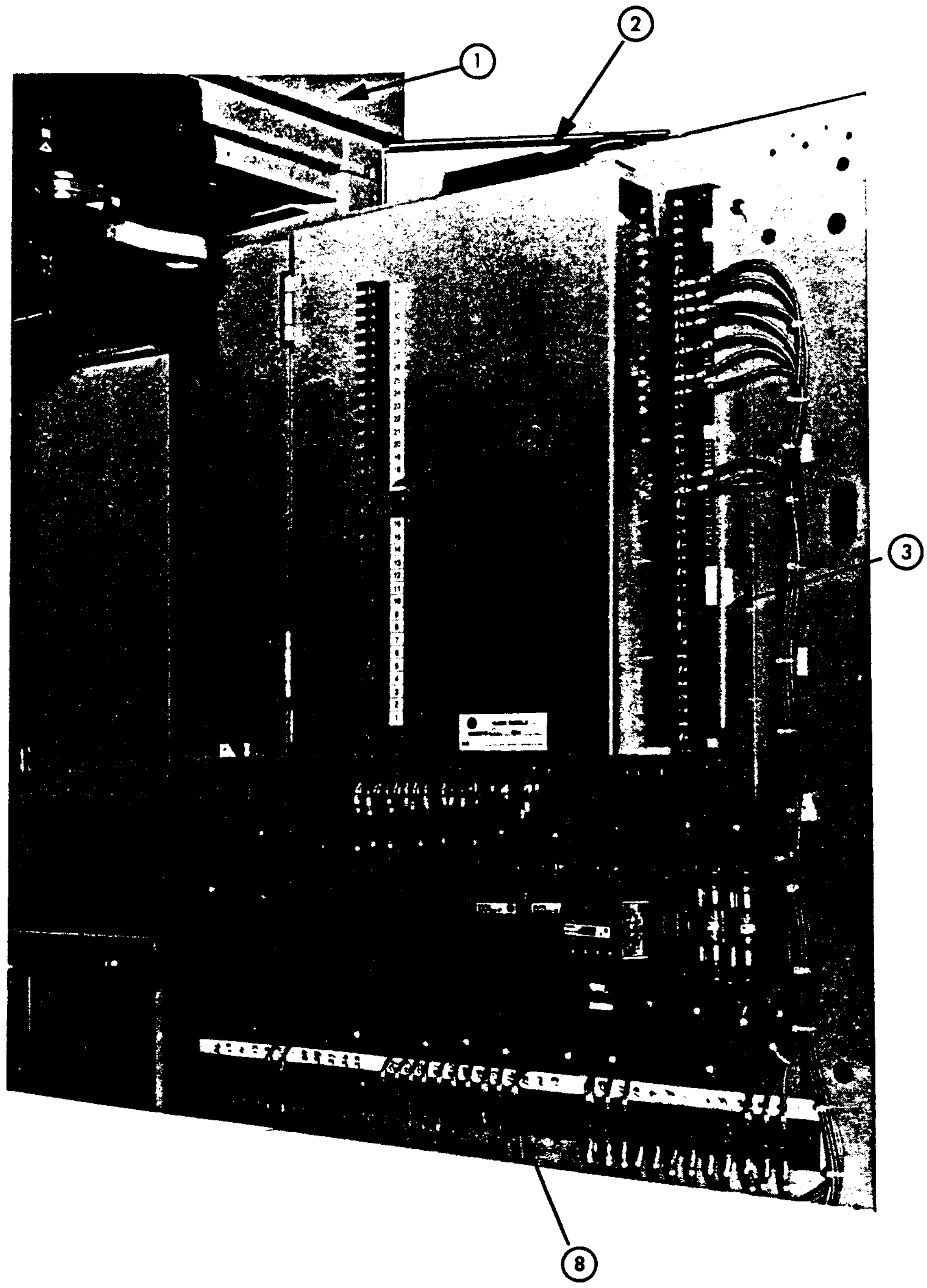
**Table 1.C**

**SPECIFICATIONS**

| |
|---|
| **Input Power Requirements** |
| **120 VAC (±15%)** |
| **Frequency** |
| 50/60 Hz [1] |
| **Power Consumption**<br>**Processor: 60 VA**<br>**RTD Option: 6 VA**<br>**Communication Card: 5 VA** |
| **Current Transformer "Burden"** |
| **0.003 VA** |
| **Operating Temperature** |
| -20° to 70°C [2]<br>(-4° to 158°F) |
| **Storage Temperature** |
| -20° to +85°C<br>(-4° to +185°F) |
| **Humidity** |
| 0 to 95° R.H.<br>noncondensing |
| **Fuses** |
| Processor: 4 amp, 250 V slo-blo |
| **Enclosure** |
| Type 1 |

[1] Factory set; specify with order

[2] The operating temperature range of the external face of Operator Panel is limited to 0° to 55°C (32° to 131°F). This is not subject to the internal temperature rise of the starter.



Legend:

1. Type 1 enclosure
2. Cable connecting Operator Panel and Processor Chassis
3. TB-A
4. TB-B
5. Optional RTD, TB-R
6. AC line fuse, 4 amp, 250 V slo-blo
7. AC line connections P1, P2, P3
8. Terminal Block TB

**Figure 1.2 — IQ-2000 Typical Installation**

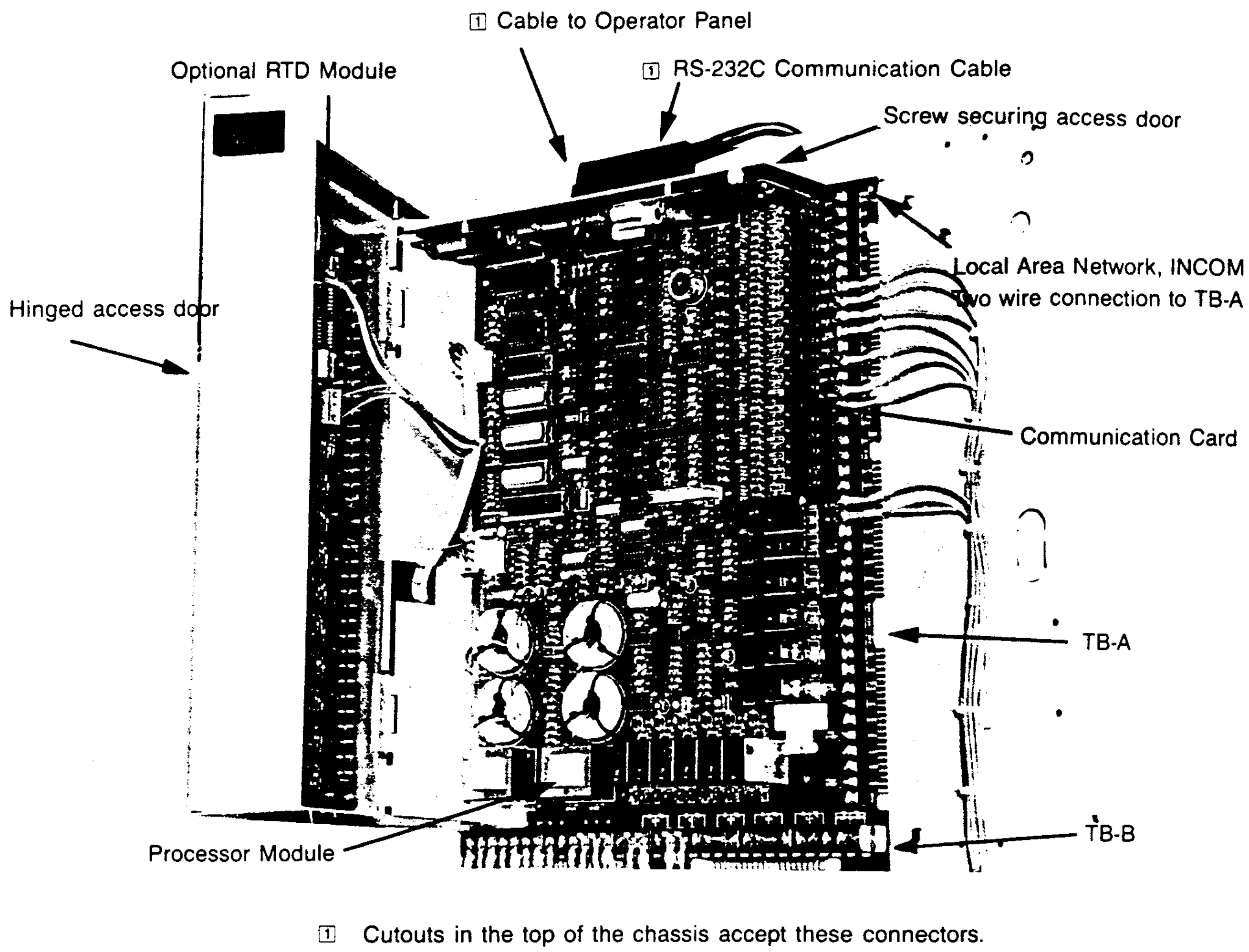



**Figure 1-3 — IQ-2000 Chassis**

- The optional RTD Module, when used, mounts inside of the hinged access door.
- The Processor Module mounts inside the Chassis on the back panel.
- The Communication Card plugs into connectors located on the Processor Module.

**1.4 Use of Manual** — This manual is designed for use during installation and troubleshooting and, if necessary, unit replacement for the IQ-2000 Model B. (Note: For specific information on the IQ-2000, Model A, refer to Instruction Leaflet number TD-11-720.)

This Manual contains information of specific importance for the user application engineer who is planning the motor control system and who is determining the setpoint values for Model B.

The manual is broad enough in scope to form the basis of new employee familiarization, refresher training sessions, and ongoing maintenance.

It is strongly advised that the application engineer carefully read Chapters 2 thru 7 **before** beginning the application's Wiring Plan Drawings and Setpoint Record Sheet. Installation teams should carefully read all of Chapter 4 **before** starting final installation. Maintenance personnel should be familiar with Chapters 7 and 8 **before** attempting to service the IQ-2000.

**1.5 Level of Repair** — This manual is written with the assumption that only board-level troubleshooting will be performed. If the cause of a malfunction is traced to a board, it should be replaced with a spare (refer to Section 8, Unit Replacement). It should then be returned to Westinghouse for factory repairs.

**1.6 Factory Correspondence** — All correspondence with Westinghouse, whether verbal or written, should include the "firmware revision" alphabetical letter preceding the STARTER CLASS setpoint display. This alphabetical letter appears in the Function Window when the starter class setpoints are displayed, as described in Paragraph 7.1.3. The firmware revision alphabetical letter is used by Westinghouse to identify the specific IQ-2000 type being discussed.

Section 2

# FUNCTIONAL THEORY

**2.0 General** — The IQ-2000 is a microprocessor-based system that controls from 1 to 4 contactors associated with a motor starter. This Chapter describes how the hardware and software function together to control, monitor and protect the motor.

The description is divided into the following areas:

- Sensing inputs (Par. 2.1)
- Protective functions (Par. 2.2)
- Motor control functions (Par. 2.4)
- Metering functions (Par. 2.5)

**2.1 Sensing Inputs** — The IQ-2000 receives information about motor current, line voltage and ground fault current as well as control inputs such as motor starting and stopping commands. (See Figure 2.1.) Optionally, RTD inputs supply temperature data. The motor current is derived from 3 separate current transformers which monitor each of 3 phases of the AC line to the motor. Optionally, 3 phase potential transformers may be used to monitor the line voltage being supplied to the motor.

**2.1.1 RTD Module** — The optional RTD Module supplies information on the winding temperature from up to 6 RTDs embedded in the stator windings of the motor. In addition,

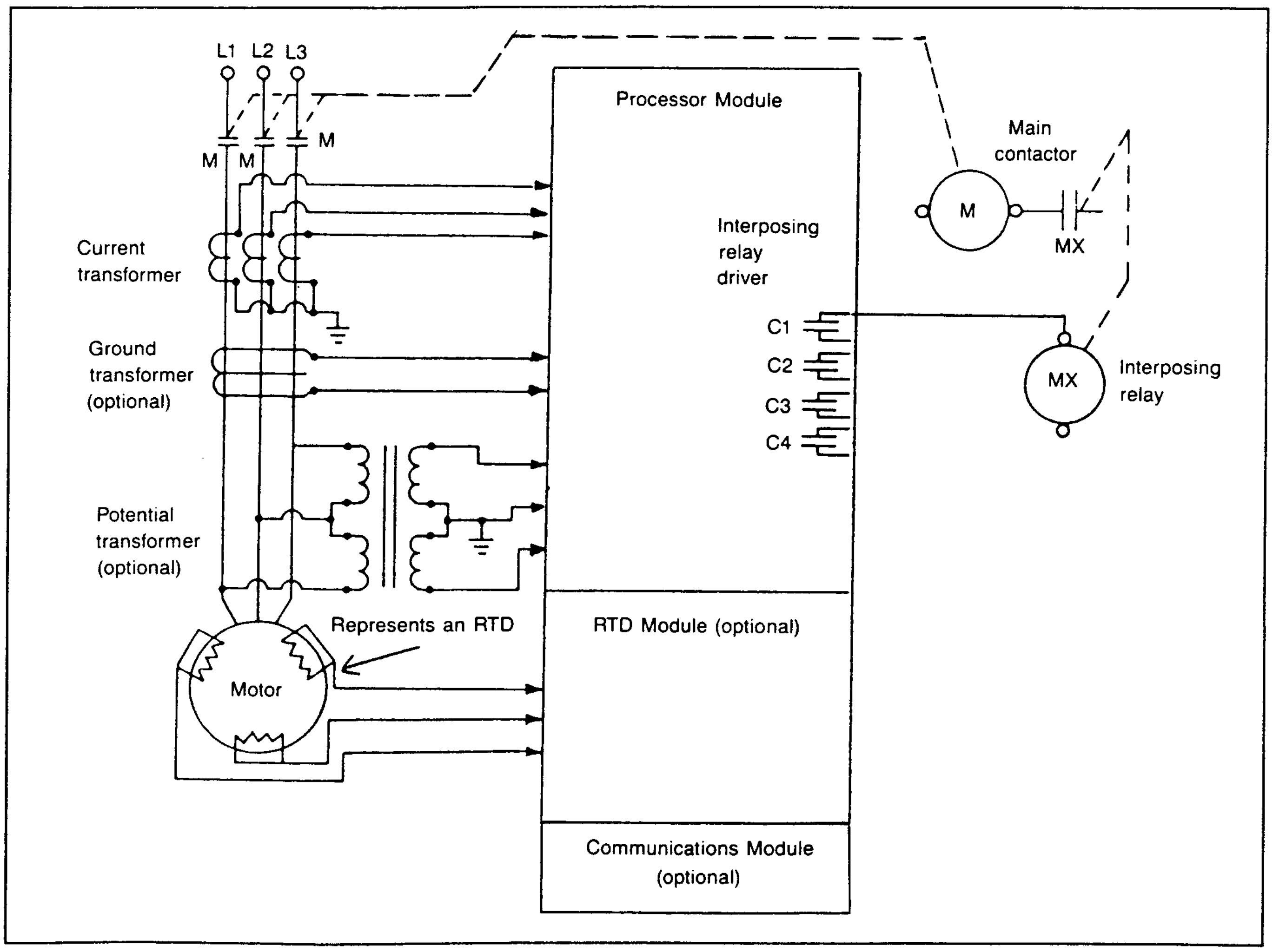



**Figure 2.1 — System Overview (Simplified)**

RTDs associated with the motor bearings and load bearings can also be monitored. The motor RTDs are used to supply information for both the winding and rotor temperature protection function and the temperature monitoring function.

**2.1.2 Control Lines** — Monitoring of the signal lines from the machine or process associated with the starter is performed by the input monitoring area of the Processor Module. (This is not shown in Figure 2.1.) These lines include the report-back signals as well as the start and stop command lines. These lines are used by the motor control area to enable and disable both the main contactor(s) and the auxiliary relays.

**2.2 Protective Functions** — Protective functions utilize motor conditions such as current and temperature on an ongoing basis and first initiate an alarm condition, where appropriate, and finally a trip condition. These conditions perform the following functions:

- Alarm condition energizes the Alarm Relay. Its contacts are used external to the IQ-2000 for control or reporting purposes.
- Trip condition removes the power from the motor and actuates a Trip Relay. The contacts of the Relay are used external to the IQ-2000 for controlling or reporting purposes.

  When a trip condition occurs, the control stores the metering functions such as motor current, temperature, etc. This "picture" is maintained for use by maintenance personnel until the RESET pushbutton is depressed.

The IQ-2000, Model B, is able to maintain the metering data prior to a trip condition for a minimum of 12 hours after AC power is removed.

The fault monitoring performed by the IQ-2000 can be divided into the following types:

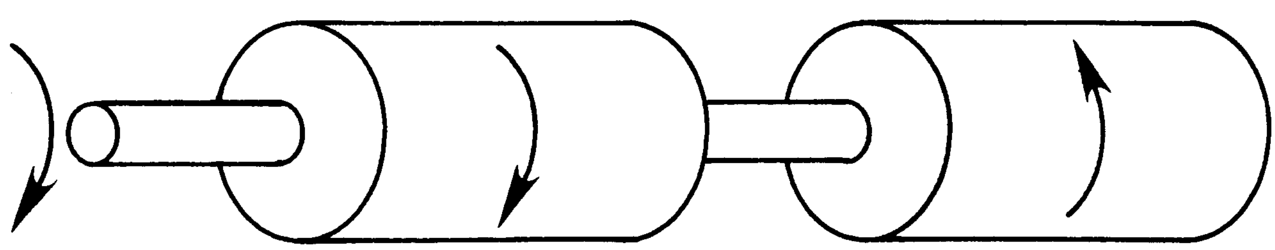
- Load-associated protection (Par. 2.2.1)
- Rotor-temperature protection (Par. 2.2.2)

**2.2.1 Load-Association Protection** — The value of the motor current is used to detect the instantaneous overcurrent, jam and underload setpoint functions. Information from the load bearing RTDs is compared with the setpoint values to initiate an alarm and/or a trip condition. (Note: all the setpoint functions are described in detail in Chapter 6.)

**2.2.2 Rotor Temperature Protection** — Each motor design has a specific damage curve usually referred to as its $I^2T$ curve (current squared multiplied by time). In AC motors, the current balance between phases is of major concern because of the additional heating associated with an unbalance. This current unbalance is caused mainly by a voltage unbalance, the result of single phase loads on the three phase system, and motor winding unbalance.

With larger horsepower motors, the design is usually rotor limited. It therefore becomes important to determine the total heating effect on the rotor. For analysis, the motor can be considered to have two rotors. (Refer to Figure 2.2.) One is the effect resulting from balanced current and the other the effect of unbalanced current. If perfect current balance existed in each phase of the motor current, then the $I_1$ first component used would be the line current squared with no error in the heating projected from this current. This positive component of current generates the motor output torque, work.

The second component of current is the negative sequence, represented as $I_2$. It is a three phase current with a reverse phase rotation from that of the AC source. This component of current generates countertorque to the motor output torque, negative work. Because the torque generated, $I_2$, does not leave the rotor, it is absorbed as heat and therefore has a more significant effect on the rotor heating than the $I_1$. Thus any three AC currents can be represented by the addition of $I_1$ plus $I_2$.



$$I^2 = I_1^2 + KI_2^2$$

**Figure 2.2 — Symmetrical Components**

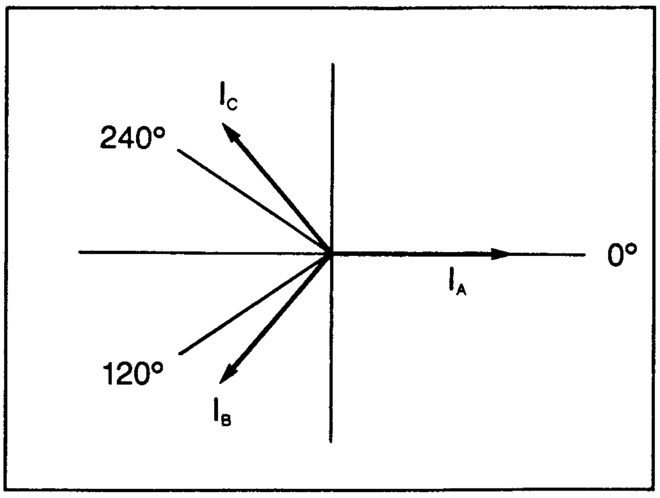



Figure 2.3 — Symmetrical Components

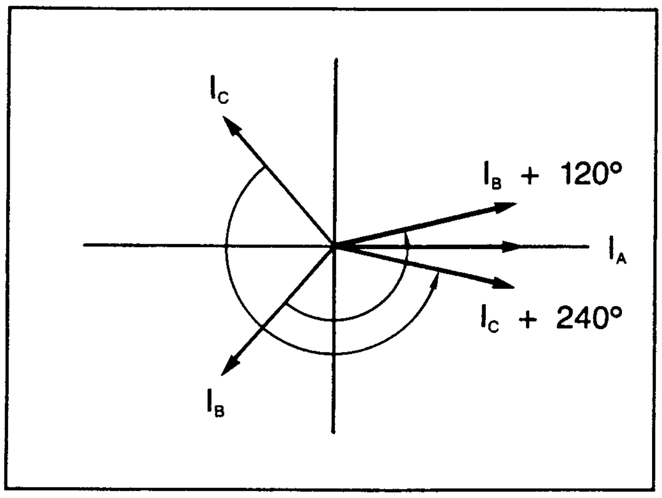



Figure 2.4 — Positive Sequence Currents

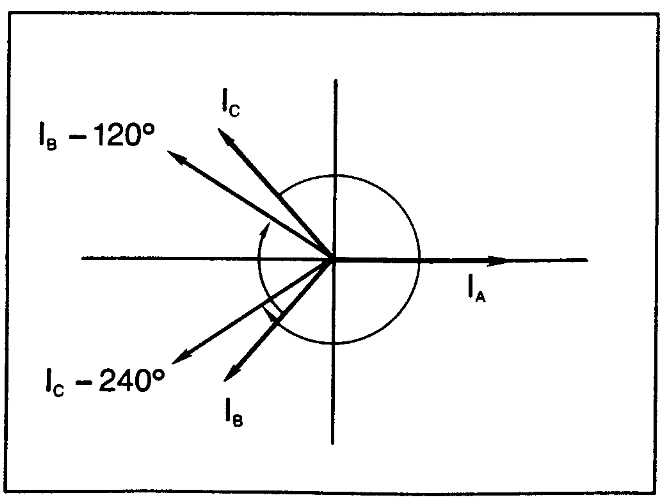



Figure 2.5 — Negative Sequence Currents

Using vector analysis to determine the positive sequence, one rotates phase B in the positive direction 120° and phase C in the positive direction 240°. (Refer to Figure 2.4.)

The result of $I_1 = \dfrac{I_A + (I_B + 120°) + (I_C + 240°)}{3}$

The negative sequence is determined by rotating phase B in the opposite or negative direction for 120° and phase C rotated in the negative direction for 240°. (Refer to Figure 2.5.) Thus the formula for $I_2$ becomes

$$I_2 = \frac{I_A + (I_B - 120°) + (I_C - 240°)}{3}$$

Prior to the use of a microprocessor in the motor command system, there was no practical way of determining the total effect of the positive and negative sequence on a continuous basis. Therefore, less than adequate assumptions had to be made. This resulted in nuisance tripping and actual or near-actual motor burnouts. The IQ-2000 microprocessor uses a unique, patented system for determining these values. Every 120° within each AC line cycle the instantaneous current in each phase is detected. Thus in 1 cycle the microprocessor has 9 readings of current. (Refer to Figure 2.6.)

The current square, as used in the calculation of the rotor heat, is:

$$I^2 = I_1^2 + KI_2^2$$

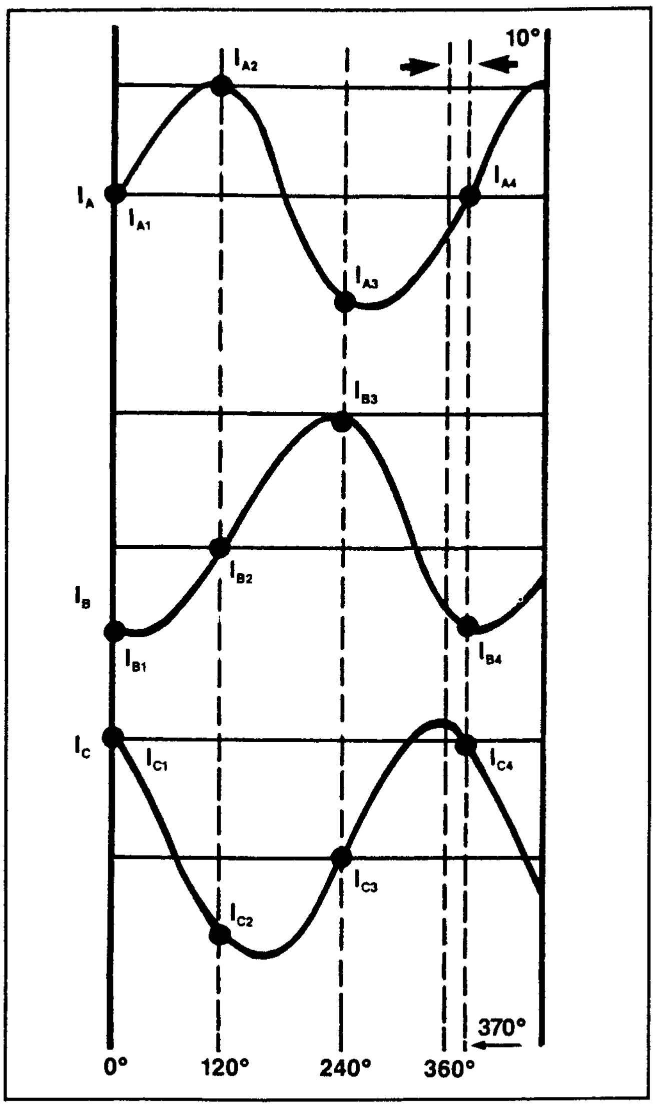
Here $I_2^2$ is weighted by K (usually 6) because of the disproportional heating caused by the negative sequence.

With the use of a microprocessor, the effects of both the positive and negative sequence are accurately taken into account. Their **combined** effect is incorporated into a "rotor protection algorithm." The algorithm is really a microprocessor-based program which effectively keeps track of the temperature of the rotor.

It is not necessary to pick an arbitrary phase unbalance setpoint to trip the motor. As long as the combined effect of the positive and negative sequence does not approach the motor damage curve, the motor is allowed to be utilized.

**2.3 True RMS** — If the line current sampling were always taken at exact intervals of 120°, all the samples would be taken from the same point on the waveform, and the current monitored would have to be a true sine wave. Realistically, the current monitored at the motor is shaped similar to a sine wave, but it has many harmonics superimposed on the basic sine wave. These are caused by the addition of power factor correction capacitors, solid state drives and adjustable-speed drives backfeeding into the electrical system of the entire plant.

Therefore, to obtain true RMS (root mean square) current, the line current sampling is delayed after every cycle of data accumulation by 10 degrees. Only after 12 individual sets of data are collected — 36 pieces of data for each phase — does the microprocessor actually calculate and monitor the RMS current and separate it into its positive and negative components.




**First Set of Data**

| 0° | 120° | 240° |
|---|---|---|
| $I_{A1}$ | $I_{A2}$ | $I_{A3}$ |
| $I_{B1}$ | $I_{B2}$ | $I_{B3}$ |
| $I_{C1}$ | $I_{C2}$ | $I_{C3}$ |

**Second Set of Data**

| 370° | 490° | 610° |
|---|---|---|
| $I_{A4}$ | $I_{A5}$ | $I_{A6}$ |
| $I_{B4}$ | $I_{B5}$ | $I_{B6}$ |
| $I_{C4}$ | $I_{C5}$ | $I_{C6}$ |

**Three $I_1$ Calculations Using First Set of Data**

$I_1 = I_{A1} + I_{B2} + I_{C3}$
$I_1 = I_{A2} + I_{B3} + I_{C1}$
$I_1 = I_{A3} + I_{B1} + I_{C2}$

**Three $I_2$ Calculations Using First Set of Data**

$I_2 = I_{A3} + I_{B2} + I_{C1}$
$I_2 = I_{A2} + I_{B1} + I_{C3}$
$I_2 = I_{A1} + I_{B3} + I_{C2}$

Figure 2.6 — Current Sampling Techniques

Thus using the 10° delayed sampling method, together with the rotor protection algorithms, the IQ-2000 is capable of combining the effects of time and RMS current (positive and negative sequence) into a single protective system. The addition of the optional Resistance Temperature Detection (RTD) Module is also factored into the rotor protective algorithm. This results in a multi-dimensional model allowing full motor utilization.

**2.4 Motor Control Functions** — The motor control function receives the "command" inputs to start and stop the motor, and coordinates the energizing and de-energizing of the contactor(s) and auxiliary control relays.

**2.5 Metering Functions** — The control calculates and displays the instantaneous and accumulated values obtained by monitoring characteristics such as motor current, ground current, RTD temperature values, etc. (Chapter 7 describes the monitoring capabilities of the control in detail.)

# Section 3

# INSTALLATION

**3.0 General** — This Chapter describes general wiring and wire-routing procedures to be followed by the electrical installation crew when installing the IQ-2000 and its associated Ampgard starter with a motor and its related machine or process equipment. The information listed here builds on earlier chapters in this manual and will be unnecessarily difficult unless they are read first.

**3.1 Ampgard Schematic** — When the starter is supplied by Westinghouse, the wiring between the Ampgard starter and the IQ-2000 is factory installed. Each specific hardware configuration is shown on a unique Ampgard Schematic shipped with the unit. (A typical Ampgard Schematic is shown in Figure 3.1.) The drawing is for a Class 11-202 induction, full-voltage, non-reversing unit.

When the motor starter is not supplied by Westinghouse, an equivalent electrical scheme is developed by the retrofitter, or original equipment manufacturer.

**3.2 Wiring Plan Drawings** — It is necessary for the customer application engineer to develop a suitable wiring plan for use by the installation team. It must reflect the control lines to the IQ-2000 or between the IQ-2000 and its associated machine or process equipment. In this manual the wiring plan is called "wiring plan drawings," although individual companies will probably have different terminology. Whatever the term, these drawings detail all customer wiring which must be performed in the field after the Ampgard and its associated IQ-2000 is shipped from Westinghouse.

The Ampgard Schematic shows all the control input and output lines for the application; the wiring plan drawings list the designations of these lines.

Note: in cases of "retrofits" where the IQ-2000 is shipped separately without an Ampgard starter, the wiring plan drawings must list the:

- Wiring between the IQ-2000 and interposing relays
- Main contactor(s) wiring
- Potential, current, ground current, and power transformer wiring

In short, it must list all of the wiring that is normally documented by the Ampgard Schematic.

**3.3 Wiring Guidelines** — The following wiring guidelines must be observed by the electrical installation crew when installing the IQ-2000 and connecting it with its associated machine or process equipment.

**3.3.1 Wire Routing** — When routing wires between the Ampgard or other starter and the associated machine or process equipment, follow these guidelines:

> DANGER
>
> Insure that the incoming AC power and all "foreign" power sources are turned OFF and locked out before performing any work on the motor starter or IQ-2000. Failure to observe this practice can result in serious or even fatal injury and/or equipment damage.

**Guideline 1** — All user-installed control lines and the RTD conductors connecting with the draw-out panel must be carefully coiled and secured to the factory-installed low-voltage conductors. (See Figure 3.2.) This coil of conductors provides a quantity of slack required for draw-out panel movement. The coil is positioned **behind** the panel as the panel is pushed into the enclosure. In order to make the coil, bundle the conductors neatly with tie-wraps, or equivalent means.

Once wiring is complete, insure that the coil is properly positioned and that it is able to clear any obstruction that may exist as the draw-out panel moves in and out.

**Guideline 2** — Do not route control or RTD conductors through the high-voltage compartment of the motor starter. If it is necessary to do so, consult the applications department, Westinghouse Control Division, for specific instructions.

**Guideline 3** — Separate the low-voltage (120 VAC) from the high-voltage (440 VAC, or higher) conductors as much as possible. In general, maintain a minimum distance of 1.5 ft. (45 cm) between the two types.

**3.3.2 Types of Wire** — The following guidelines list the generally acceptable types of conductors and wiring practices used in the industrial environment. For specific types of wire, consult your application engineer.

**Guideline 4** — Any low-voltage control wiring routed out of the motor starter cabinet should be at least AWG No. 14 stranded copper wire.

**Guideline 5** — The wiring between the RTD Module contained in the starter cabinet and the RTDs in the motor must be AWG No. 18 3-conductor, shielded cable. (See Figure 3.3.) Use Belden No. 8770, or equivalent. Note: in cases where the leads from the motor or other resistance temperature devices provide only 2 leads each, connect 2 conductors from the RTD Module to one of these leads. Follow Figure 3.4 carefully when selecting the 2 conductors to tie together. Also it is important to connect the 2 conductors as close to the motor as possible.

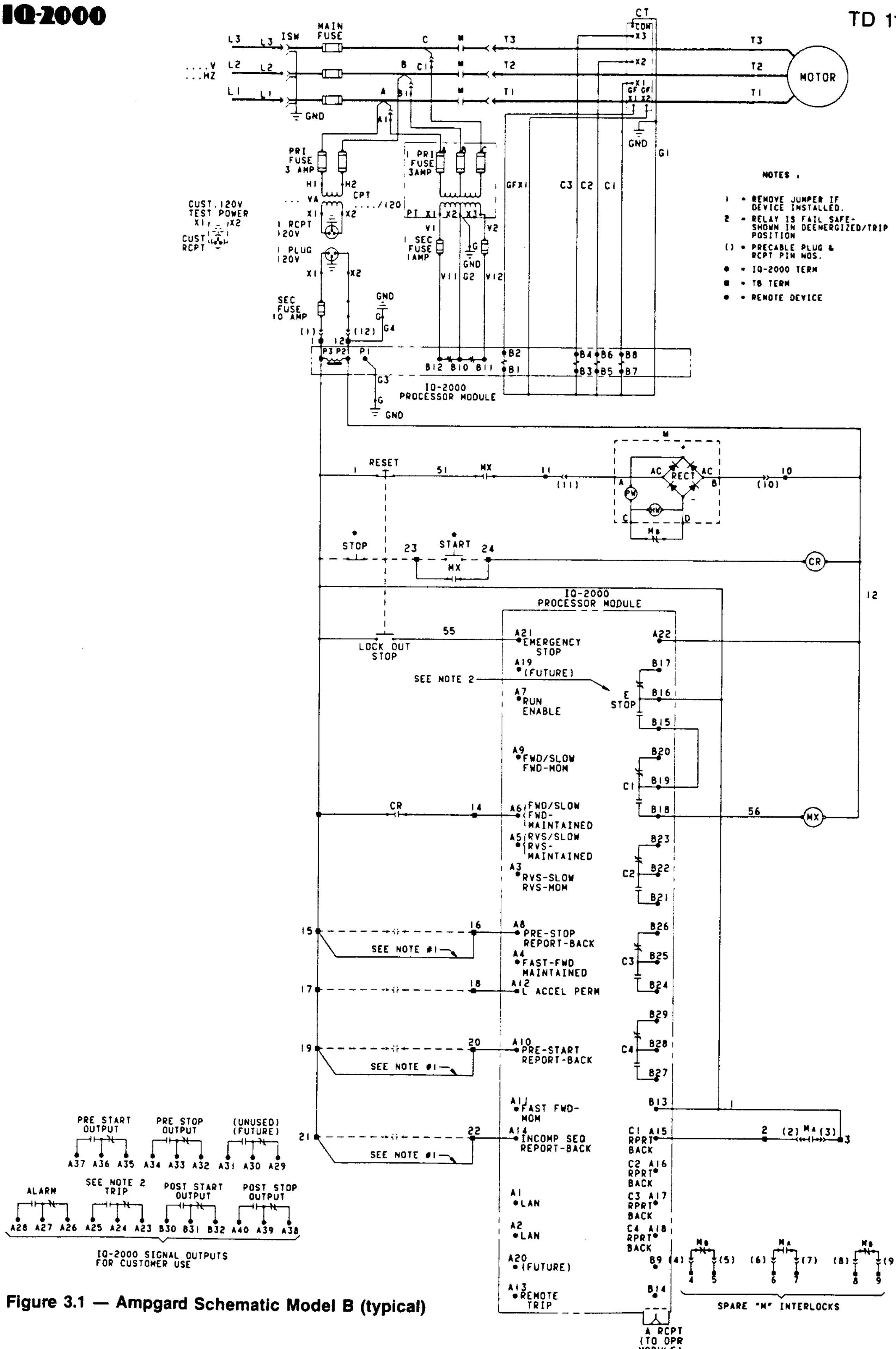



**Figure 3.1 — Ampgard Schematic Model B (typical)**

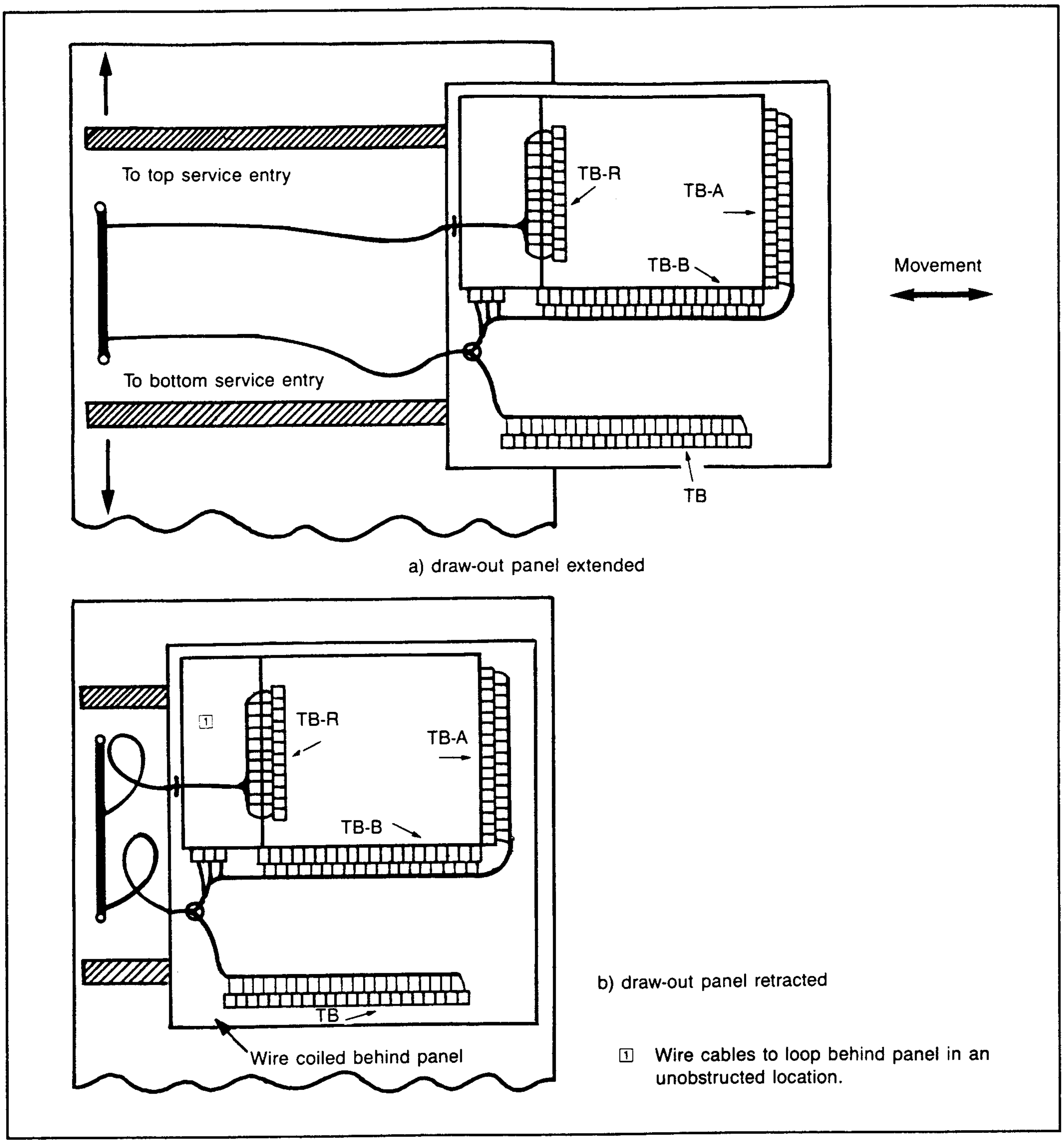
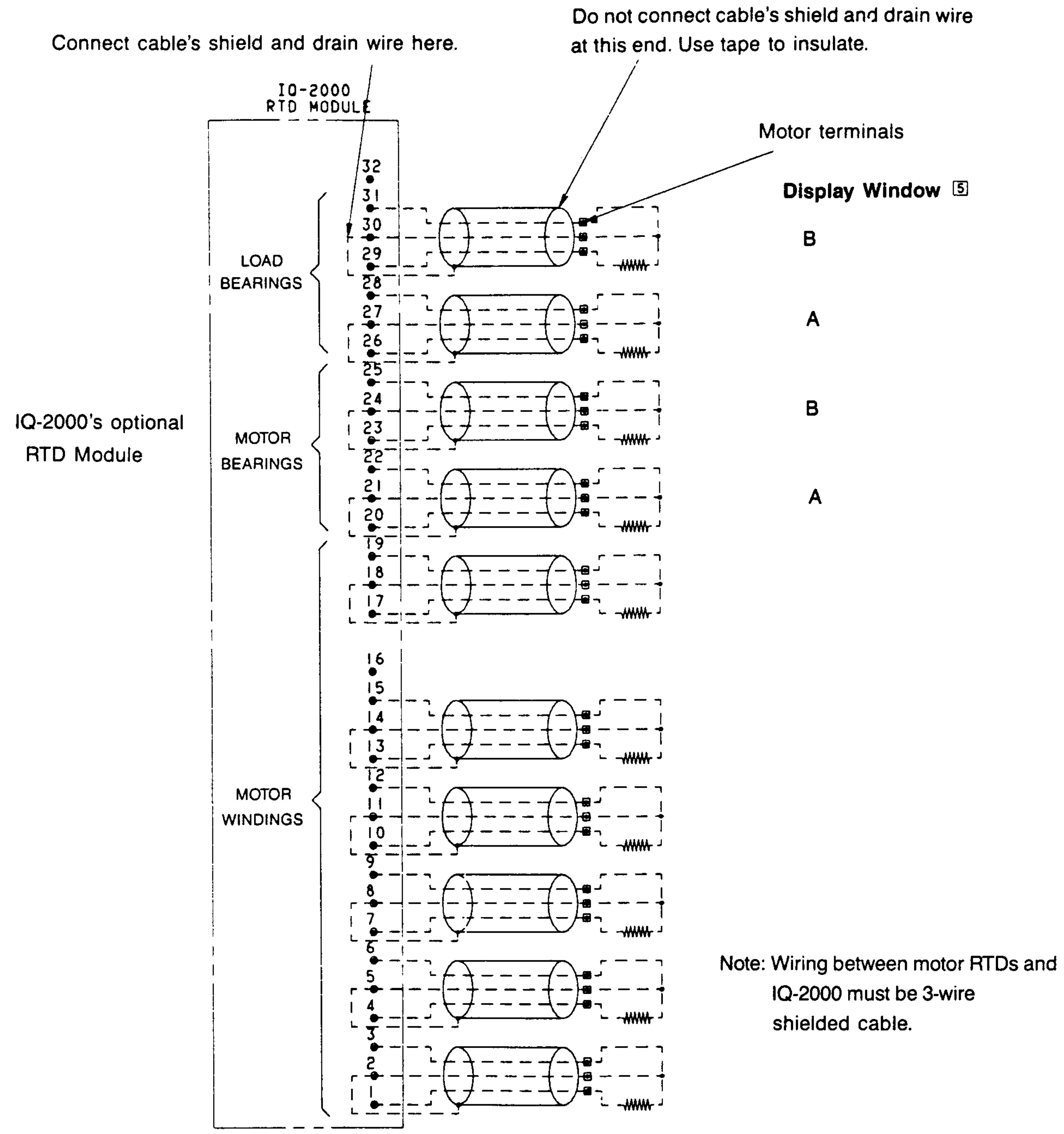



**Figure 3.2 — Wiring to Draw-Out Panel**

**Guideline 6** — Connect the shield and drain wire from RTD cables to the common terminals on the RTD Module, as shown in Figure 3.3. Note: connect the shield **only** at the RTD Module. Use shrink tubing or electrical tape to insure that the shields do not make accidental contact with ground or other terminals at the RTD end.

**3.3.3 Grounding** —A typical grounding plan for a starter is shown in Figure 3.5. Note carefully these guideline before making grounding connections.

**Guideline 7** — Install an "equipment grounding conductor" between the motor starter's ground stud (or grounding bus) and a suitable plant grounding bus or to earth ground. Consult the local application engineer or the wiring plan drawings for information on specific gauges.




1. Each shielded cable's conductors must be connected on IQ-2000 as shown.
2. Use of 3-lead RTDs is recommended.
3. RTDs must not be grounded at the motor, and no common connections between RTDs should be made at the IQ-2000 or the motor.
4. If motor or load bearing RTDs are used, they must be the same ohmic value and material.
5. During the monitoring operation, the load bearing and motor bearing temperatures are displayed in the A and B VALUES windows, as listed here. (See Monitoring, Paragraph 4.1.5.)

**Figure 3.3 — RTD Wiring (3-Lead Type)**

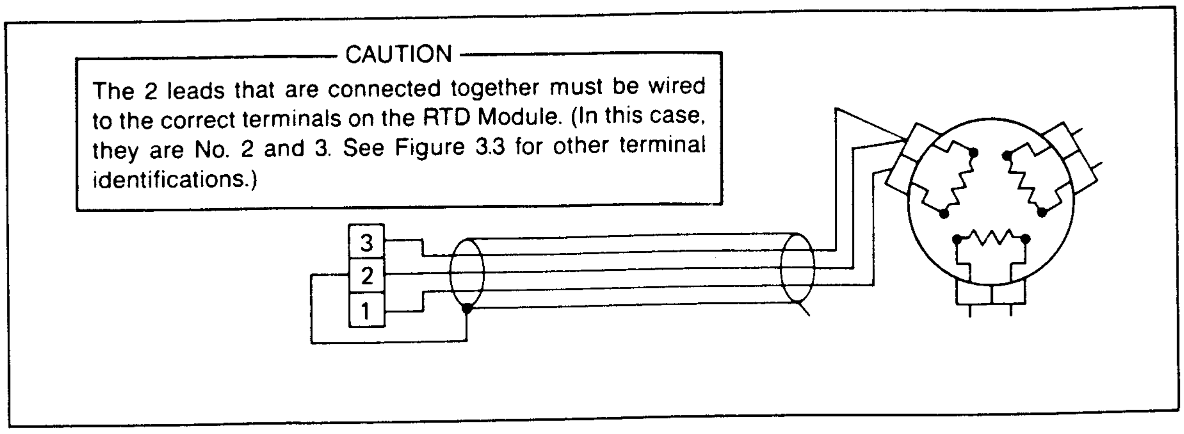



**Figure 3.4 — Two-Lead RTD Wiring**

**3.4 Wiring Checklist** — Complete the following checks on the field-installed wiring **before** applying AC power for the first time.

Each item contained in the checklist also has a small box at its immediate left. The box is intended to be used to provide verification that a specific step has been performed. Follow these checks in sequence.

- ☐ When the Ampgard isolating switch and the high-voltage door are open, the step-down control transformer is accessible. Remove the plug from the receptacle to disable the secondary circuit, as shown in Figure 3.7.

  Alternately, with starter motors other than the Ampgard, disable the secondary circuit to remove AC power to the IQ-2000 and the low-voltage control circuit of the motor starter.
- ☐ Verify that all "foreign" external power sources are disconnected from the starter cabinet.
- ☐ Open the access door to the low-voltage compartment. Examine the wiring terminals of the draw-out panel. Look for foreign material, pieces of wire, screws. Check screws for tightness.
- ☐ Verify that the field-installed wiring is exactly as shown on the wiring plan drawings.
- ☐ If the application contains an RTD Module, verify that the cable shields are wired to the correct terminals, as shown in Figure 3.3. Also verify that the shield drain wires are insulated with tape or shrink tubing so they cannot ground nor cause shorts.
- ☐ Verify that unused RTD Module inputs, if any, are jumpered out. Each set of 3 unused inputs must be jumpered. For example, if the 2 load bearing RTDs, as shown in Figure 3.3, are not used, jumper terminals 29, 30 and 31. Also separately jumper terminals 26, 27 and 28.
- ☐ Be sure that cable shields and drain wires are **not** connected at the RTD end. They are to be cut short and insulated.
- ☐ In some cases there may be factory-installed jumpers between the terminals as shown in the solid jumpers in Figure 3.6. It is necessary to determine whether or not there should be jumpers installed. Consult the wiring plan drawings to determine if any jumpers should be in place or removed for each application.

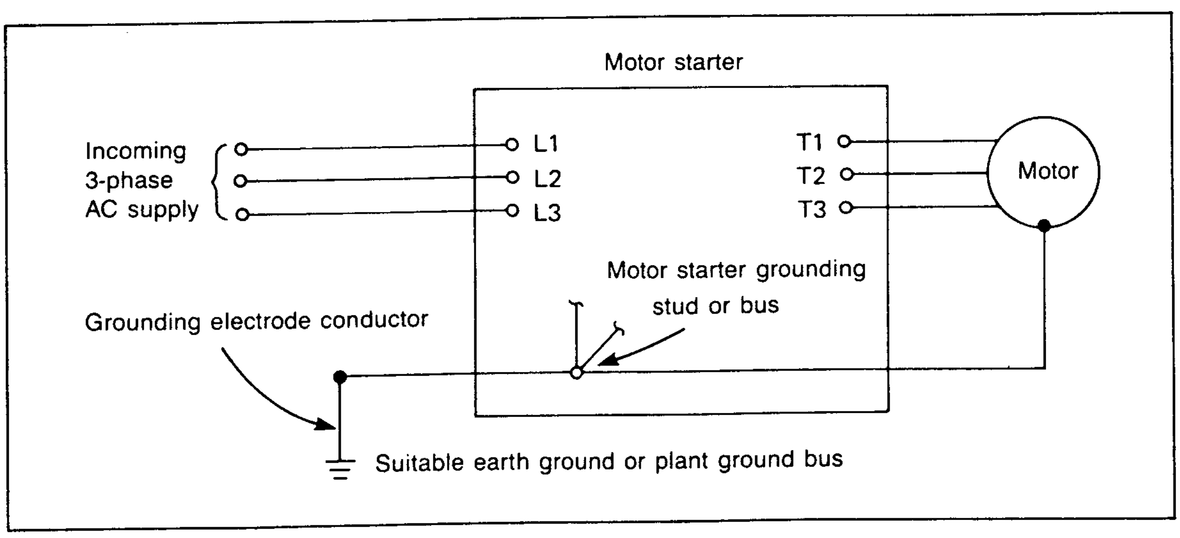
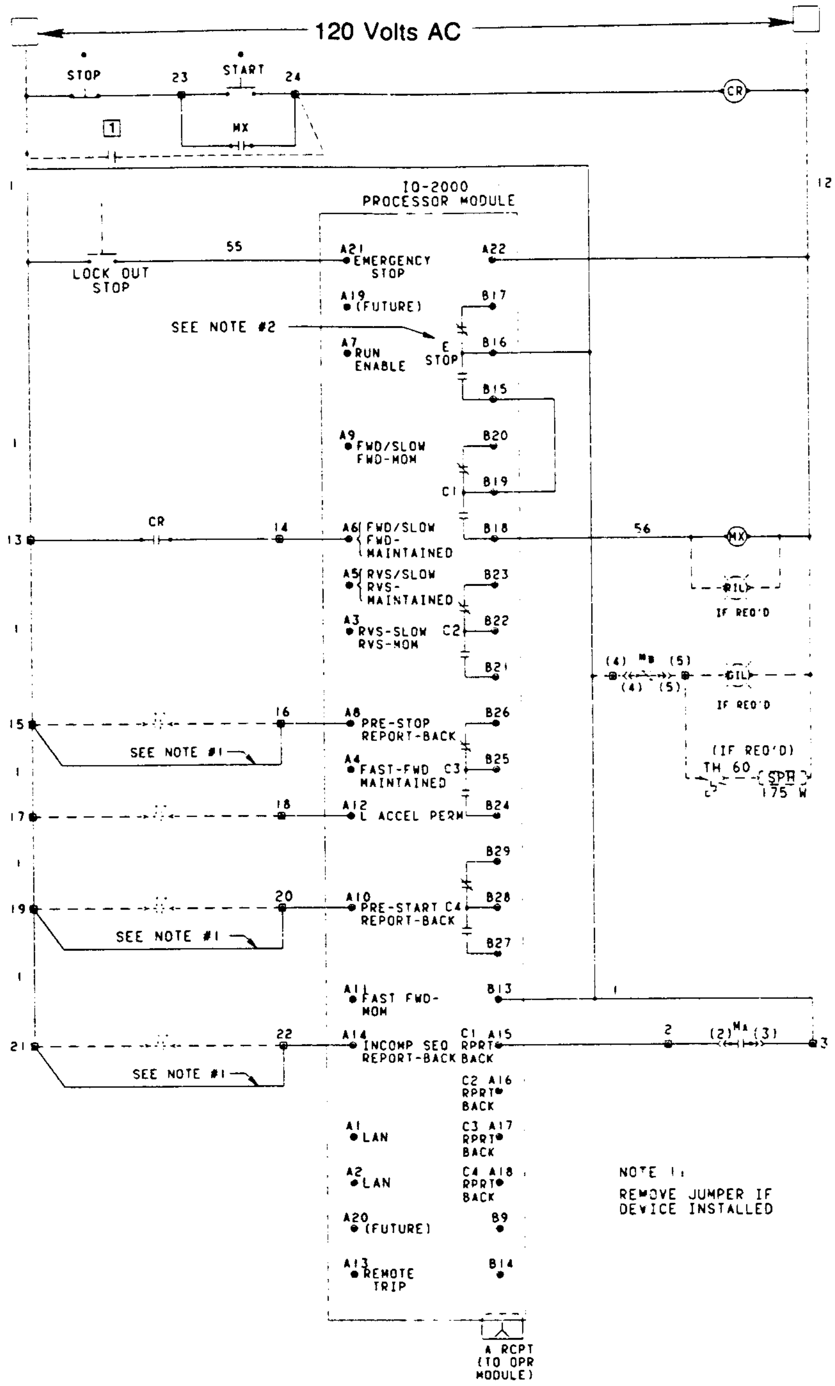



**Figure 3.5 — Typical Grounding Plan (simplified)**




1 Contacts from control devices such as pressure switch, level switch, etc.

Note: if the control device is a programmable controller, its signal must energize a control relay and its "dry contact" wired to the IQ-2000.

2 Squares indicate Westinghouse TB terminal block connections.

3 If a field device — as shown in dashed lines — is to be installed, remove the associated jumpers — as shown in solid lines — during installation.

**Figure 3.6 — Jumper and Field Wiring (Typical)**

Note: when an external device, such as a limit or pressure switch, is to be wired between the terminals, as shown in Figure 3.6, the factory-installed jumper must be removed.

☐ Move the draw-out panel in and out to make sure that wiring to the panel does not bind or scrape in such a way that the insulation is damaged.

☐ Verify that there are no stray strands of wire which could cause shorts.

☐ Turn the Keyswitch to the **Program** mode prior to energizing the starter with temporary control power (test power). The IQ-2000 as shipped from the factory has no programmed setpoints. It must be field calibrated as described in Section 4, STARTUP.

☐ With an Ampgard starter, temporarily plug the control power receptacle, as shown in Figure 3.7, into a 120 VAC extension cord receptacle. Using a meter, check polarity and verify that 120 VAC (±15%) is present.

Alternately, when a motor starter other than an Ampgard is used, temporarily connect 120 VAC (±15%) to the IQ-2000 AC power P1/P2/P3 terminal strip, where:

P1 = Gnd
P2 = AC lo, L2, Gnd
P3 = AC hi, L1

Be sure there is no possible path for the 115 volt test power to back feed through the control transformer or potential transformers.

The application is now ready to be started up as detailed in Chapter 4. Do **not** start the motor at this time. Wait until the setpoints have all been entered into the control and the Ampgard or other starter is sequenced with the external 120 VAC used as temporary control power (test power).

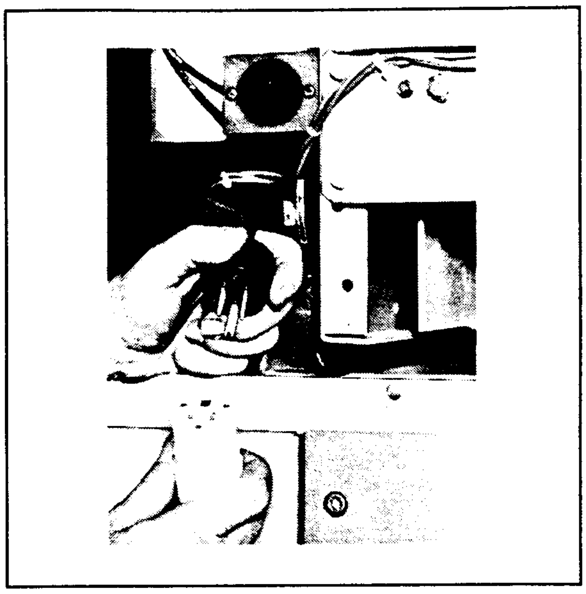


**Figure 3.7 — Ampgard Internal View**

# Section 4

# STARTUP

**4.0 General** — This chapter describes the IQ-2000's Operator Panel and explains setpoint entry procedures. It is designed primarily to assist with the starting up of a system. Detailed explanations of available setpoint functions, their ranges and features, are contained in Chapter 6, "Setpoint Value Considerations." Therefore, Chapter 4 is designed primarily for the individual responsible for the startup, and Chapter 6 is designed primarily for the engineer in charge of the specific application.

Note that the setup cannot be performed without a completely and correctly filled in Setpoint Record Sheet, which is shown in Table 6.B.

> CAUTION
>
> Do not attempt to startup an IQ-2000 or to enter setpoints without a completed and validated Setpoint Record Sheet. Equipment damage could result if incorrect data is entered.

The information contained in this chapter is organized into 6 major groupings:

- Operator Panel description (Par. 4.1)
- Initial AC power-on checks (Par. 4.2)
- Entering setpoint values (Par. 4.3)
- Initial control checkout (Par. 4.4)
- Initial motor startup (Par. 4.5)
- Initial main power-on (Par. 4.6)

**4.1 Operator Panel Description** — The Operator Panel is primarily controlled by the RUN/PROGRAM keyswitch which provides 2 modes of operation:

- **Run Mode.** When the keyswitch is in the RUN position, normal operation of the motor, reviewing of programmed setpoint values, and monitoring of setpoint values may all be performed. Additionally, electrical characteristics, including the actual values of many functions, can be monitored.
- **Program Mode.** When the keyswitch is in the PROGRAM position, the programmed setpoint values can be displayed and/or modified. In this mode, starting and running of the IQ-2000 is inhibited.

  Note: when the motor is running, turning the keyswitch to the PROGRAM position will not cause the program mode to be initiated until the motor is stopped.

In general, all Operator Panel operations may be divided into 3 types:

- **Programming Setpoints.** In this operation, the setpoint values for the various functions are entered. When programming setpoints, it is necessary to place the RUN/PROGRAM keyswitch in the PROGRAM position.
- **Reviewing Setpoints.** In this operation, the previously programmed setpoint values can be monitored. When reviewing setpoints, the RUN/PROGRAM keyswitch is normally placed in the RUN position. The programmed setpoint values may also be reviewed when the motor is not running and the keyswitch is in the PROGRAM position. (See Paragraph 4.1.5 for details on the reviewing operation.)
- **Monitoring System Characteristics.** In this operation, actual electrical characteristics are displayed, according to a predetermined list, in the FUNCTION window of the Operator Panel. The actual values associated with these selected functions will be displayed. When monitoring characteristics, the RUN/PROGRAM keyswitch must be in the RUN position. (Refer to Chapter 7 for a complete description.)

In the following paragraphs the function of each switch, pushbutton and indicator is listed and explained. Refer to Figure 4.1 where an Operator Panel is shown.

**4.1.1 RUN/PROGRAM Keyswitch** — IQ-2000 operations are controlled by a 2-position keyswitch labeled RUN/PROGRAM. The key may be removed when it is in the RUN position. The selected position determines the operations the control will perform. These are:

- **Run.** With the switch set to RUN, the IQ-2000 enters the run mode which controls normal operation of the motor including starting, running and stopping. This is also the normal position for the reviewing of programmed setpoints or the monitoring of electrical characteristics.

  When switching from PROGRAM to RUN, there is a delay of 5 seconds after which the message CALC SETPOINTS is displayed for 15 seconds. After this delay the RUN indicator lights, and the motor can be started when an external start command is received by the IQ-2000.
- **Program.** With the keyswitch set to PROGRAM and the motor stopped, the control enters the program mode which allows the programming of setpoint values. The PROGRAM LED indicator lights when this mode is entered.

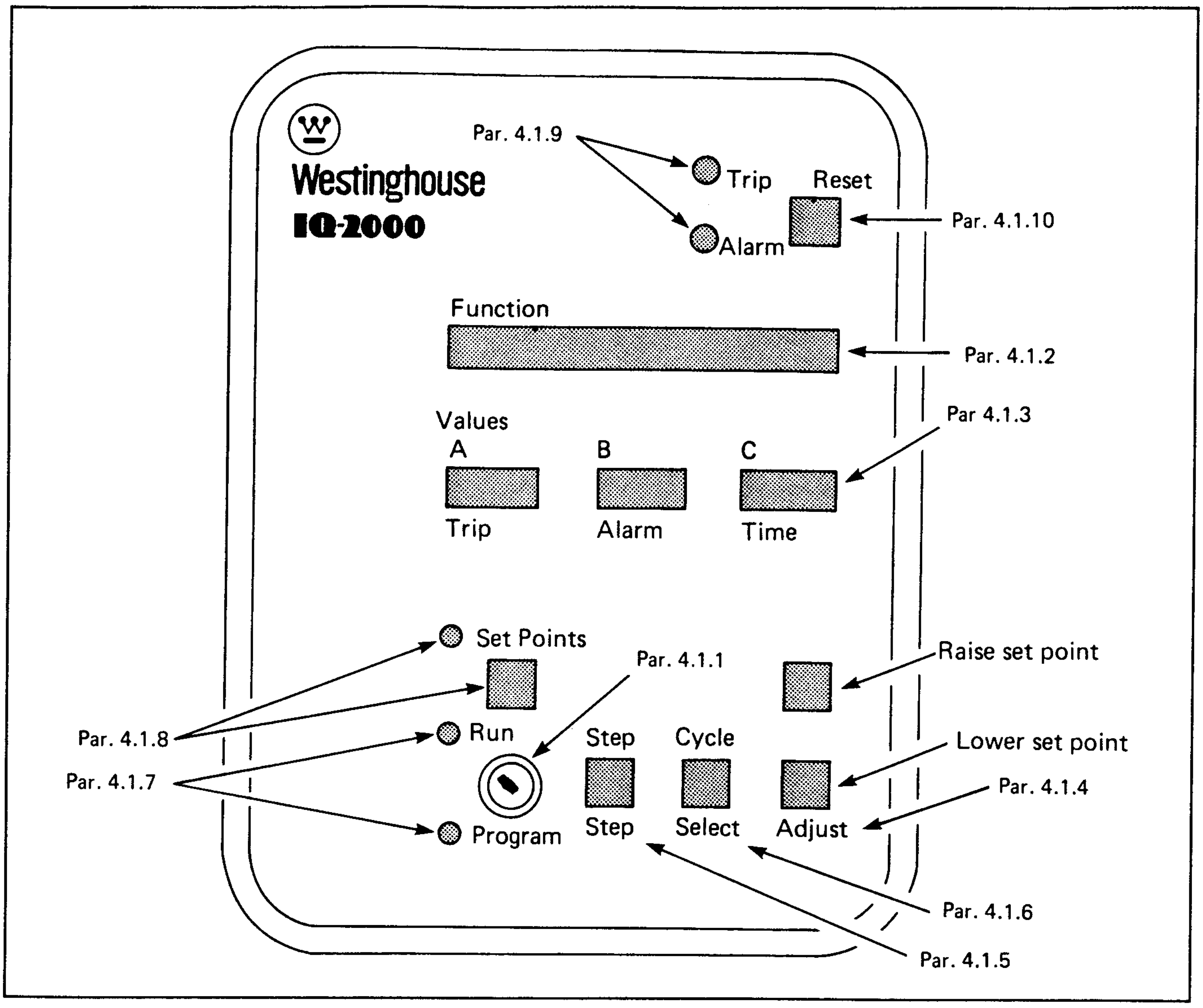



**Figure 4.1 — Operator Panel with Manual References**

**4.1.2 FUNCTION Window** — The FUNCTION window displays the following information:

- Names of setpoint functions. (Note that these can be displayed in either the run or program mode.)
- Names of selected electrical characteristics. These include motor current or line voltage. (The numerical values are displayed in the VALUES window.)
- Error and status messages. (A complete listing of messages is given in Chapter 7, Troubleshooting.)

**4.1.3 VALUES Windows** — There are 3 numerical VALUES windows on the operator Panel. These are labeled with the letters A, B and C and, also, with the titles TRIP, ALARM and TIME. The information displayed is:

- Trip, alarm and time setpoint values entered when in the programming mode.
- Trip, alarm and time programmed setpoint values being reviewed when in the run mode.
- Selected electrical characteristics and their numerical values can be displayed when a monitoring operation is performed in the run mode.
- Trip, alarm and time setpoint values that cause the trip/alarm condition to be displayed in the run mode. In this instance, the SET POINTS LED indicator on the Operator Panel lights to indicate that the values displayed are setpoint values.

**4.1.4 ADJUST Pushbuttons** — The setpoint values may be raised or lowered by means of the upper and lower ADJUST pushbuttons, respectively. The control must be in the program mode to modify the setpoint values. The numerical values will increase or decrease continuously until the pushbutton is released.

When a specific setpoint function is first displayed, all related numerical values in the A, B and C VALUES windows are also displayed. Press the SELECT pushbutton once, and only the A window displays a value — which can then be modified by means of one or the other ADJUST pushbuttons. Press SELECT again, and the B window displays a value, if one is called for by that function.

**4.1.5 STEP Pushbutton** — the 2-function STEP pushbutton is used in all 3 operations, as described here:

- **Programming.** When in the programming mode, depressing the STEP pushbutton causes the various setpoint functions to be sequentially advanced and displayed. (The sequence is identical to the listing in the Setpoint Record Sheet.)
- **Monitoring.** When in the run mode, each time the STEP pushbutton is depressed, a new characteristic is displayed: the name is in the FUNCTION window, and the numerical values are in the VALUES windows. The display will continue until the STEP pushbutton is depressed or an alarm, trip or stop condition occurs.

  Note that the selected characteristics appear according to a fixed order. (A complete listing is shown in Table 7.A.)
- **Reviewing.** When in the run mode, depressing the SET POINTS pushbutton once and the STEP pushbutton once causes the programmed setpoint values to be displayed. The first values displayed relate to the first function in the fixed sequence, which is always winding temperature. Depressing STEP repeatedly advances the display through the list noted on the Setpoint Record Sheet.

  Each setpoint function is displayed for up to 4 seconds. If the STEP pushbutton is not depressed again, the IQ-2000 automatically terminates this reviewing function.

**4.1.6 CYCLE/SELECT Pushbutton** — The function of the CYCLE/SELECT pushbutton varies with the type of operation being performed. Each operation is listed in the following paragraphs.

- **Programming Setpoints.** When in the programming mode, first depress the STEP pushbutton to initiate the display of a setpoint function. At this time all programmed setpoint values that apply are displayed in the VALUES window. Then depress the CYCLE/SELECT pushbutton so that only a single value will be displayed. (This is necessary when modifying previously programmed values.) After the first time the pushbutton is depressed, only the VALUES window labeled TRIP contains a display. After a second depression, the ALARM window displays a value. After a third, the TIME window illuminates.

  Once an individual value is displayed, it can be changed. Depress the upper or lower ADJUST pushbuttons in order to increase or decrease the value.

  In the case of a function with a single setpoint, it is not necessary to press the CYCLE/SELECT pushbutton. Depress the appropriate ADJUST pushbutton immediately to modify the value.
- **Monitoring.** When in the run mode, depress the CYCLE/SELECT pushbutton to cause the IQ-2000 to sequence through each electrical characteristic. Each of these will be displayed for approximately 6 seconds. After all characteristics have been displayed, the sequencing stops.

**4.1.7 RUN, PROGRAM LEDs** — The red RUN and PROGRAM LEDs indicate which mode is active. If AC line power is applied but neither of these indicators lights, an alarm or trip condition has occurred.

**4.1.8 SET POINTS Pushbutton, LED** — The SET POINTS pushbutton is used only in the run mode. Depressing it is a necessary precondition for using the STEP pushbutton to sequence through the setpoint functions. Press STEP repeatedly to advance through the sequence. (The SET POINTS pushbutton is not used in the programming mode.)

The red LED associated with the SET POINTS pushbutton lights after the SET POINTS pushbutton is depressed.

Setpoint functions are each displayed for approximately 4 seconds. Unless the STEP pushbutton is depressed again within this time, the monitoring operation ceases.

To automatically review all setpoints, depress the SET POINTS pushbutton and then depress the CYCLE pushbutton. The setpoint functions, along with their respective setpoint values, will be sequentially displayed for approximately 4 seconds each in the order listed in Table 6.A.

If a trip or alarm condition occurs, the setpoint function which initiated that condition is displayed in the FUNCTION window. Also, the associated programmed values are displayed and the red SET POINTS LED lights.

**4.1.9. TRIP, ALARM, LEDs** — The red TRIP and ALARM LEDs are used to indicate that the actual value of a function equals or exceeds its trip or alarm programmed setpoint value. These LEDs function in the run mode.

When one of these conditions occurs, the specific setpoint function which initiated the condition is displayed in the FUNCTION window. Also, the programmed setpoint value is displayed in the VALUES window. At this time the red SET POINTS LED lights, thereby indicating that the displayed values are the setpoint values.

In the case of an alarm condition, the Alarm Relay will energize until the actual value drops below the programmed value. As it passes through the setpoints, the alarm condition automatically clears, and the Alarm Relay is de-energized.

In the case of a trip condition, the motor enters a controlled stop cycle. Once the actual value is lower than the setpoint, the motor can be restarted by first depressing the RESET pushbutton and then one of the application's START pushbuttons.

**4.1.10 RESET Pushbutton** — The RESET pushbutton is used to manually reinitiate operation after the actual trip value falls below the programmed setpoint value.

Depressing the RESET pushbutton may not, in many instances, immediately cause resumption of operation. For example, if the trip condition results from the rotor temperature accumulator sensing an overtemperature level, the RESET pushbutton will have no effect on the motor until the rotor temperature drops below 75% of the trip setpoint value. (The rotor temperature is monitored in the temperature storage accumulators.)

**4.2 Initial Programming and Sequencing Checks** — Before entering any setpoint values, the following hardware checks must be performed.

DANGER

The following start-up procedures must be performed only by qualified personnel who are familiar with the IQ-2000 and its associated controlled motor and machines. Failure to observe this caution can result in serious or even fatal personal injury and/or equipment damage.

These initial checks only need to be performed once — just before initial AC power is applied at installation. Note that a box appears to the left of each check. As each item is completed, mark it off in the corresponding box in order to avoid skipping one.

The following checks are divided between those to be performed with the main power off but with control power available, and those with the main power on just prior to starting the motor.

**4.2.1 Power Off** — With the incoming AC line power locked off at the starter's isolation switch, perform these checks:

☐ Verify that the isolation switch on the starter cabinet is in the OFF position.

☐ Verify that there is **no** possibility of backfeeding of control power through the control transformer or potential transformers, thereby resulting in high voltage being present on the primary side of the transformers.

☐ Pull the draw-out panel out of the enclosure. Verify that all items from the checklist in Chapter 3, Paragraph 3.4 have been performed.

☐ Place the Keyswitch in the PROGRAM position. Failure to do so can result in a trip condition. (At this point, the only way to recover from a trip condition is to remove and restore AC power while the Keyswitch is in the PROGRAM position.)

☐ When using an Ampgard starter, temporarily plug the control power receptacle, as shown in Figure 3.7, into a 120 VAC extension cord receptacle. Using a meter, check polarity and verify that 120 VAC (±15%) is present.

Alternately, with a motor starter other than Ampgard, temporarily connect 120 VAC (±15%) power to the IQ-2000.

This action insures that the "low-voltage control circuit" also has 120 VAC applied. Note: the low-voltage control circuit refers to any low-voltage circuitry associated with the coil of the motor's contactor.

**4.2.2 Control Power Only** — These checks are to be performed when control power is first applied to the IQ-2000 but without power being available to the motor.

CAUTION

The IQ-2000 is a solid state device. Do not use a megger or perform high potential testing on the connections associated with the unit. Failure to comply will result in equipment damage.

☐ Insert the key into the RUN/PROGRAM keyswitch. Turn it to the PROGRAM position.

☐ Verify that 120 VAC (±15%) is available at terminals TB-P2 and TB-P3. (See Figure 3.1(a), middle left-hand area.)

☐ Observe the Operator Panel. The red TRIP and ALARM indicators should be OFF. If either is ON, refer to Chapter 7, Troubleshooting.

At this point the PROGRAM LED should light, and the FUNCTION window should display the message WINDING TEMP. (If they do not, refer to Section 7, Troubleshooting.)

**4.3 Entering Setpoints** — This discussion of setpoint value entry is divided into 2 parts:

- Setpoint Record Sheet (Par. 4.3.1)
- Value entry (Par. 4.3.2)

**4.3.1 Setpoint Record Sheet** — Locate the Setpoint Record Sheet for the specific IQ-2000 being started up. This sheet should be filled in and made available by the application engineer. (A blank sheet is shown in Figure 4.2, but refer to Chapter 6, Table 6.B.)

DANGER

Do not attempt to enter any values without using the appropriate Setpoint Record Sheet. Improper operation and/or personal injury could result if this procedure is not followed.

Before entry, refer to the Sheet and note the following:

- A total of 28 functions and their associated setpoint values are shown on the Sheet. Not all IQ-2000s require all functions; thus it may be unnecessary to enter the full number available. (With the single exception of P.T. Ratio, any value may appear for an unused function since no field device will be wired into the control.)
- The name of each function is sequentially displayed in the FUNCTION window in the same order as they appear on the Sheet.
- Some functions require that 3 setpoint values (trip, alarm and time) be entered. Others require only 1 or 2.
- In some cases values other than 0 may already be factory-entered. It may thus be necessary to increase or decrease these numbers to match the desired setpoints.

**4.3.2 Value Entry** — The following steps are to be followed in order to enter setpoint values.

**Step 1** — Turn the RUN/PROGRAM keyswitch to the PROGRAM position. At this time the FUNCTION window displays the message WINDING TEMP. If any setpoint values were previously entered, they will be shown in the VALUES windows. (See Figure 4.3.) If not, zeroes will be shown.

**Step 2** — If a function other than the winding temperature setpoint function is to be modified, repeatedly depress the STEP pushbutton until the desired function is displayed.

**Step 3** — It is necessary to depress the CYCLE/SELECT pushbutton once to display and allow modification of the trip value. Note: if the function does not have a trip setpoint value associated with it, the alarm value will be displayed. If the setpoint function has only one value associated with it, the CYCLE/SELECT pushbutton need not be used.

**Step 4** — At this point the trip value can be modified. Use the ADJUST pushbuttons to increase or decrease the value, as required.

**Step 5** — Once the trip value is modified, depress the SELECT pushbutton to display the alarm setpoint. Modify it as necessary.

**Step 6** — In order to advance to the next function, depress STEP once. Each time STEP is depressed, the displayed function advances.

**Step 7** — While referring to the Setpoint Record Sheet, step through each function. Enter values for each function used by the specific application.

**SETPOINT RECORD SHEET**

Ampgard Schematic No.: (drawing number) ____________

Plant Designation: ________ End User: ________ Motor Designation: ____________

Plant Location: ________ OEM: ________ Motor Model No.: ____________

| 1 | Setpoint Function | Trip 2 | Alarm 3 | Time 4 | Setpoint Value Ranges |
|---|---|---|---|---|---|
| 1 | WINDING TEMP 5 | | | | Trip & alarm: 0° to 199°C (1°C incre.) |
| 2 | MOTOR BGR TEMP 5 | | | | Trip & alarm: 0° to 199°C (1°C incre.) |
| 3 | LOAD BGR TEMP 5 | | | | Trip & alarm: 0° to 199°C (1°C incre.) |
| 4 | GROUND FAULT | | | | Trip: 4 to 12 amps primary circuit (1 amp incre.)<br>Alarm: 0 to 12 amps primary circuit (1 amp incre.)<br>Time: 0 to 5 sec. (1 sec. incre.) |
| 5 1 | INST OVERCURRENT | | | | Trip: 300 to 1500% of full-load amperes (in 100% incre.) Use numbers 3 to 15 only. |
| 6 1 | LOCKED ROTOR CUR | | | | Trip: 300 to 1200% (in 10% incre.) Use numbers 30 to 120 only. The decimal point here shown as: 3-0, 12-0<br>Time: 0 to 60 sec. (in 1 sec. incre.) |
| 7 | LONG ACCELERAT | | | | Time: 0 to 99 sec. (in 1 sec. incre.) |
| 8 | JAM | | | | Trip: 70 to 1200% of full-load amps (in 1% incre.) Use numbers 70 to 1200.<br>Time: 0 to 100 sec. (in 1 sec. incre.) |
| 9 | UNDERLOAD START | | | | Time: 0 to 100 sec. (in 1 sec. incre.) 8 |
| 10 | UNDERLOAD RUN | | | | Trip: 0 to 90% of full-load amps (in 1% incre.)<br>Time: 0 to 10 sec. (in 1 sec. incre.) |
| 11 1 | ULTIMATE TRIP | | | | Amp: 85 to 125% of full-load amps (in 1% incre.) 2 Use numbers 85 to 125 |
| 12 | OVERVOLTAGE 7 | | | | Trip: 0 to 9999 VAC (in 1 volt incre.)<br>Time: 0 to 99 sec. (in 1 sec. incre.) |
| 13 | UNDERVOLTAGE 7 | | | | Trip: 0 to 9999 VAC (in 1 volt incre.)<br>Time: 0 to 99 sec. (in 1 sec. incre.) |
| 14 | PRE-START TIMER | | | | Time: 0 to 255 sec. (in 1 sec. incre.) |
| 1 15 | PRE-RUN TIMER | | | | Time: 0 to 60 sec. (in 1 sec. incre.) |
| 16 | PRE-STOP TIMER | | | | Time: 0 to 60 sec. (in 1 sec. incre.) |
| 17 | INCOMPL SEQUENCE | | | | Time: 0 to 240 sec. (in 1 sec. incre.) |
| 18 | ANTI-BACKSPIN | | | | Time: 0 to 255 sec. (in 1 sec. incre.) |

(Partial illustration of form.)

**Figure 4.2 — Setpoint Record Sheet (typical)**

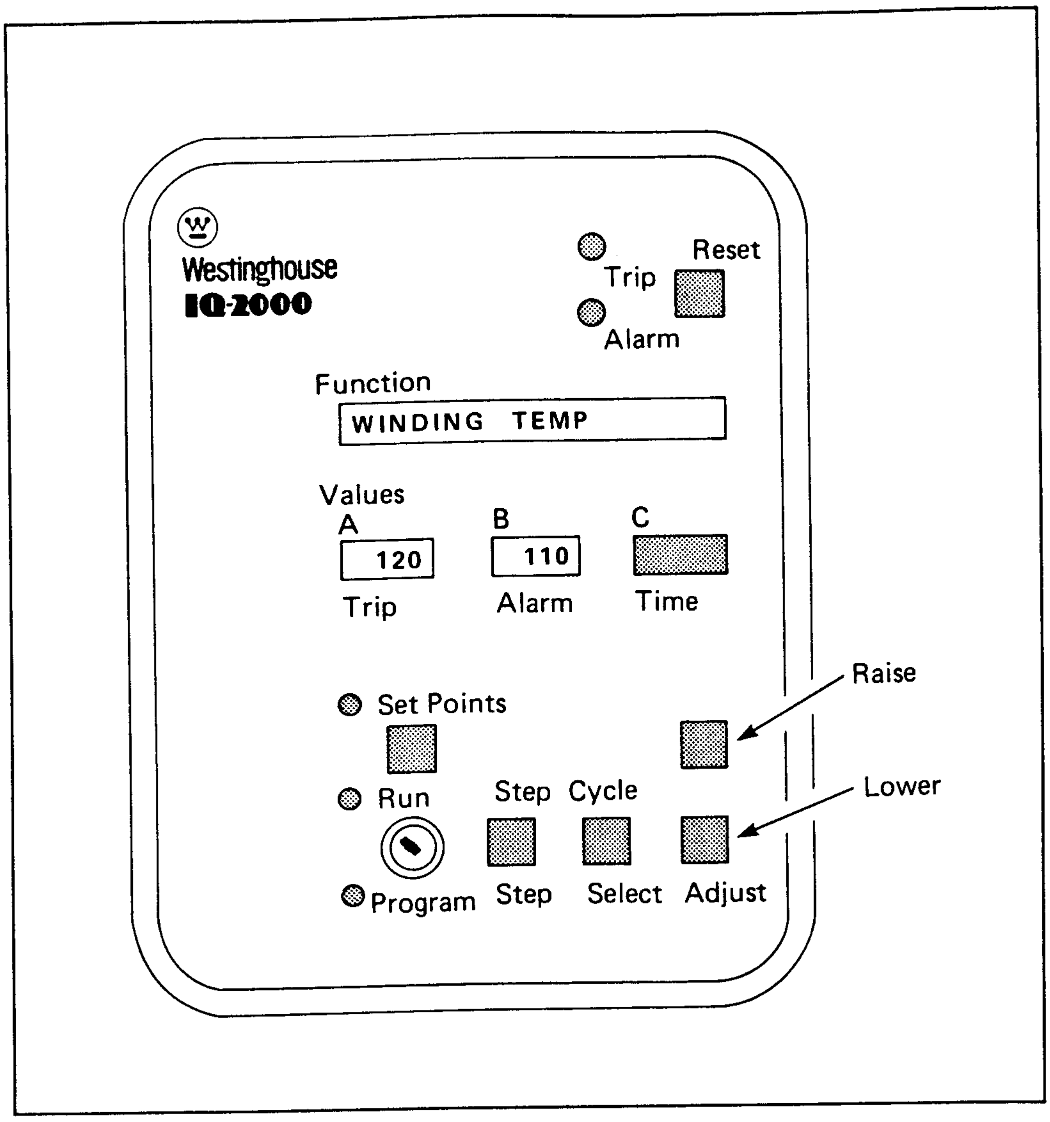



**Figure 4.3 — Winding Temperature Displays**

**Step 8** — After all values are entered, simply depress the STEP pushbutton to again display the first setpoint function and its associated values. Carefully compare the entered value with the desired value as noted on the Setpoint Record Sheet. Confirm that the 2 values match. Modify the programmed value if necessary.

**Step 9** — Move on to subsequent functions in order to confirm the correctness of their entries.

**4.4 Initial Control Checkout** — This procedure describes the method of verifying that the setpoints previously entered actually function as anticipated **before** enabling high voltage or main power to the motor starter. If this test can be successfully completed, the control wiring can be assumed to be correct. (If the test cannot be completed — for example, BAD REPORTBACK — one possible cause is incorrect control wiring.)

The following checklist verifies the operation of these internal and external control functions.

- ☐ Turn the Keyswitch to the RUN position. Verify that, after 5 seconds, the message CALC SETPOINTS is displayed and remains for a short period.
- ☐ Verify that within 20 seconds the CALC SETPOINTS message is replaced with the message READY and that the RUN LED lights at the same time.
- ☐ Initiate the run sequence.

Note: If the IQ-2000 displays PHASE ERROR, program the potential transformer ratio to 0 while testing with only control test voltage.

**DANGER**

It may at times be necessary to install jumpers in order to initiate the run sequence. Signals from equipment associated with the motor starter such as the remote interlock or run enable lines may need to be jumpered since the motor will not actually be running. If one or more jumpers are installed, tag these jumpers for ease of removal later. Failure to do so can result in serious or fatal personnel injury and/or equipment damage.

The balance of this procedure monitors the start and stop cycles using the Operator Panel. If necessary, review the use of the Operator Panel, as described in Paragraph 4.1.

Initiate the run sequence and verify the following items:

- ☐ Monitor the pre-start timer function and verify that it is timing, as listed in the Setpoint Record Sheet.
- ☐ Monitor that the appropriate contactor(s) is/are being energized. Note: Table 6.D lists the contactor uses for the various starter classes.
- ☐ Monitor the pre-run timer function and verify that it is timing as listed in the Setpoint Record Sheet. The display changes from START SEQUENCE to RUN SEQUENCE in the Function window.

Initiate the stop sequence and verify the following items:

- ☐ Monitor the pre-stop timer function and verify that it is timing as listed in the Setpoint Record Sheet.
- ☐ Monitor that the appropriate contactors are being de-energized. Note: Table 6.D lists the contactor uses for the various starter classes.
- ☐ Monitor the post-stop timer function and verify that it is timing as listed in the Setpoint Record Sheet.
- ☐ Monitor the anti-recycle function and verify that it is operating as listed in the Setpoint Record Sheet.
- ☐ Monitor the anti-backspin function and verify that it is operating as listed in the Setpoint Record Sheet.

This concludes the initial IQ-2000 control checkout without any high voltage being applied.

**4.5 Initial Motor Startup** — Depending on the motor type, specific application and completeness of the installation, it may be a good practice to disconnect the load from the motor before applying power for the first time. Consult the application engineer for suggestions. Always keep in mind the cautions listed in Paragraphs 4.2 and 4.3 when first starting the motor.

**CAUTION**

Since the IQ-2000 is phase-sensitive, verify that the incoming AC supply lines (L1, L2, and L3) are properly phased and wired to the IQ-2000. Failure to do so will result in a trip condition when power is first applied. If a PHASE ERROR exists, see Table 7.C for a listing of corrective action.

**4.6 Initial Main Power-on** — Before closing the isolation switch associated with the motor starter, the following hardware checks must be performed:

- ☐ Remove the extension cord temporarily providing 120 VAC control power. (Plug the power cord into the intended receptacle as shown in Figure 3.7.)
- ☐ Inspect the motor and driven mechanics to verify that the devices — such as the couplings, belts, etc. — are secure and that all required safety guards, shields and/or covers are in place. If possible, manually rotate the driven mechanisms to verify free movement.
- ☐ Clear all personnel from the immediate area of the motor and driven mechanisms.
- ☐ Close the high voltage door.
- ☐ Close the starter cabinet's isolation switch.
- ☐ Verify that 120 VAC ($\pm$15%) is available at terminals TB-P2 and TB-P3. (See Figure 3.1, middle left-hand area.)

Section 5

# APPLICATION CONSIDERATIONS

**5.0 General** — This chapter describes the protective and control characteristics of the IQ-2000. It is intended for the engineer who is responsible for matching the control to an individual application. Information presented here is especially useful for understanding the setpoint value considerations described in Chapter 6. It may be helpful to read Chapter 5 and 6 quickly, and then reread and study Chapter 5 slowly. After doing so, reread Chapter 6, Paragraph 6.0, and select those setpoints from Table 6.A which relate to the specific application.

**5.1 Motor Protection** — The IQ-2000 protects the motor, starter, and load in the following ways:

- Motor overload protection
- Overtemperature protection
- Instantaneous overcurrent
- Ground fault protection
- Phase loss/phase reversal/phase unbalance (voltage)
- Phase loss/phase reversal, and unbalance (current)
- Overvoltage protection
- Undervoltage protection
- Motor bearing temperature
- Jam
- Underload
- Long acceleration provision
- Load Bearing Temperature

**5.1.1 Overload Protection without RTDs** — The motor overload protection feature guards against excessive motor temperature. If the temperature of the rotor, as calculated by the IQ-2000, reaches 75% of the specified maximum, an OVERLOAD WARNING message is displayed. If the calculated motor temperature exceeds the maximum permissible rating, a trip condition occurs, and the motor stops. A LOCKED ROTOR CUR message is displayed. Note that the motor will not be permitted to restart until the temperature of the rotor, as calculated by the IQ-2000, falls below 75% of its maximum value. (The algorithm has both a heating and a cooling calculation.)

To do this, a microprocessor located in the Processor Module maintains a short-term history of the motor's operation. (A rotor protection algorithm maintains the history. See Figure 5.1.) The following variables are used as input data for the history:

- Motor current ($I_1$), the positive sequence current
- Motor current ($I_2$), the negative sequence current or "unbalanced current"
- Time

This data can be considered as the current feedback from the motor.

In addition to the variable data feedback from the motor, certain motor constants are needed. They are supplied to the IQ-2000 when the setpoints are programmed into the memory. These are:

- Full-load amps
- Maximum allowable locked-rotor current and stall time
- Ultimate trip

With these motor constants and with the IQ-2000 accurately measuring motor currents and time, an accurate tracking of the calculated rotor temperature is accomplished, assuming a 40°C ambient.

**5.1.2 Overload Protection with RTDs** — The temperature data obtained from the addition of RTDs is used in the following 2 ways by the IQ-2000 to help protect the motor:

- Direct measurement of the winding temperature versus the programmed trip temperature. (This gives a fixed trip point based on actual, measured stator winding heating and cooling.)
- RTD winding temperatures — when combined with the monitored positive sequence motor current, the negative sequence motor current and time, in the algorithm for motor protection — incorporates the anticipated cooling of the rotor based on the actual winding temperature. (This will be described in more detail in Paragraphs 5.1.3.6. and 5.1.4.)

The following motor input variables are used by the IQ-2000:

- Motor current ($I_1$), the positive sequence current
- Motor current ($I_2$), the negative sequence current or "unbalanced current"
- Time
- Stator winding temperature

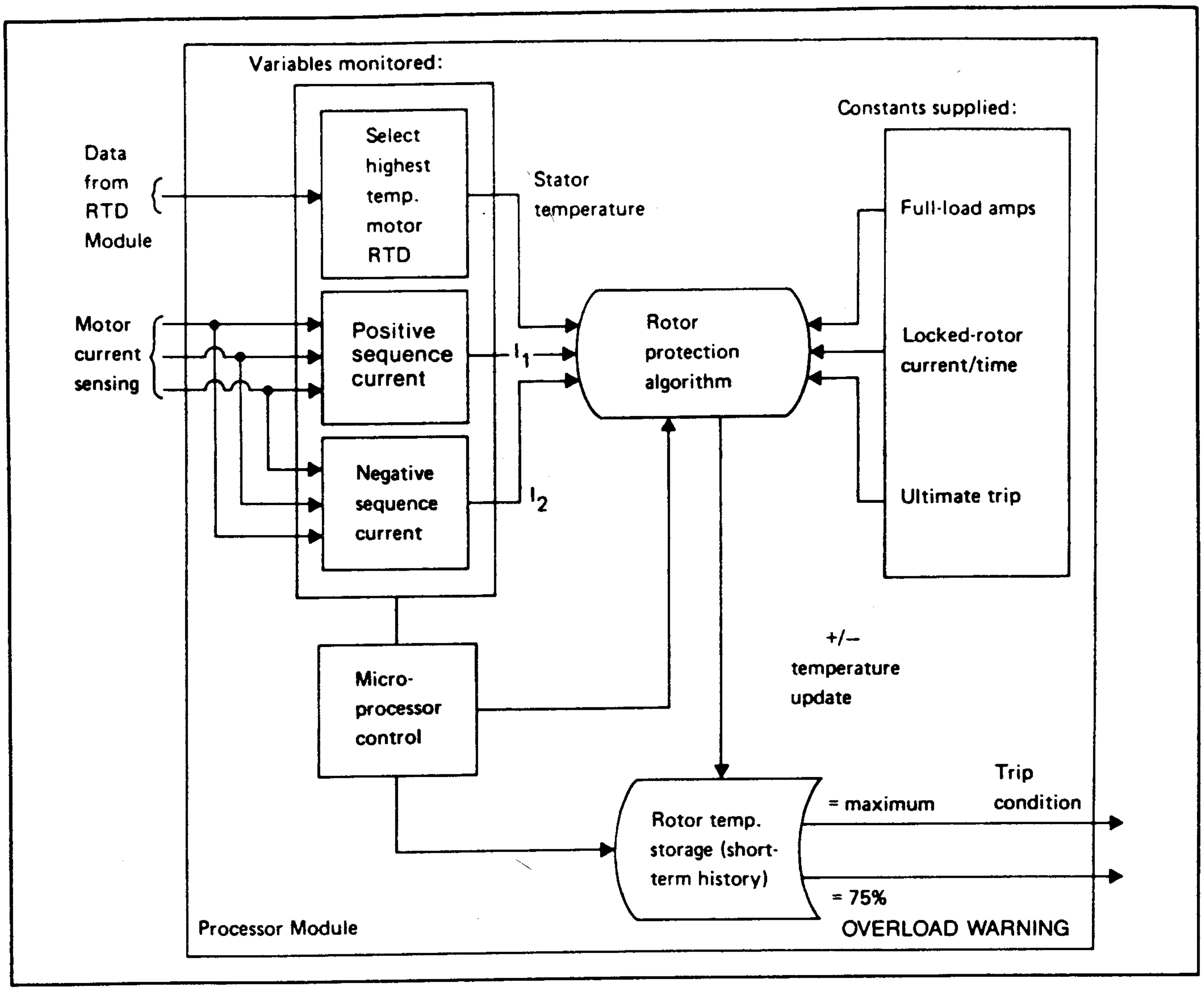



**Figure 5.1 — Rotor Temperature Tracking**

This data can be considered as the feedback from the motor. (See Figure 5.1.)

In addition to the variable data, certain motor constants are needed. They are supplied to the IQ-2000 when the setpoints are programmed into the IQ-2000's memory. These are:

- Full-load amps
- Maximum allowable locked-rotor current and stall time
- Ultimate trip
- Winding temperature trip value

The IQ-2000 has these setpoints plus an accurate measurement of the feedback variables. Thus the IQ-2000 can more accurately protect the rotor, while the stator is protected by direct measurement through the RTDs.

**5.1.3 Protection Curve** — The motor protection curve defines the motor-versus-time relationship that exists as a direct result of the IQ-2000's hardware and the programmed setpoint values. (See Figure 5.2.) Ideally this curve is located as close as possible to the motor damage curve, thus allowing maximum utilization of the motor and, at the same time, fully protecting the motor from damage. (The motor damage curve is defined as that point in the relationship of the motor current and time where thermal damage results.) When the motor current-versus-time relationship exceeds this damage curve, a trip condition occurs, and the main contactor opens.

The correct motor protection curve for a specific application will automatically be calculated by the IQ-2000 after the correct setpoint values are programmed for the full-load amps, maximum allowable locked-rotor current and stall time, and ultimate trip. A brief discussion of how these values affect the motor protection curve follows.

The typical curve shown in Figure 5.2 is the result of the factors listed in the following Paragraphs.

**5.1.3.1 Instantaneous Overcurrent** — The instantaneous overcurrent in Figure 5.2 is set at 12 times full-load amps. The

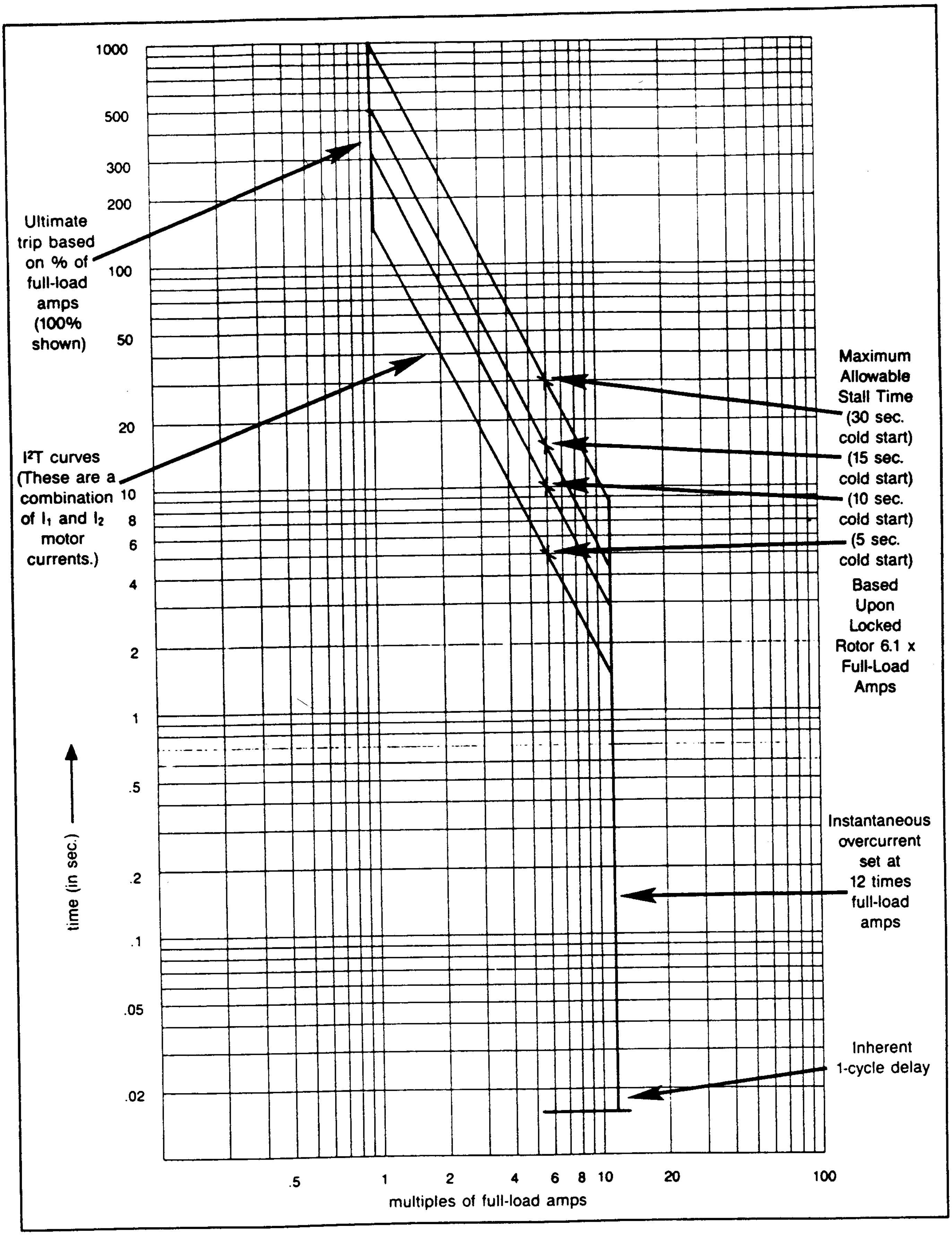



**Figure 5.2 — Motor Protection Curve**

instantaneous overcurrent should be set for a value equal to or higher than 1.6 times the locked-rotor current ratio. (The range may be 3 to 15.) Note that instantaneous overcurrent has an inherent 1-cycle delay to avoid nuisance tripping. This protective function overrides all other functions.

**5.1.3.2 Allowable Locked-Rotor Current, Time** — The curves shown on Figure 5.2 are based upon the maximum allowable locked-rotor current being 6.1 times full-load amps. The actual values can be greater or less as programmed into the IQ-2000. (The range may be 3 to 12 times.) All curves shown are based upon maximum allowable stall time with a cold start.

Since the IQ-2000 algorithm retains a history of the operating current and time of the motor, it is not necessary to program it for hot starts. The IQ-2000 automatically takes into consideration if it is a cold or hot start. Therefore, the stall time as based upon the cold start should be used in programming the IQ-2000.

**5.1.3.3 Ultimate Trip** — It is necessary to program the ultimate trip value. This would normally be set at 100%. If the motor has a service factor larger than 100% and it is decided to make use of this factor, this situation shifts the ultimate curve to the right on the time-current graph and has an effect where the $I^2T$ curve intersects the ultimate trip curve.

Note that the $I^2T$ curves are a combination of the positive current and negative sequence current, with the negative sequence current weighted to reflect the additional rotor heating it causes. (Figure 5.2 shows the curves that result from maximum stall times.)

**5.1.3.4 Underload Function** — When the motor is running, a sudden reduction of current below a programmed value for a programmed time would indicate a malfunction in the driven equipment, and an underload trip would be activated. (Refer to Figure 5.3.)

Shutdown protection is used in the event of mechanical problems such as a blocked flow in a pump, loss of back pressure in a pump, or a broken drive belt or drive shaft. A programmed lockout during a motor start cycle may occur if

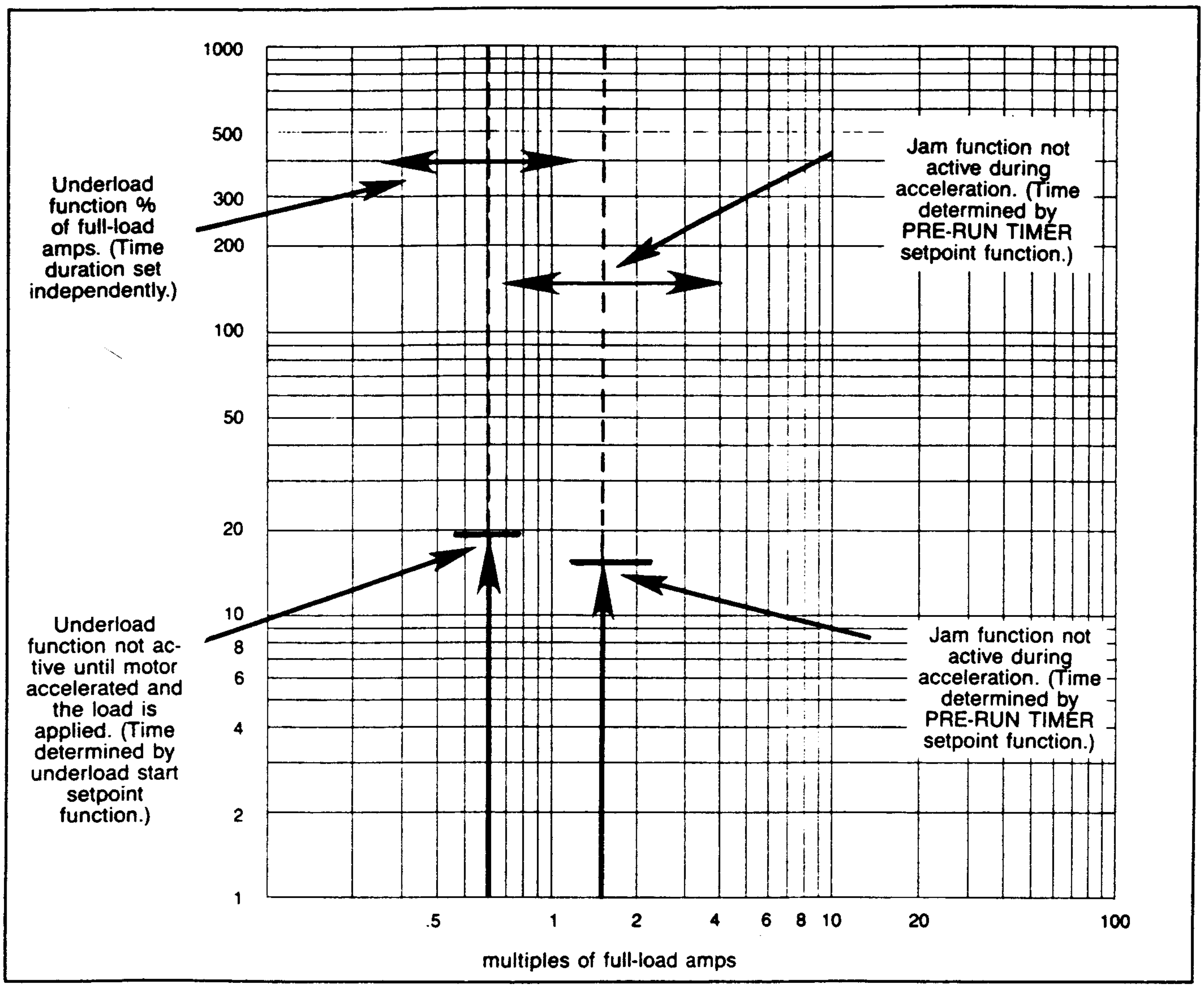



Figure 5.3 — Underload and Jam Protection

the load is not immediately applied. This is determined by the setpoint value of the underload start timer.

If this function is not required, the underload setpoint function should be set at 0. This function is not required to protect the motor but may be desirable to provide system protection.

**5.1.3.5 Jam Function** — Once the motor is running, if an instantaneous current exceeds a programmed value for a programmed time, a trip will occur. (See Figure 5.3 where the jam setpoint is set for 180% of full-load current.) When the Resistance Temperature Detection Option is applied, this jam protection is desirable with gear train and other mechanical type loads where an overload or physical jam could cause damage. The jam function is not active during acceleration; this permits locked-rotor current during acceleration.

> NOTE
>
> The locked-out time function during motor acceleration is programmed by the time set of the PRE-RUN TIMER.

If this function is not required, the jam function should be set at 1200% for 2 seconds. This function is not required for motor protection but may be desirable to provide system protection.

**5.1.3.6 Temperature Effects** — The motor protection function is affected by the calculated rotor temperature. Without RTDs, the temperature is assumed to be 40°C. Thus the actual ambient temperature has no effect on both the starting and running of the motor. The customer application engineer should take these factors into consideration and compensate for them if a higher ambient temperature is anticipated. The best solution is the use of RTDs, since any compensation for a higher ambient temperature results in overprotecting the motor during lower temperature conditions. Without RTDs, the IQ-2000 calculates the current and time and converts this to a calculated stator/rotor temperature. The constant $I^2T$ curve, as established by the maximum allowable locked-rotor current and time, must be assumed to adequately protect the motor for all values of motor current above the ultimate trip value. Should the curve not be adequate to protect the motor due to stator limitations at elevated ambient conditions, then the use of RTDs is recommended. The use of RTDs allows a fuller utilization of the power available from the motor and reduces unnecessary shutdowns.

**5.1.4 Typical Motor Protection Curves** — To illustrate the effects of these protection features, 2 sample curves are shown. Using specific motor data, typical motor protection curves of the IQ-2000 are shown in Figure 5.4 without the use of RTDs. The use of RTDs is assumed in Figure 5.5. The following data was used:

- Instantaneous overcurrent 12 times full-load amps
- Maximum allowable locked-rotor amps 6.1 times full-load amps
- Maximum stall time 15 seconds, cold start
- Ultimate trip 100% of full-load amps
- Acceleration of motor loaded, 10 seconds
- Motor running loaded at 90% of full-load amps
- Underload protection set at 60% of full-load amps for a 5-second duration
- Jam protection 180% full-load amps for a 5-second duration

The basic difference with the addition of RTDs is shown in Figure 5.5 in the time period after 60 seconds. With RTDs, the actual monitored temperature automatically overrides the ultimate trip setting of the IQ-2000. It should be noted that the ambient conditions that the motor is operating under will affect the top portion of the curve. The curve is shifted to the left with increasing ambient temperature, and to the right for decreasing temperature.

The effects of the motor winding temperature setpoint value which is available when RTDs are used are not evident in Figure 5.5. This setting is independent of the effects of temperature on the algorithm trip curve. The setting is based upon the recommended maximum stator temperature as supplied by the motor manufacturer. Depending upon the specific setting, the temperature trip curve would be to the left of the motor protection RTD algorithm.

The IQ-2000 allows maximum utilization of the power available from the motor by setting its trip conditions as close as possible to the motor damage curve.

**5.1.5 Motor Current** — The negative sequence and positive sequence motor currents are both monitored by the IQ-2000.

**5.1.5.1 Negative Sequence Currents** — Throughout the discussion of the motor protection curves, the effects of negative sequence currents cannot be emphasized too strongly. For maximum motor utilization, the actual load should be matched closely to the full horsepower of the motor. However when this is done, the effect of motor voltage unbalance — that results in the negative sequence current — becomes more critical. The IQ-2000 accurately calculates negative sequence currents on an ongoing basis. It is not necessary to arbitrarily pick a specific percent unbalance to shut the motor down. As long as the rotor temperature as calculated by the IQ-2000 does not equal the motor damage curve, the motor will be allowed to operate.

**5.1.5.2 Positive Sequence Currents** — True RMS motor current is monitored. A total of 36 samples are taken in each phase during a 24-cycle period to calculate the positive and negative sequence currents. The sample point is constantly shifting; thus the IQ-2000 will also monitor non-sinusoidal wave forms. This is important for applications where power factor correction capacitors and rectified systems are on the same main bus.

**5.2 Motor Control** — The term motor control refers to the starting and stopping of a motor as controlled by the IQ-2000. In addition to precisely controlling the contactors, auxiliary functions are also sequenced on and off. The explanation here centers on the control features associated with starting and stopping a motor.

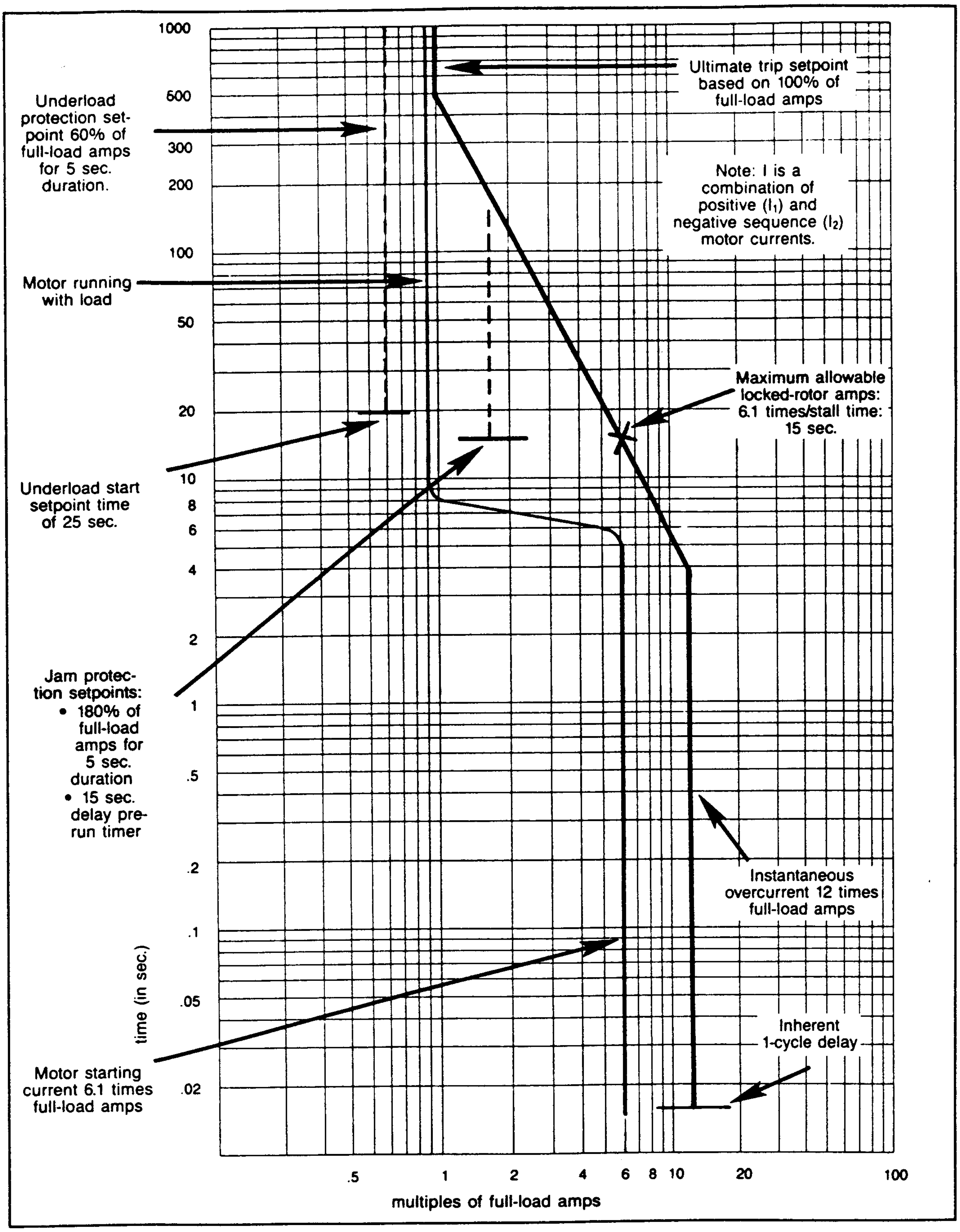



**Figure 5.4 — Motor Protection Curve (without RTDs)**

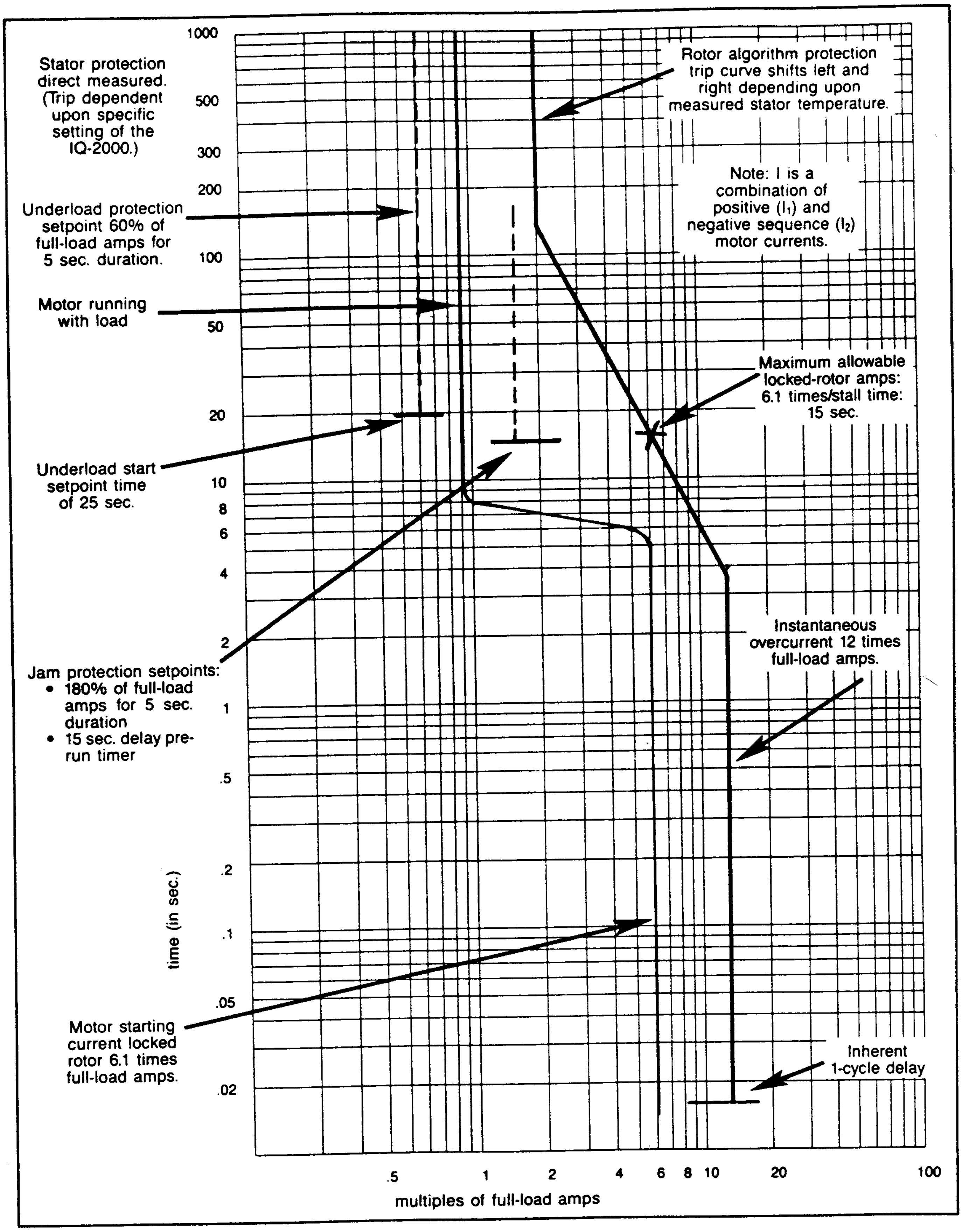
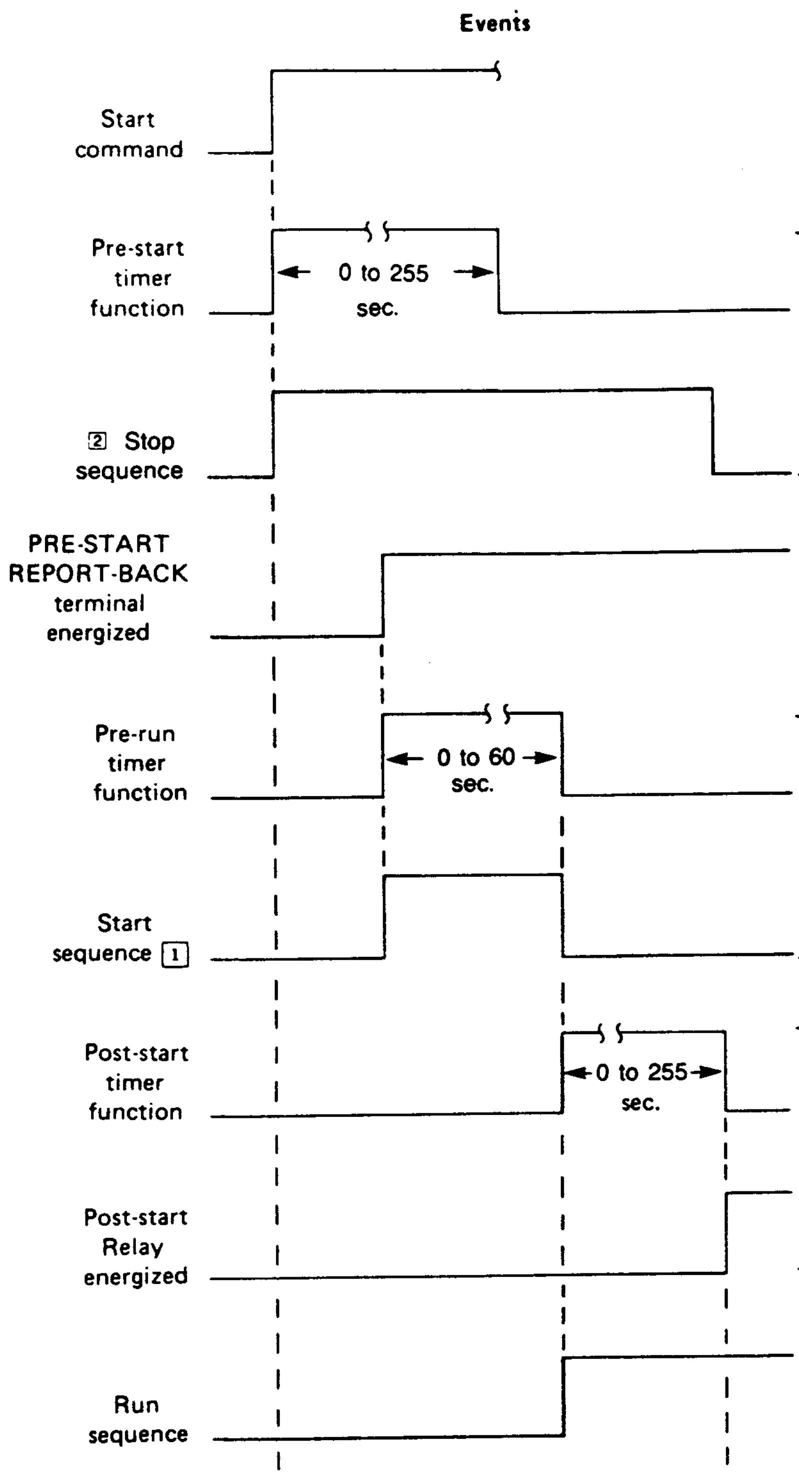



**Figure 5.5 — Motor Protection Curve (with RTDs)**




The start cycle is initiated by either a momentary or maintained start signal, as listed in Table 5.C.

The pre-start timer function enables the Pre-start Relay. The function must **not** time out before the PRE-START REPORT-BACK terminal (TB-A10) is energized. The Pre-start relay de-energizes when the stop sequence is completed.

When this terminal is energized, it initiates the pre-run timing function.

In reactor or autotransformer applications the momentary contactors are energized during the pre-run timing interval. It is also used in conjunction with the JAM function. Refer to Paragraph 5.1.3.5.

When the post-start timing is completed, the Post-start Relay is energized.

The run sequence is the normal or steady state of the contactors.

1 The start "sequence" represents the time beginning with the energizing of the PRE-START REPORT-BACK terminal (TB-A10) and ending with timing out of the programmed pre-run timer function. The start "cycle" represents the period containing all function associated with the starting of the motor.

2 See Figure 5.7 for a description of the stop sequence.

**Figure 5.6 — Motor Start Cycle Events Diagram**

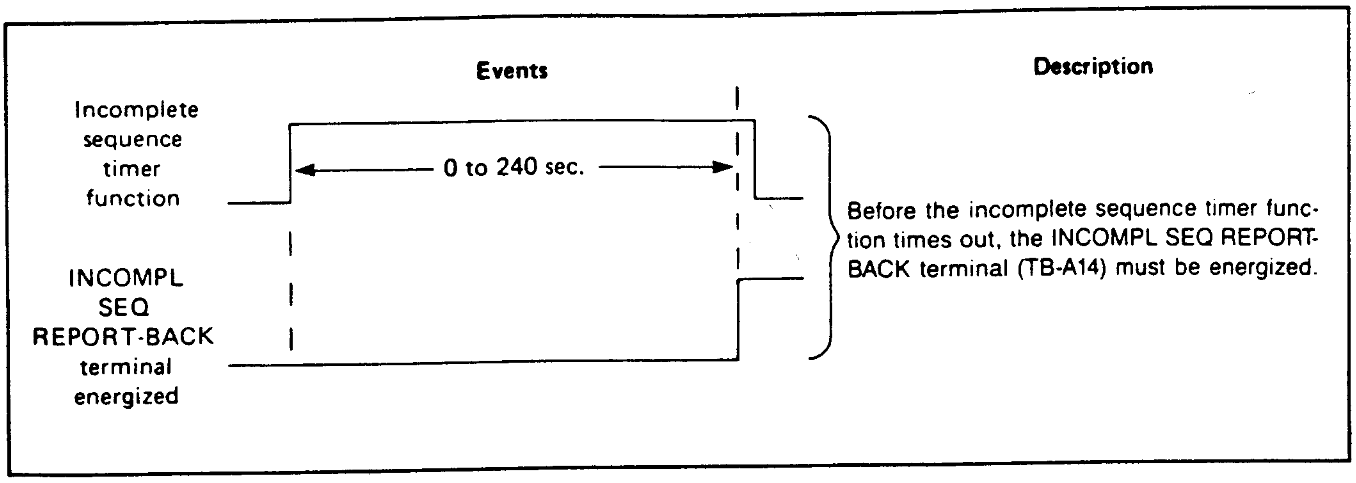



**Figure 5.6 — (Cont'd.)**

**5.2.1 Motor Starting** — When starting a motor, it is often desirable to control auxiliary functions such as coolant pumps, louvers or valves in coordination with the sequencing of the main motor contactor. Equally desirable is the ability to delay the enabling or disabling of the contactor until receiving a feedback signal. In this manual the signal is called a "report-back." The IQ-2000 allows the application engineer to select and program the following related setpoints:

- Pre-start timing
- Post-start timing
- Pre-run timing
- Incomplete sequence timing

The relationships among the timing functions, the contactor(s) and the feedback signals during the start cycle are shown in Figure 5.6. Note the following:

- The entire start cycle is initiated by a start command — such as when the FWD/SLOW FWD-MAINT terminal (TB-A6) is energized. (See Figure 3.6.) Note that other input signals may also initiate the start cycle. (See Paragraph 5.4.1.)
- Upon actuating the start command, the Pre-start Relay's output contacts at TB-A36 and TB-A37 close.
- When the pre-start timer output contacts are energized, the message PRE-START is displayed in the FUNCTION window.
- The PRE-START REPORT-BACK terminal (TB-A10) must be energized **before** a start sequence continues. Note, however, that the pre-start timer setpoint function can be disabled if it is not required. (See Paragraph 6.14.)

**NOTE**

The PRE-START REPORT-BACK terminal monitored by the IQ-2000 is only active during the length of the pre-start time. After the pre-start function is timed out, the PRE-START REPORT-BACK terminal has no effect on the run sequence.

- If the pre-start timer function times out **before** the PRE-START REPORT-BACK terminal (TB-A10) is energized, the starting cycle is aborted. At this time the message BAD START RESET is displayed in the FUNCTION window.
- In a multi-step application where, for example, the Class 11-502 is used, the momentary contactor is closed for a time determined by the pre-run setpoint function. (It is programmable from 0 to 60 seconds.) Even if the application is for an across-the-line starter, the pre-run timer is used. (See Paragraph 6.15.)
- When the PRE-START TIMER REPORT-BACK terminal is energized, the message START SEQUENCE is displayed in the FUNCTION window.
- After the time duration is set on the pre-run timer, the contactors are shifted to a run configuration. Even if the starter is an across-the-line starter, this timer function is still used to disable the JAM function until the motor has accelerated to full speed. (See Paragraph 6.15.)
- At this time, the completion of the pre-run timing sequence, the message RUN SEQUENCE is displayed in the FUNCTION window.
- After the run sequence is established, the post-start timing sequence starts.
- Only after the post-start timer function times out is the Post-start Relay energized. It remains energized until after the stop sequence becomes active. The function is programmable from 0 to 255 seconds. Contacts from this Relay may be used for auxiliary control functions such as enabling a load or, in stepping or process type applications, enabling the next sequence or step in the process.
- The incomplete sequence timing function causes a trip condition if the INCOMPL SEQ REPORT-BACK terminal (TB-A14) is not energized before this timing function is complete. The trip stops the motor. The incomplete sequence function can be disabled if it is not required. (See Paragraph 6.17.)

NOTE

The INCOMPL SEQ REPORT-BACK terminal is monitored continuously by the IQ-2000. If the terminal is de-energized at any time after the incomplete sequence timer function times out, the stop sequence is initiated.

**5.2.2 Long Acceleration Starting** — There are some applications where the acceleration time exceeds the stall time. The IQ-2000 eliminates the necessity of choosing to start the load with the motor unprotected, or to protect against locked rotor. Initially the motor manufacturer must confirm that the motor is capable of starting the load. The long acceleration function works as follows: when the motor is started, locked-rotor protection is in effect. The IQ-2000 projects the temperature of the rotor, and, if it exceeds the trip value, shuts down the motor. If the motor starts to move the load, then the rotor starts to self-cool. A zero-speed switch is required to allow the IQ-2000 to go into the long acceleration mode. (This is wired to L ACCEL PERM, TB-A12.) In this mode the IQ-2000 limits the rotor temperature storage to a value one count below the trip condition setpoint value. If, at the end of the long acceleration time, the current is reduced to a value such that the rotor protection algorithm is decreasing the value of the rotor temperature storage, the motor is allowed to continue to rotate. If the rotor temperature storage is still increasing, the IQ-2000 goes immediately into a trip condition.

**5.2.3 Motor Stopping** — When stopping a motor, it is often desirable to be able to control auxiliary functions such as pumps, louvers or valves in coordination with the main contactor(s). The following setpoint functions may be selected by the engineer and programmed as required by the individual application:

- Pre-stop timer
- Post-stop timer
- Anti-backspin timer
- Anti-recycle

The relationships among the timing functions and the de-energizing of the contactor(s) is shown in Figure 5.7. Note the following:

- The motor's stop cycle is initiated when the hardware stop/start circuit de-energizes control relay CR. Figure 3.6 shows a typical start/stop circuit. Contacts from the CR relay de-energize the FWD-MAINTAINED terminal (TB-A6), initiating the pre-stop timer function. Note that the motor's stop cycle can also be initiated by any trip condition including instantaneous overcurrent, overvoltage, etc.
- The stop sequence, which de-energizes the contactor, is initiated when both the PRE-STOP REPORT-BACK terminal (TB-A8) is energized and the pre-stop timing function is active. If the terminal is not energized before the pre-stop timer function has timed out, a stop condition occurs. Also, the message BAD STOP RESET is displayed in the FUNCTION window.

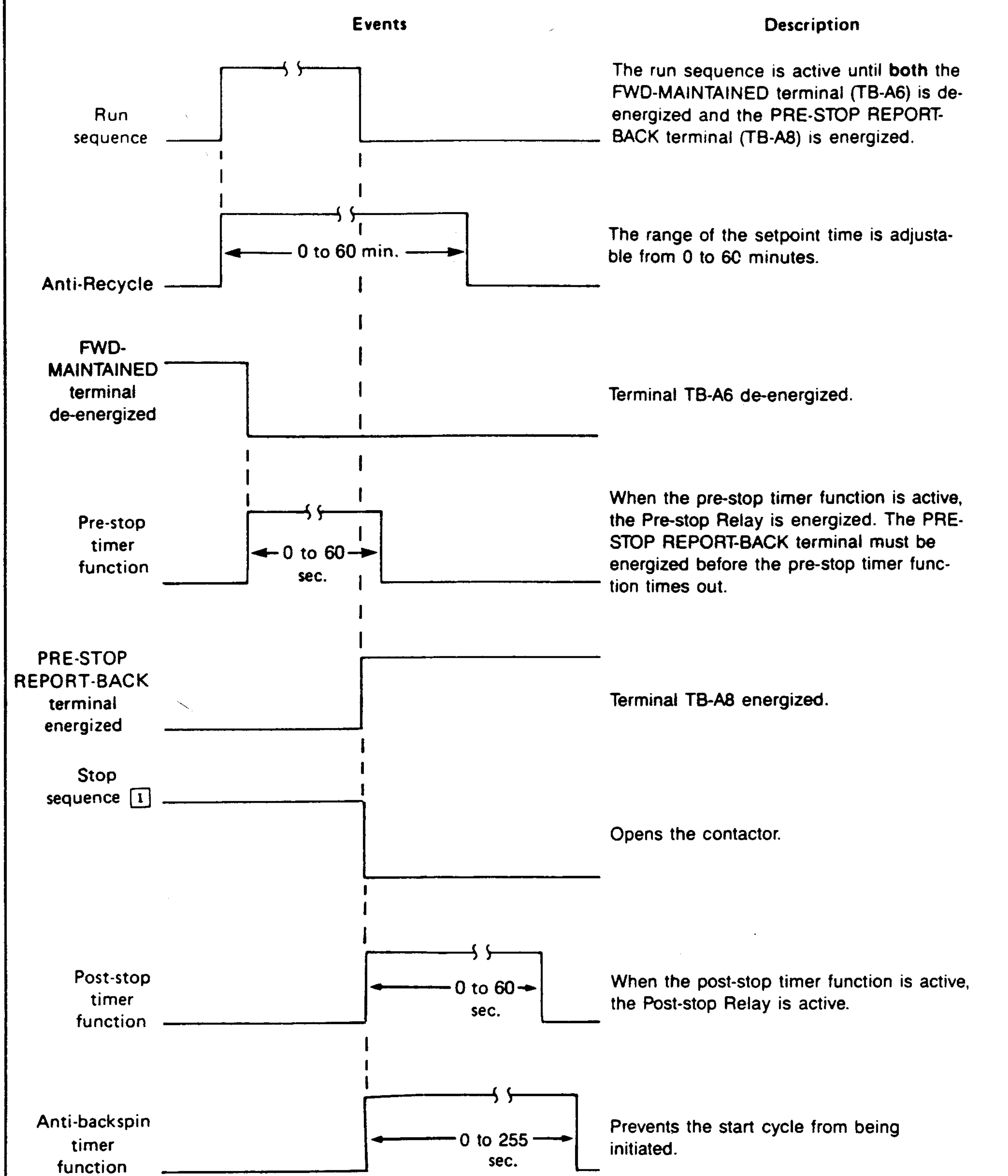
  Note, however, that the pre-stop timing function can be disabled if it is not required by the application. (See Paragraph 6.16)
- After the stop sequence is complete, the post-stop timing function is enabled. It is programmable from 0 to 60 seconds.
- A Pre-stop Relay is energized when the pre-stop timer setpoint function is active. It may be used to control auxiliary functions such as disabling a load, closing a valve, etc.
- The Post-stop Relay is energized while the post-stop timing function is active. Typically, it is used to control such auxiliary functions as in stepping or process controls, to disable the next sequence or function in the process.
- The ANTI-BACKSPIN timer function prevents the initiation of a new start cycle until the programmed duration has timed out. It is assumed that during the programmed duration between 0 and 255 seconds the motor's reverse rotation will come to a full stop. Note, however, that the anti-backspin timer function can be disabled if it is not required. (See Paragraph 6.18.)
- The ANTI-RECYCLE prevents a motor restart for the period of time programmed in minutes. It prevents restarting of the motor whether or not the start cycle was completed. Its timing function starts at the beginning of the motor run sequence.

**5.3 AC Line Interruptions** — The IQ-2000 is designed to operate in a controlled and predictable manner during incoming AC line interruptions. The events flow chart shown in Figure 5.9 lists the predictable events which occur during various AC line interrupts for an Ampgard starter. The times may vary when other types of motor starters are used. The chart assumes a complete, or nearly complete, loss of AC power. (For situations where AC power is low but present, refer to Paragraph 6.20, undervoltage setpoint function.)

**5.4 Control Signal Wiring** — The IQ-2000 communicates with the motor, contactor and associated machine or process through the following:

- Sensing inputs from the ground, current and optional potential transformers supplied by Westinghouse and, if used, shown on the Ampgard schematic.
- Discrete inputs from devices such as pushbuttons or relay contacts.
- Outputs in the form of relay contacts from the IQ-2000. (These include the Post-stop and Pre-stop Relays.)
- Outputs in the form of contacts of the main contactor and interlock contacts.

**5.4.1 Discrete Inputs** — The discrete input terminals are designed to receive 120 VAC from such devices as switches, pushbuttons, relay contacts, etc. (The majority of these are on TB-A. See Figure 3.6.) The characteristics of these input circuits are listed in Table 5.A. The control step-down transformer supplying 120 VAC is shown on the Ampgard schematic.




[1] The motor stop "sequence" is initiated when the PRE-STOP REPORT-BACK terminal is energized. The stop "cycle" includes the time from the de-energizing of the FWD/SLOW FWD-MAINT. terminal (TB-A6).

**Figure 5.7 — Motor Stop Cycle Events Diagram**

> NOTE
>
> Momentary contacts **must** remain closed for a minimum time of 17 cycles in order to be sensed by the IQ-2000. This duration allows a distinction to be made between electrical noise and an actual 60-Hertz input signal.

A description of each discrete input is shown in Table 5.B. Note that the inputs used for motor control are further described in Table 5.C. Depending on the specific starter class, these contacts can initiate movements indicated in the table.

**5.4.2 Output Contacts** — The IQ-2000's output contacts can in general be divided into the following groups:

- Relays C1 thru C4, which are contained on the Processor Module. When the IQ-2000 is supplied in an Ampgard starter, the C1 thru C4 relay contacts are pre-wired by Westinghouse to the interposing relays contained on the draw-out panel.
- Spare interposing relay interlock contacts. These are wired to the machine or processed through the TB terminal block as shown on the Ampgard Schematic for each IQ-2000.

  These contacts are rated for 120 VAC at 10 amperes, or 28 VDC at 6 amperes.
- Miscellaneous control function relay contacts such as the Pre-start Relay's Form C contacts. A complete list of these is shown in Table 5.D.

  These contacts are rated for 120 VAC at 10 amperes, or 28 VDC at 6 amperes.

**Table 5.B**

**INPUT TERMINAL DESCRIPTION**

| Terminal | Designation | Description |
|---|---|---|
| TB-A21 | E-STOP | Hard-wired to the lock-out stop/reset switch. It is used to inform the IQ-2000 when a lock-out stop is initiated. Highest priority in IQ-2000 logic. |
| TB-A9<br>TB-A3<br>TB-A6<br>TB-A5 | FWD/SLOW FWD-MOM<br>RVS/SLOW RVS-MOM<br>FWD/SLOW FWD-MAINT.<br>RVS/SLOW RVS-MAINT. | See Table 5.C for a description of the input terminal functions as they relate to the various starter types. TB-A9 and TB-A3 are used only as shown in Figure 5.8. |
| TB-A8 | PRE-STOP REPORT-BACK | Optionally used during the motor stop cycle to enable the stop sequence. Requires 120 VAC signal to enable. (See Par. 5.2.3 for details.) |
| TB-A7 | RUN ENABLE | Must be energized to allow the start cycle. If de-energized, the stop cycle will be initiated. Used only as shown in Figure 5.8. |
| TB-A10 | PRE-START REPORT-BACK | Optionally used during the start cycle to enable the start sequence. Requires 120 VAC to signal enable. (See Par. 5.2.1 for details.) |
| TB-A12 | L ACCEL PERM | Optionally used during the start cycle. (See Par. 6.7.) |
| TB-A14 | INCOMPL SEQ REPORT-BACK | Optionally used during the motor starting sequence. If the incomplete sequence timing function is completed before this terminal is energized, the stop cycle is initiated. (See Par. 5.2.1 for details.) |
| TB-A13 | REMOTE TRIP | When energized with 120 VAC, the stop cycle is initiated, and REMOTE TRIP will be displayed in the FUNCTION window of the Operator Panel. |

**Table 5.C**

**MOMENTARY AND MAINTAINED INPUT TERMINALS**

| Input [2] Terminal | Designation | Starter Types/Input Terminal Function [1] 11-202 13-202 14-202 | 11-212 13-212 14-212 | 11-502 14-502 11-602 | 11-512 14-512 11-612 |
|---|---|---|---|---|---|
| [3] TB-A6 | FWD/SLOW FWD-MAINT. | Forward | Forward | Forward | Forward |
| [3] TB-A5 | RVS/SLOW RVS-MAINT. | - | Reverse | - | Reverse |
| [5] TB-A4 | | - | - | - | - |
| [4] TB-A9 | FWD/SLOW FWD-MOM | Forward | Forward | Forward | Forward |
| [4] TB-A3 | RVS/SLOW RVS-MOM | - | Reverse | - | Reverse |
| [5] TB-A11 | | - | - | - | - |

[1] See Par. 6.28 for a description of starter classes.

[2] Momentary contacts must be closed for a minimum of 17 cycles to insure the command's acceptance.

[3] When a maintained-start input initiates the start cycle, the stop cycle is subsequently initiated when the maintained input is de-energized.

[4] When a momentary start input initiates the start cycle, the stop cycle must subsequently be initiated when the RUN ENABLE terminal (TB-A7) is de-energized. (Refer to Figure 5.8.)

[5] For future use.

**5.4.3 Interposing Relays** — The term "interposing relays," when used with the IQ-2000, refers to the relays located between:

- Output contacts of the IQ-2000 and the main contactor(s) of the motor starter
- Start/stop contacts or pushbuttons and the input terminals of the IQ-2000

When Westinghouse supplies the Ampgard starter, certain interposing relays are factory-wired, as listed in Paragraph 5.4.2.

For applications not factory-wired by Westinghouse, select industrial-type interposing relays using low-impedance coils such as Westinghouse Type BF or AR relays.

**CAUTION**

Use of high-impedance coil relays such as miniature plug-in type relays for interposing relays can result in the relay being unexpectedly energized. Personnel injury and/or equipment damage can result from unexpected or erratic interposing relay operation.

**5.5 Wiring Considerations** — A suitable wiring plan that shows the interconnection between the IQ-2000 and the associated machine or process must be developed. This paragraph contains general guidelines to be followed by the application engineer who is developing a specific wiring plan. The Ampgard schematic developed by Westinghouse for each unique application shows the interconnection between the

Table 5.D

CONTROL FUNCTION RELAY CONTACTS

| Terminal | Function | Designation | Description |
|---|---|---|---|
| TB-A37<br>TB-A36<br>TB-A35 |  | Pre-start | The Pre-start Relay is energized when the pre-start timing function is active. (See Par. 5.2.1) |
| TB-A34<br>TB-A33<br>TB-A32 |  | Pre-stop | The Pre-stop Relay is energized when the pre-stop timing function is active. (See Par. 5.2.3) |
| TB-A28<br>TB-A27<br>TB-A26 |  | Alarm | The Alarm Relay is energized during any alarm condition — such as would occur when the programmed motor bearing temperature alarm setpoint value is exceeded. |
| TB-A25<br>TB-A24<br>TB-A23 |  | Trip [1] | The Trip Relay is actuated during any trip condition — such as would occur when the programmed winding temperature trip setpoint value is exceeded. |
| TB-A30<br>TB-A31<br>TB-A32 |  | Post-start | The Post-start Relay is energized after the post-start timing function is timed out (See Par. 5.2.1.) |
| TB-A40<br>TB-A39<br>TB-A38 |  | Post-stop | The Post-stop Relay is energized when the post-stop timing function is active. (See Par. 5.2.3.) |
| TB-B15<br>TB-B16<br>TB-B17 |  | E-stop [1] | The Emergency Stop Relay's normally open contacts are closed during normal running conditions. |

[1] The contacts of the Emergency Stop Relay TB-B15, -B16 and -B17 and the Trip Relay TB-A23, -A24 and -A25 are **FAIL SAFE**. They change position when power is applied. They drop open upon loss of power or trip condition.

NOTE

The control function relay contacts listed in Table 5.D offer a convenient means of monitoring the various operating states of the IQ-2000. These contacts can be hardwired into conventional relay control wiring schemes. Also, any of these contacts can be wired as inputs to a programmable controller in order to be examined in that unit's ladder diagram program.

IQ-2000 and the Ampgard Starter. It also defines which control inputs and outputs are available. (Refer to Figure 3.1, which shows a **typical** Ampgard Schematic.)

When other types of motor starters are used with the IQ-2000, a drawing equivalent to the Ampgard schematic must be devised.

All wiring must be in conformance with the National Electrical Code as well as any other applicable state and/or local codes.

**5.5.1 RTD Wiring** — If the optional RTD Module is used, it must be wired as shown in Figure 5.10. Also, note the following requirements:

- Use 10-ohm copper, 100-ohm platinum, or 120-ohm nickel RTD device. The RTD type must be specified at the time of order.
- Use AWG No. 18 3-conductor, stranded, twisted, copper wires, such as Belden No. 8770, or equivalent.
- At the RTD, 2 return lines must be wired together, as shown in Figure 3.3.
- In cases where the motor provides only 2 leads from the RTD, connect 2 of the 3 conductor wires together at one of the leads. Make this connection as close to the RTDs as possible. (See Figure 3.4.) If only 2 wire leads are connected between the motor and the IQ-2000, the IQ-2000 will not function properly.
- The cable's shield and drain wire must be connected to the appropriate terminal on the RTD Module. At the op-

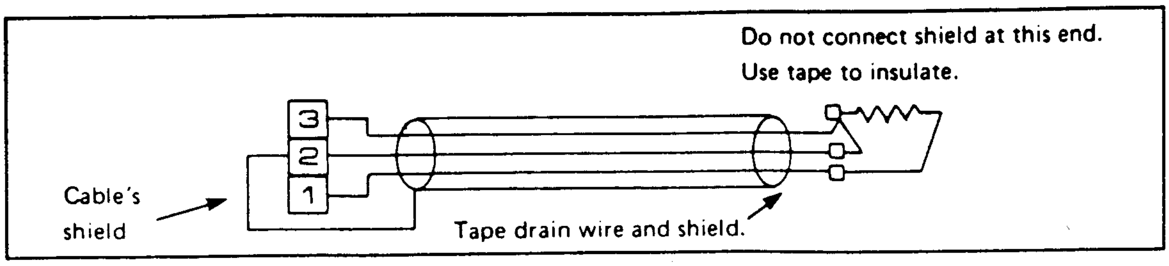



**Figure 5.10 — RTD Wiring**

posite end cut the shield and drain wire short, and tape them to prevent shorts. **Do not** connect these at the RTD device end.

- In cases where one or more of the 10 possible RTDs is/are not used, it is recommended to jumper out each set of unused RTD inputs separately. For example, if the 2 load bearing RTD inputs are not used, jumper terminals 29, 30 and 31 together and separately jumper terminals 26, 27 and 28.

An RTD wiring diagram is shown in Figure 3.3.

**5.5.2 Grounding** — Observe these guidelines when planning grounding.

- It is necessary to place a suitable grounding electrode between the earth ground electrode (or plant ground bus) and the ground stud of the motor starter enclosure.
- The sizing and type of insulation for the AC supply line and grounding electrode conductor must be in conformance with the National Electrical Code.

A typical grounding plan is shown in Figure 3.5.

**5.5.3 Wire Routing** — Wire routing is divided into 2 types: high-voltage (440 VAC and higher) and low-voltage (120 VAC and VDC signals). Low-voltage tends to be control and RTD wiring. Note the following guidelines when developing a wire plan:

- **Separation.** Maintain a separation of at least 1½ to 2 ft. (45 to 60 cm) between high- and low-voltage conductors. **Never** route high- and low-voltage lines in the same raceway.
- **Low-Voltage Lines.** It is necessary to route the draw-out panel's low-voltage wiring so that it loops behind the panel when it is closed. (See Paragraph 3.3.1.)
- **High-Voltage Compartment. Never** route low-voltage wires through the high-voltage compartment. If, in extreme cases, it is necessary to do so, contact Westinghouse Control Division for information.

**5.6 Environmental Considerations** — Consideration must be given to the actual location of the Ampgrad/IQ-2000 enclosure in the plant. The Ampgard's operating ambient temperature range varies among applications. The IQ-2000 operates in a range between 0° and 55°C (32° to 131°).

The IQ-2000's circuit boards are Conformal-coated to withstand environmental contaminants. However, special precautions may be required for extremely dirty or corrosive environments. (Consult Westinghouse Control Division's applications department.)

# Section 6

# SETPOINT VALUE CONSIDERATIONS

**6.0 General** —This Chapter contains information needed by an application engineer to organize the setpoint values for a specific IQ-2000 so that they may be easily entered. Twenty-eight separate functions are provided. (See Table 6.A which summarizes them and acts as a quick locator.) Since many of the functions have more than one associated value, it is strongly recommended that **all** the setpoints be established and verified **before** any entry is begun. To this end, a Setpoint Record Sheet is included here to act as a permanent record of the setpoint values. (See Table 6.B.) Copies of it can be made and stored in a number of locations, including the enclosure.

Not all setpoint functions or values may be required by a given IQ-2000. In such cases, perform one of the following:

- Place N/A or some other notation in the space if the value has no effect on operation. (For example, winding temperature when there is no RTD Module.)
- Write in the value — which is usually zero — required to disable the function. (If functions must be disabled, specific instructions are given in the following paragraphs.)

Those setpoint functions involving both the trip and alarm setpoint values will usually be different; however, they can be identical if the application requires it.

Note that the VALUES window does not provide a decimal point, as such. However, a solid line at the bottom of the display takes its place.

A copy of a correctly filled-in Setpoint Record Sheet must be given to the individual responsible for value entry. The IQ-2000 displays its setpoint functions in a fixed sequence that is duplicated on the Setpoint Record Sheet. Thus the sheet minimizes programming time. (Specific entry procedures are described in Paragraph 4.3.2.)

Each of the 28 setpoint functions is described separately in the following paragraphs.

To easily understand the timing functions explained between Paragraph 6.14 and 6.22, refer to Figure 5.6 where various timing diagrams of the motor starting events are shown in a consolidated form.

**Table 6.A**

**SETPOINT FUNCTION INDEX** [1]

| Setpoint | Par. | Page |
|---|---|---|
| Winding temperature | 6.1 | 44 |
| Motor bearing temperature | 6.2 | 45 |
| Load bearing temperature | 6.3 | 45 |
| Ground fault | 6.4 | 45 |
| Instantaneous overcurrent | 6.5 | 45 |
| Locked rotor current | 6.6 | 45 |
| Long acceleration | 6.7 | 48 |
| Jam | 6.8 | 48 |
| Underload start | 6.9 | 49 |
| Underload run | 6.10 | 49 |
| Ultimate trip | 6.11 | 49 |
| Overvoltage | 6.12 | 49 |
| Undervoltage | 6.13 | 49 |
| Pre-start timer | 6.14 | 50 |
| Pre-run timer | 6.15 | 51 |
| Pre-stop timer | 6.16 | 51 |
| Incomplete sequence | 6.17 | 51 |
| Anti-backspin | 6.18 | 53 |
| Anti-recycle, minutes | 6.19 | 53 |
| Time undervoltage | 6.20 | 54 |
| Post-start timer | 6.21 | 54 |
| Post-stop timer | 6.22 | 54 |
| Start counts/hours | 6.23 | 55 |
| Open/unbalance phase | 6.24 | 55 |
| Full-load current | 6.25 | 55 |
| Current transformer ratio | 6.26 | 56 |
| Potential transformer ratio | 6.27 | 56 |
| Starter class | 6.28 | 56 |

[1] See Table 6.B for programming information.

**6.1 Winding Temperature** — Only when the optional RTD Module is used in the IQ-2000 is the winding temperature function used. It provides the control with the ability to monitor the temperature of a motor's stator windings. The resulting information is used in determining the motor protection curve.

Individual setpoint values may be entered for both trip and alarm conditions. The function is displayed as WINDING TEMP.

The ranges of values are:

- Trip: 0° to 199°C
  (in 1° increments)
- Alarm: 0° to 199°C
  (in 1° increments)

**6.2 Motor Bearing Temperature** — Only when the optional RTD Module is used and when motor bearing RTDs are supplied is the motor bearing temperature setpoint function used. It provides the control with the ability to monitor the temperature of the bearings.

Setpoint values may be enetered for both trip and alarm conditions. The function is displayed as MOTOR BGR TEMP.

The ranges of values are:

- Trip: 0° to 199°C
  (in 1°C increments)
- Alarm: 0° to 199° C
  (in 1°C increments)

**6.3 Load Bearing Temperature** — Only when the optional RTD Module is used and when the load bearing RTDs are supplied is the load bearing setpoint temperature function used. It provides the control with the ability to monitor the temperature of the load bearings.

Setpoint values may be entered for both trip and alarm conditions. The function is displayed as LOAD BGR TEMP.

The ranges of values are:

- Trip: 0° to 199°C
  (in 1°C increments)
- Alarm: 0° to 199°C
  (in 1°C increments)

Note: when the RTD Module is installed but no external connections are made to it, the IQ-2000 functions properly even without RTD data at the unused terminals. The same is true of cases where some of the terminals are unused. Note: It is, however, recommended to jumper out unused RTD Module terminals, as described in Paragraph 5.5.1.

**6.4 Ground Fault** — The ground fault setpoint function monitors the ground leakage current and compares it with user-programmed setpoints for both amount and time. The ground fault protection function requires a ground fault (zero sequence) transformer be installed in a grounded system where the secondary of main power transformer feeding the motor is wired in a wye grounded configuration.

Setpoint values may be entered for trip, alarm and time conditions. The function is displayed as GROUND FAULT.

The ranges of values are:

- Trip: 4 to 12 amperes
  (in 1 amp increments)
- Alarm: 0 to 12 amperes
  (in 1 amp increments)
- Time: 0 to 5 seconds
  (in 1 sec. increments)

Ground fault trip conditions can be initiated by motor-suppression devices or power factor-correction devices. Capacitors in these devices offer low impedance to the voltage when it is first applied to the motor. Increase the ground fault setpoint, Time, as needed.

NOTE

With certain suppression or power factor correction devices-and-motor combinations, increasing the time setpoint will not eliminate the ground fault trip upon energization of the motor. In these cases disable the ground fault as directed by Westinghouse and use alternative ground fault detection external to the IQ-2000.

**6.5 Instantaneous Overcurrent** — The instantaneous overcurrent setpoint function provides the IQ-2000 with the ability to monitor motor current on a continuous basis. A trip condition is initiated when the actual current exceeds the programmed setpoint. The instantaneous overcurrent setpoint value must be set equal to, or higher than, 1.6 times the locked-rotor current ratio. A one-cycle "lockout" prevents nuisance trips becuse the control responds only after the second AC cycle when an overcurrent occurs.

A setpoint value may be entered only for a trip condition. The function is displayed as INST OVERCURRENT.

The available value range is:

- Trip: 300 to 1500% of full-load amperes
  (in 100% increments)

Note that only the digits 3 thru 15 are used to represent 300 thru 1500.

**6.6 Locked-Rotor Current** — The locked-rotor current setpoint function defines the amount of current and time that must elapse to initiate a trip condition.

Setpoint values must be entered for trip and time conditions. The function is displayed as LOCKED ROTOR CUR.

The ranges of values are:

- Trip: 300 to 1200%
  (in 10% increments)
- Time: 1 to 60 seconds
  (in 1 sec. increments)

Note that only the 3_0 thru 12_0 are shown on the display. A dash at the bottom between the numbers represents the trip range of 300 to 1200%. Also, these programmed values are used by the rotor temperature protection algorithm, as described in Paragraph 5.1.

Note that the maximum allowable stall current and time values **must** be obtained from the motor manufacturer.

**Table 6.B**

**SETPOINT RECORD SHEET**

Plant Designation: ________ End User: ________ Ampgard Schematic No.: (drawing number) ________ Motor Designation: ________

Plant Location: ________ OEM: ________ Motor Model No.: ________

| 1 | Setpoint Function | Trip 2 | Alarm 3 | Time 4 | Setpoint Value Ranges |
|---|---|---|---|---|---|
| 1 | WINDING TEMP 5 | | | | Trip & alarm: 0° to 199°C (1°C incre.) |
| 2 | MOTOR BGR TEMP 5 | | | | Trip & alarm: 0° to 199°C (1°C incre.) |
| 3 | LOAD BGR TEMP 5 | | | | Trip & alarm: 0° to 199°C (1°C incre.) |
| 4 | GROUND FAULT | | | | Trip: 4 to 12 amps primary circuit (1 amp incre.)<br>Alarm: 0 to 12 amps primary circuit (1 amp incre.)<br>Time: 0 to 5 sec. (1 sec. incre.) |
| 5 1 | INST OVERCURRENT | | | | Trip: 300 to 1500% of full-load amperes (in 100% incre.) Use numbers 3 to 15 only. |
| 6 1 | LOCKED ROTOR CUR | | | | Trip: 300 to 1200% (in 10% incre.) Use numbers 30 to 120 only. The decimal point here shown as: 3-0, 12-0<br>Time: 0 to 60 sec. (in 1 sec. incre.) |
| 7 | LONG ACCELERAT | | | | Time: 0 to 99 sec. (in 1 sec. incre.) |
| 8 | JAM | | | | Trip: 70 to 1200% of full-load amps (in 1% incre.) Use numbers 70 to 1200.<br>Time: 0 to 100 sec. (in 1 sec. incre.) |
| 9 | UNDERLOAD START | | | | Time: 0 to 100 sec. (in 1 sec. incre.) 6 |
| 10 | UNDERLOAD RUN | | | | Trip: 0 to 90% of full-load amps (in 1% incre.)<br>Time: 0 to 10 sec. (in 1 sec. incre.) |
| 11 1 | ULTIMATE TRIP | | | | Amp: 85 to 125% of full-load amps (in 1% incre.) 2 Use numbers 85 to 125 |
| 12 | OVERVOLTAGE 7 | | | | Trip: 0 to 9999 VAC (in 1 volt incre.)<br>Time: 0 to 99 sec. (in 1 sec. incre.) |
| 13 | UNDERVOLTAGE 7 | | | | Trip: 0 to 9999 VAC (in 1 volt incre.)<br>Time: 0 to 99 sec. (in 1 sec. incre.) |
| 14 | PRE-START TIMER | | | | Time: 0 to 255 sec. (in 1 sec. incre.) |
| 1 15 | PRE-RUN TIMER | | | | Time: 0 to 60 sec. (in 1 sec. incre.) |
| 16 | PRE-STOP TIMER | | | | Time: 0 to 60 sec. (in 1 sec. incre.) |
| 17 | INCOMPL SEQUENCE | | | | Time: 0 to 240 sec. (in 1 sec. incre.) |
| 18 | ANTI-BACKSPIN | | | | Time: 0 to 255 sec. (in 1 sec. incre.) |

(Cont'd.)

**Table 6.B**

**SETPOINT RECORD SHEET (Cont.)**

| [1] | Setpoint Function | Trip [2] | Alarm [3] | Time [4] | Setpoint Value Ranges |
|---|---|---|---|---|---|
| 19 | ANTI-RECYCLE, MIN | | | | Time: 0 to 60 min. (in 1 min. incre.) |
| 20 | TIME UNDER VOLT | | | | Time: 0 to 20 sec. (in 1 sec. incre.) |
| 21 | POST-START TIMER | | | | Time: 0 to 255 sec. (in 1 sec. incre.) |
| 22 | POST-STOP TIMER | | | | Time: 0 to 60 sec. (in 1 sec. incre.) |
| 23 | START COUNTS/HRS | | | | Counts: 1 to 10 counts (in 1 count incre.) [2]<br>Time: 0 to 24 hr. (in 1 hr. incre.) |
| 24 | OPEN/UNBALANCE PHASE | | | | Alarm: 5 to 30% of full-load amps (in 1% incre.)<br>Time: 0 to 25 sec. (in 1 sec. incre.) |
| [1] 25 | FULL LOAD CUR-A | | | | Amp: 1 to 1000 (in 1 amp incre.) [4] |
| 26 [1] | C. T. RATIO | | | | Ratio: 2, 4, 5, 8, 10, 15, 20, 30, 40, 50, 60, 80, 100, 120, 160, 200<br>(Where: 2 = 2:1, etc.) [4] |
| 27 | P. T. RATIO [7] | | | | Ratio: 0, 2, 4, 5, 20, 30, 35, 40, 55, 60, 70<br>(Where: 4 = 4:1, etc.) [4] |
| 28 [1] | STARTER CLASS | | | | Prefix in ALARM window: 11, 13, 14<br>Suffix in TIME window: 202, 212, 502, 512, 602, etc. |

[1] Some values must be assigned to the setpoint function in order to startup and run the motor.

[2] Normally the TRIP window represents the setpoint value. However with the start count/hrs. function, it represents counts in hours. With the ultimate trip setpoint function, it represents % of full-load amps.

[3] Normally the ALARM window represents the setpoint value. However with the starter class function, it represents the 2-digit prefix of the class.

[4] Normally the TIME window represents the setpoint value. However with the full-load current setpoint function, it represents current. With the control transformer and potential transformer functions, it represents a ratio. With the starter class, it represents the class suffix.

[5] Unless the optional RTD Module is installed, setpoints will have no effect.

[6] Although the underload start setpoint function involves a time value, it is entered with the underload run function. (See Paragraph 6.10.)

[7] Unless the optional Potential Transformer is used, setpoints must be set at 0.

CAUTION

The rotor temperature protection algorithm uses the maximum allowable locked-rotor current and time values to calculate the rotor temperature protection curve. Incorrect setpoint values can result in excessive rotor temperatures and motor damage.

**6.7 Long Acceleration** — The long acceleration setpoint function provides extended motor acceleration periods as may be necessary with certain motors where the allowable stall time is less than the normal acceleration time.

The function limits the motor temperature accumulator during the time value programmed. The accumulator is capped with a count of 1 less than the maximum value which will initiate a trip condition based upon the locked rotor current curve. When timed out, the accumulator is allowed to operate normally; that is, if the rotor's calculated temperature continues to increase, a trip condition occurs. An example of this is a condition of load current being higher than Full Load Amperes. If there is no raising (incrementing) of the temperature accumulator, normal operation will continue.

Note that before this function may be used, the manufacturer **must** confirm that the motor is capable of starting a load over a period of time.

The available value range is:

- Time: 0 to 99 seconds (in 1 sec. increments)

If this function is not used, zero **must** be entered as a time value. If the function is used, it must be initiated by a contact closure input to the L ACCEL PERM terminal (TB-A12). See Figure 6.1. The contact is typically an external zero-speed switch.

**6.8 Jam** — The jam setpoint function, active after the start cycle is completed, provides the control with the ability to initiate a trip condition if a jam occurs in the driven load. When the motor current exceeds the current setpoint value for the time value specified, the trip is initiated. This function is used due to the system's limitations.

Setpoints may be entered for trip and time conditions. The function is displayed as JAM.

The ranges of values are:

- Trip: 70 to 1200% of full-load amperes (in 1% increments)
- Time: 0 to 60 seconds (in 1 sec. increments)

Note that in this case the numbers 70 thru 1200 are used.

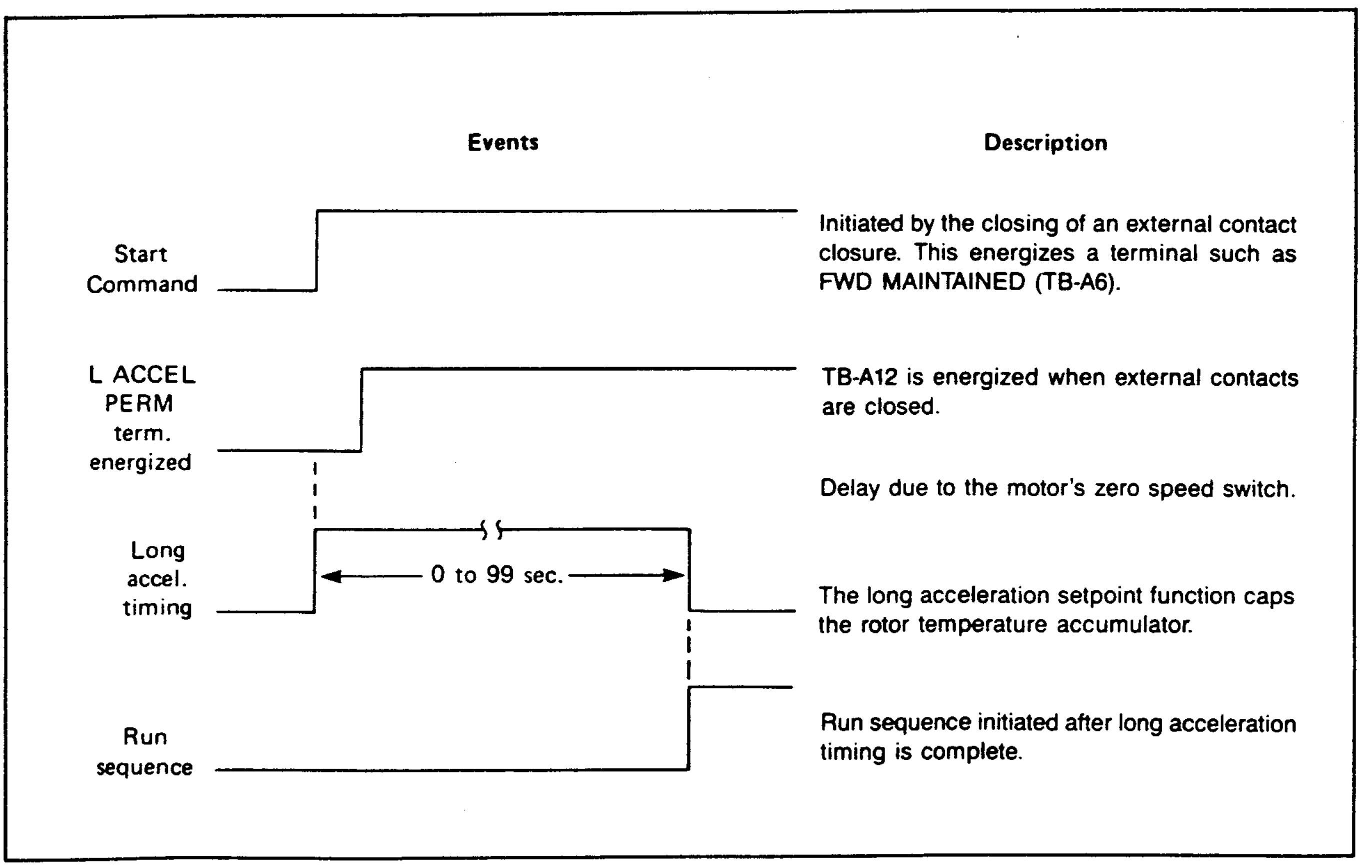



**Figure 6.1 — Long Acceleration Events Diagram**

When the jam setpoint function is other than 1200%, the prerun timer setpoint must be at least 2 seconds longer than the motor's acceleration time. Failure to set the PRE-RUN TIMER accordingly will initiate a jam trip condition, on start-up of the motor.

If this function is not required, set the trip setpoint value at 1200% for 2 seconds.

**6.9 Underload Start** — The underload start setpoint function "blocks," or disables, the underload run setpoint function from initiating a trip condition when starting a motor. The time period that the underload run tip is disabled is determined by this function's time setpoint value.

The available value range is:

- Time: 0 to 100 seconds (in 1 sec. increments)

The trip value is not entered here.

If it is desired to disable the underload start trip function, program a zero for this value.

**6.10 Underload Run** —The underload run function initiates a trip condition **after** the start sequence if the actual motor current drops below the ampere trip level for the programmed time value.

Setpoints may be entered for trip and time conditions. The function is displayed as UNDERLOAD RUN.

The ranges of values are:

- Trip: 0 to 90% of full-load amps (in 1% increments)
- Time: 0 to 10 seconds (in 1 sec. increments)

If it is desired to disable the underload run trip function, program a zero for the time value and set the trip value for 0%. This entry also disables the underload **start** function at the same time.

**6.11 Ultimate Trip** — The ultimate trip setpoint function defines a percent of full-load amperes that is allowed **before** a trip condition is initiated. In effect, this function modifies the motor's full-load ampere rating by a factor between 0.85 to 1.25. (See Paragraph 5.1.3.3 for details.) When this function's setpoint value is less than 100%, the permissible full-load ampere rating is less than 100%. Its setting selects the point where the $I^2T$ curve becomes asymptotic in cases where RTDs are **not** used.

Some possible reasons for a conservative approach where the ultimate trip is less than 100% are:

- When ambient temperatures above 40°C are anticipated and the optional RTD Module is **not** used in the application. (See Paragraph 5.1.3.6.)
- When the motor is properly rated, yet an additional safety factor is critical for the application.

A setpoint for % of full-load amperes is entered in the TRIP window. The function is displayed as ULTIMATE TRIP.

The available value range is:

- Amps: 85 to 125% full-load amps (in 1% increments)

In cases when a value from 101 to 125% is programmed, the permissible motor full-load amps will be greater than the programmed full-load current setpoint value. This can occur when the motor manufacturer's ultimate trip rating for the motor is above 100% of full-load amperes. The ultimate trip should be entered to correspond to the motor's service factor rating if service factor is to be utilized.

CAUTION

If the ultimate trip setpoint is set above 100% and the motor does not have a service factor rating higher than 1, motor damage can result.

**6.12 Overvoltage** — The overvoltage setpoint function initiates a trip condition if the incoming AC supply line voltage exceeds the programmed trip value for the programmed time.

The actual incoming AC supply voltage is reduced to 120 VAC by optional potential transformers which monitor this voltage. If these transformers are **not** installed, the overvoltage function is automatically disabled regardless of programmed values.

Setpoints may be entered for trip and time conditions. To avoid nuisance tripping, it is suggested that a setpoint value at least 10% higher than the nominal value be entered.

The function is displayed as OVERVOLTAGE.

The ranges of values are:

- Trip: 0 to 9999 VAC (in 1 volt increments)
- Time: 0 to 99 seconds (in 1 sec. increments)

**6.13 Undervoltage** — The undervoltage setpoint function initiates a trip condition if the incoming AC supply line voltage drops below the programmed trip value for the programmed time.

The actual incoming AC supply line voltage is reduced to 120 VAC by optional potential transformers which monitor this voltage. If these transformers are **not** installed, the undervoltage function is automatically disabled regardless of programmed values. Note: the IQ-2000 is activated by the stepdown control transformer. Regardless of the undervoltage setpoint, the motor will be stopped and the control will be automatically turned off when the line voltage drops below approximately 30% of the normal rating.

Setpoints may be entered for trip and time conditions. To avoid nuisance tripping, it is suggested to install a setpoint at least 25% lower than the nominal value.

The function is displayed as UNDERVOLTAGE.

The ranges of values are:

- Trip: 0 to 9999 VAC (in 1 volt increments)

- Time: 0 to 99 seconds
  (in 1 sec. increments)

Note: the undervoltage setpoint time must be set larger than the time delay undervoltage listed in Paragraph 6.20. If not, the undervoltage protection enters a trip and cannot be restarted without depressing the RESET pushbutton.

**6.14 Pre-start Timer** — The pre-start timer setpoint function, initiated at the beginning of a start cycle, provides a programmable period within which a report-back signal from a machine or process must be received at the PRE-START REPORT-BACK terminal (TB-A10). If the signal is not sensed within that time, the start cycle is aborted. This function provides a safety feature for auxiliary, but necessary, external events.

In terms of hardware, when a start comand, such as the FWD/SLOW FWD-MAINT. at TB-A6 occurs, the IQ-2000's Pre-start Relay is energized, and its contacts close. It remains energized as long as the pre-start timer function is active. (See Figure 6.2 and 5.6.) These contacts may be used to enable external functions such as lube oil flow, cooling or priming pumps.

A setpoint may be entered for the time duration. The function is displayed as PRE-START TIMER. During a pre-start condition in the run mode, this message also appears.

The available value range is:

- Time: 0 to 255 seconds
  (in 1 sec. increments)

In summary, the motor start sequence begins only when the following conditions exist:

- A pre-start timing function is active
- The PRE-START REPORT-BACK terminal (TB-A10) on the IQ-2000 is energized.

If these preconditions do not exist, the pre-start timer function times out, the start sequence never begins, and the message BAD START RESET is displayed.

If it is desired to disable the pre-start timer function, program a zero for the time value. It is also necessary to disable the PRE-START REPORT-BACK terminal (TB-A10) in order to prevent the aborting of the start cycle unnecessarily. As shown in Figure 3.6, a jumper must be placed between the PRE-

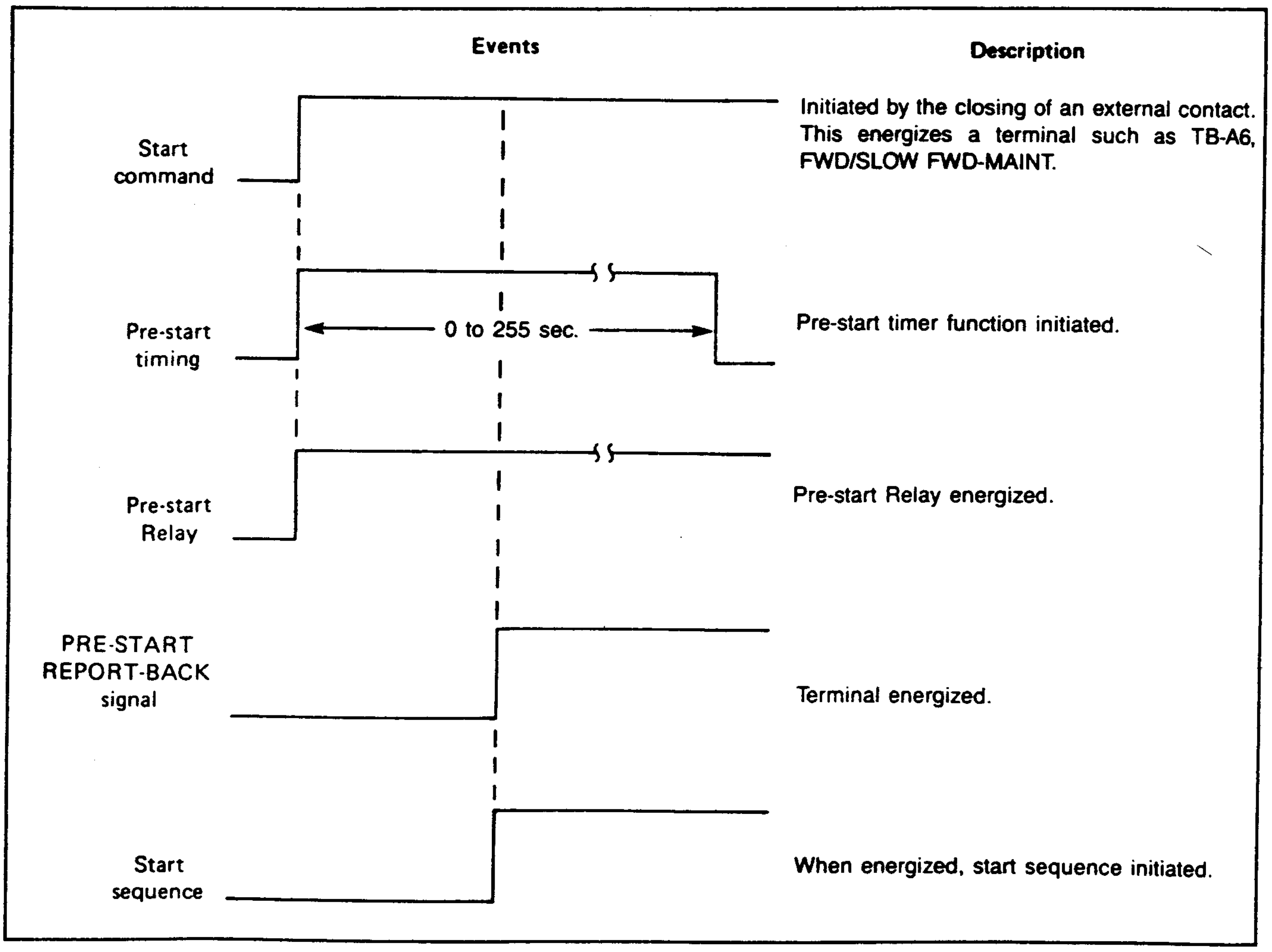



**Figure 6.2 — Pre-start Events Diagram**

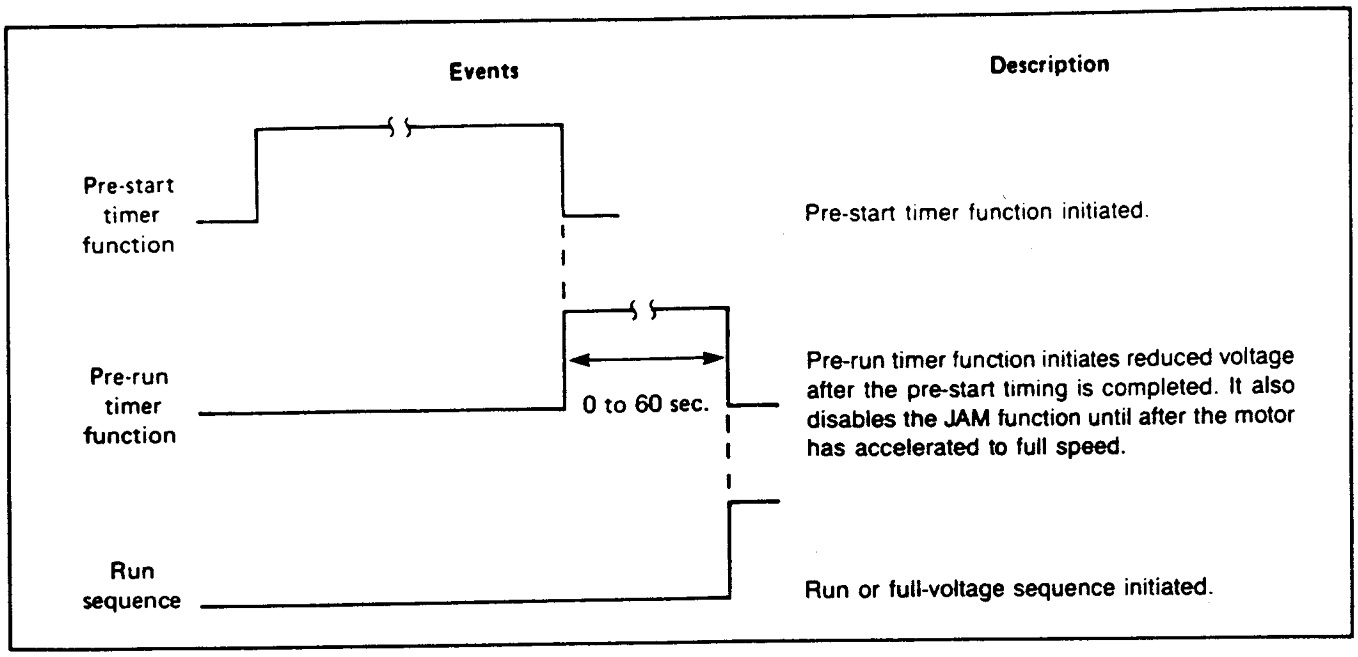



**Figure 6.3 — Pre-run Events Diagram**

START REPORT-BACK terminal (TB-A10) and the available 120 VAC.

Note: The 120 VAC is available at TB-19 with an Ampgard starter.

**6.15 Pre-Run Timer** — The pre-run timer setpoint function is used with multi-step starter applications — such as reactor or autotransformer type starters — to define the time that the intermediate or reduced-voltage contactor will be energized. This function is initiated during the start cycle immediately after the pre-start timer function has timed out. (See Figure 6.3 and 5.6.) After the pre-run timer function has timed out, the run (full-voltage) sequence begins. The pre-run timer function is also used in conjunction with the JAM FUNCTION. It disables the jam function until after the motor has accelerated up to full speed.

It is recommended that the pre-run timer be set at least 2 seconds longer than the motor takes to accelerate to full speed.

A setpoint may be entered for the time duration. The function is displayed as PRE-RUN TIMER. During a pre-run condition in the run mode, the message START SEQUENCE is displayed.

The available range is:

- Time: 0 to 60 seconds (in 1 sec. increments)

**6.16 Pre-stop Timer** — The pre-stop timer setpoint function, initiated after the stop command is received, can be used to control auxiliary functions during the stop sequence. For example, cooling pumps may be enabled or valves and louvers may be closed just **before** the motor turns off. As shown in Figure 6.4, the pre-stop timer function and the Pre-stop Relay are enabled when a stop command occurs.

When the PRE-STOP REPORT-BACK terminal (TB-A8) is energized, the stop sequence is initiated.

In terms of hardware, contacts of the Pre-stop Relay control the auxiliary functions. These contacts are enabled for the programmed time while the pre-stop timer function is in progress.

A setpoint value may be entered for the time duration. The function is displayed as PRE-STOP TIMER.

The available range is:

- Time: 0 to 60 seconds (in 1 sec. increments)

The operation of this function is influenced by the use of the PRE-STOP REPORT-BACK terminal (TB-A8). In some applications external field devices are connected to this terminal. In such cases, **after** the function is initiated, the pre-stop report-back signal must be received at terminal TB-A8. (See Figure 3.6.) In instances where the signal is not received, and the stop timing cycle is completed, the message BAD STOP RESET is displayed. Automatic restarting is inhibited. A manual reset must be performed after the cause of the problem is cleared. (Use the Operator Panel's RESET pushbutton.)

In Ampgard applications where the pre-stop report-back capability is not used, a jumper must be placed between terminal TB-16 and the 120 VAC available at terminal TB-15.

With starters other than Ampgard, the 120 VAC must be connected to the PRE-STOP REPORT-BACK terminal TB-A8.

If it is desired to disable the pre-stop function, program a zero for the time value.

**6.17 Incomplete Sequence** — The incomplete sequence setpoint function is applied during a start cycle. It initiates a stop cycle if, at the end of the programmed time, the report-back signal is not received at the INCOMPL SEQ REPORT-BACK terminal TB-A14. (See Figure 6.5.) Typical applications for this function include monitoring for critical associated conditions

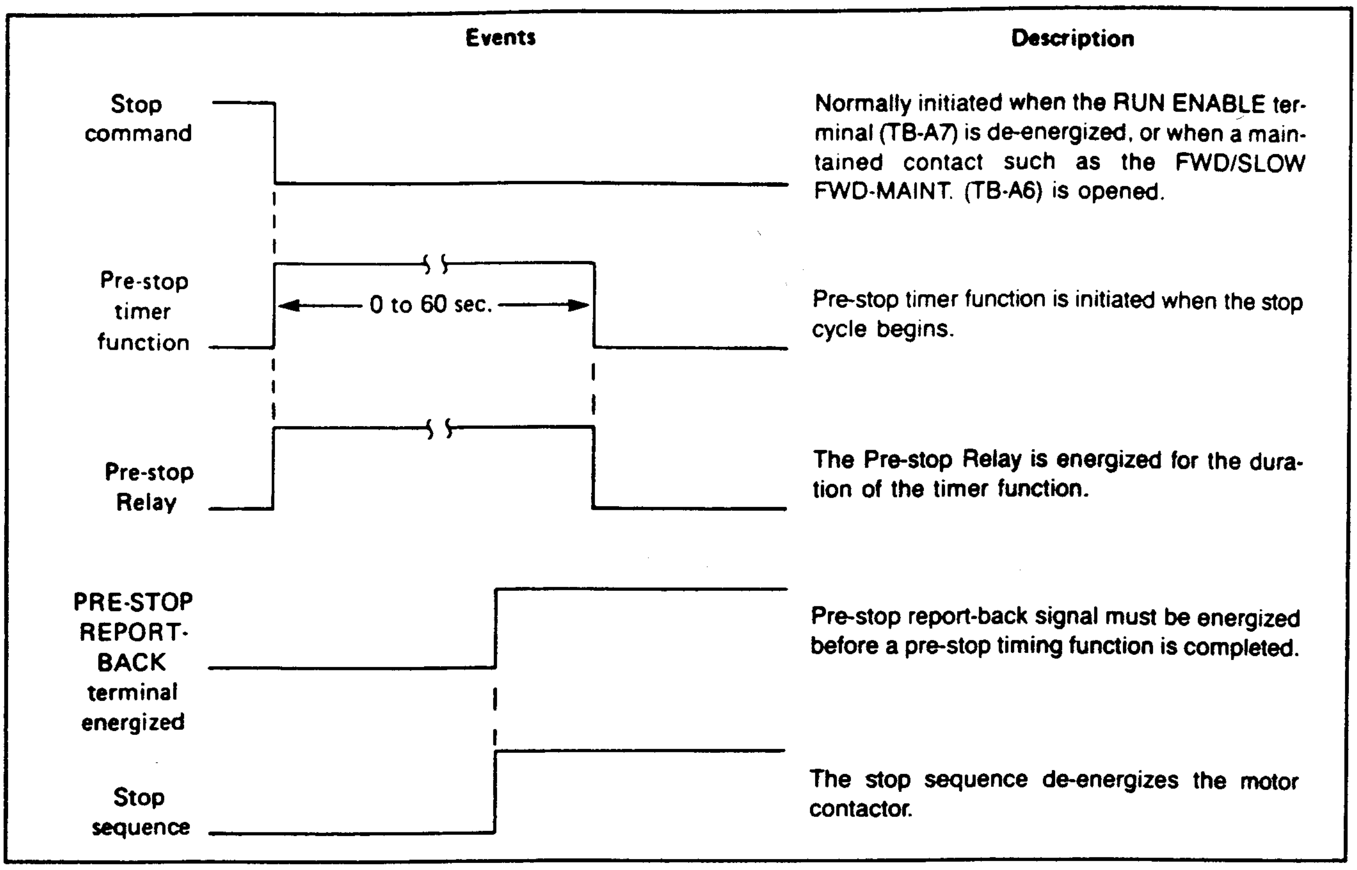



**Figure 6.4 — Pre-stop Events Diagram**

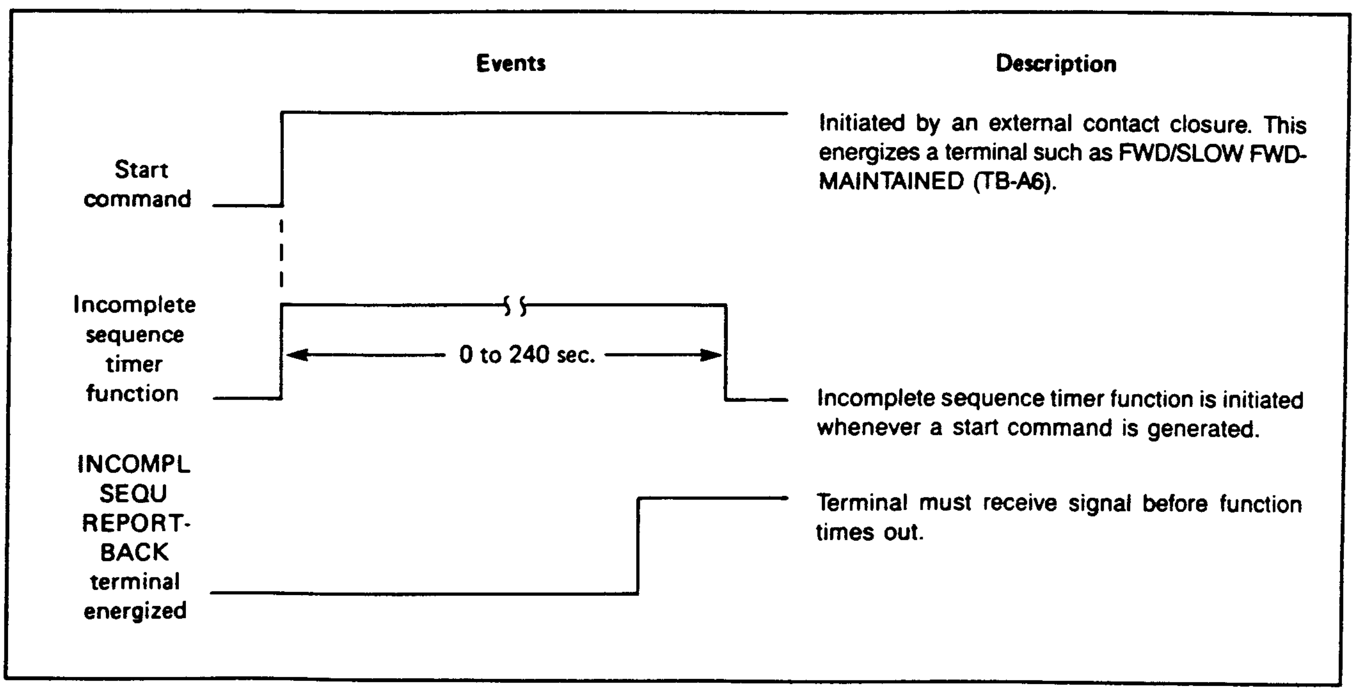



**Figure 6.5 — Incomplete Sequence Events Diagram**

such as field loss for synchronous machines or "tie-ins" with additional motors.

When used in conjunction with a synchronous motor protection, it is recommended that the time be set at least 2 seconds longer than the motor takes to synchronize.

A setpoint value may be entered for the time value. The function is displayed as INCOMPL SEQUENCE.

The available range is:

- Time: 0 to 240 seconds (in 1 sec. increments)

**NOTE**

**The INCOMPL SEQ REPORT-BACK terminal is monitored continuously by the IQ-2000. If the terminal is de-energized at any time after the incomplete sequence timer function times out, the stop sequence is initiated.**

If it is desired to disable the incomplete sequence function in Ampgard applications, a jumper must be placed between the INCOMPL SEQ REPORT-BACK terminal (TB-22) and the 120 VAC at TB-21. (See Figure 3.6.)

With starters other than an Ampgard, the 120 VAC must be connected to the INCOMP SEQ REPORT-BACK terminal TB-A14.

**6.18 Anti-backspin** — The anti-backspin setpoint function prevents a motor restart for the duration of the programmed time. The anti-backspin setpoint time is initiated immediately after the motor's stop cycle is complete. This prevents attempting to start the motor while it is rotating in a reverse direction, as may be caused by certain types of loads. (See Figure 5.7.) A typical example is the backspin of a pump and motor caused by the descent of a column of water after pumping is terminated.

A setpoint may be entered for the time value. The function is displayed as ANTI-BACKSPIN.

The available value is:

- Time: 0 to 255 seconds (in 1 sec. increments)

If it is desired to disable the anti-backspin function, enter zero for the time value.

**6.19 Anti-recycle, Min** — The anti-recycle setpoint function prevents a motor restart for the duration of the programmed time. The function begins timing when the motor's start cycle is complete. The function is used to prevent:

- Jogging or other rapid restarts that could inadvertently occur
- Restarting of the motor whether or not the start cycle was completed

A setpoint may be entered for time duration. The function is displayed as ANTI-RECYCLE, MIN.

The available range is:

- Time: 0 to 60 minutes (in 1 min. increments)

Note: this is the only IQ-2000 setpoint timing function which is in minute increments.

If it is desired to disable the anti-recycle function, enter zero for the time value.

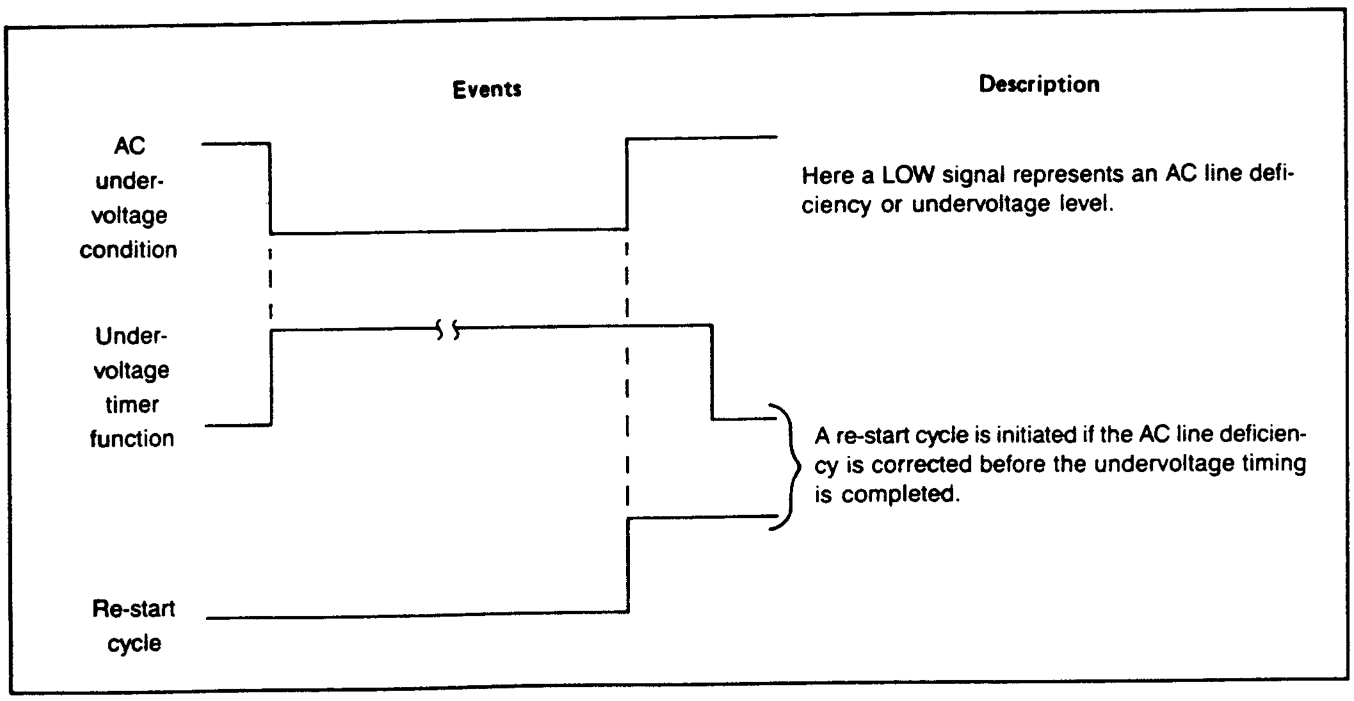



**Figure 6.6 — Time Undervoltage Timing**

**6.20 Time Undervoltage** — The time undervoltage function provides the capability to initiate a start cycle after the incoming AC supply is interrupted — that is, drops below 70% of the normal voltage. If the incoming AC supply is restored before the time undervoltage setpoint time has elapsed, a start cycle is initiated. This is utilized with a 3-wire momentary contact START/STOP pushbutton application, as shown in Figure 5.8. The time undervoltage timing is shown in the diagram of Figure 6.6.

NOTE

The time undervoltage function is inactive and cannot be used with a maintained-contact start control application such as the one shown in Figure 3.6.

The AC line undervoltage time setpoint must be programmed longer than the time undervoltage setpoint as described in Paragraph 6.13.

A setpoint may be entered for time duration. The function is displayed as TIME UNDER VOLT.

The available range is:

- Time: 0 to 20 seconds (in 1 sec. increments)

If it is desired to disable the timer undervoltage function, enter a zero for the time value.

**6.21 Post-start Timer** — The post-start timing setpoint function, initiated after the end of the pre-run sequence, can be used to enable auxiliary control functions **after** the sequence begins. (See Figure 6.7.) For example, a load may be increased on a motor; another motor may be enabled; or, in stepping or process control applications, the next step in the process may be enabled.

In terms of hardware, the Post-start Relay is energized to control the auxiliary functions. These contacts are energized after the post-start timer function is complete.

A setpoint may be entered for the time value. The function is displayed as POST-START TIMER.

The available value range is:

- Time: 0 to 255 seconds (in 1 sec. increments)

If it is desired to disable the post-start timer function, program a zero for the time value.

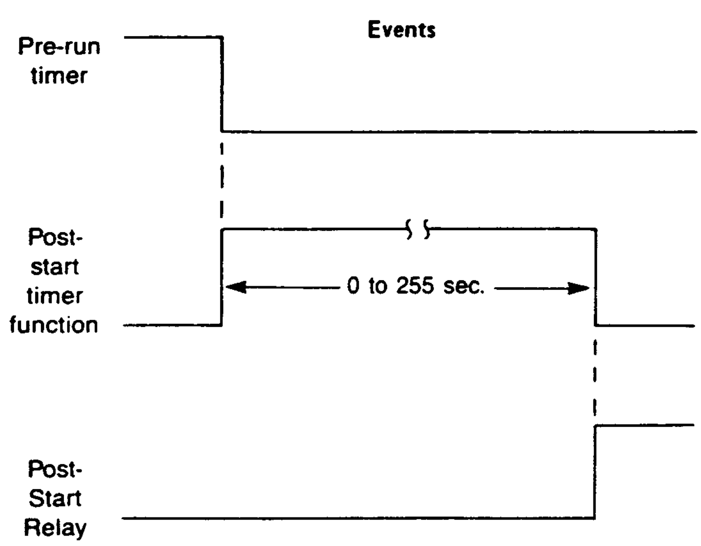
**6.22 Post-stop Timer** — The post-stop timer setpoint function, initiated immediately after the stop sequence is complete, can be used to disable auxiliary functions **after** the sequence. (See Figure 6.8.) For example, cooling pumps and other motors may be controlled. In process control, the next step in the process may be disabled.

In terms of hardware, the Post-stop Relay is energized to control the auxiliary functions.

A setpoint may be entered for the time value. The function is displayed as POST-STOP TIMER.

The available value range is:

- Time: 0 to 60 seconds (in 1 sec. increments)




**Description**

The pre-run timing diagram is shown in Figure 6.3. The pre-run timer function is used with multi-step starter applications and the JAM function. The post-start timer function begins when the pre-start timing is completed.

Post-start timer function begins.

Relay energized at the end of the post-start timing period.

[1] The start sequence can also be initiated when a maintained input such as the FWD/SLOW FWD-MAINT terminal (TB-A6) is energized.

**Figure 6.7 — Post-start Events Diagram**

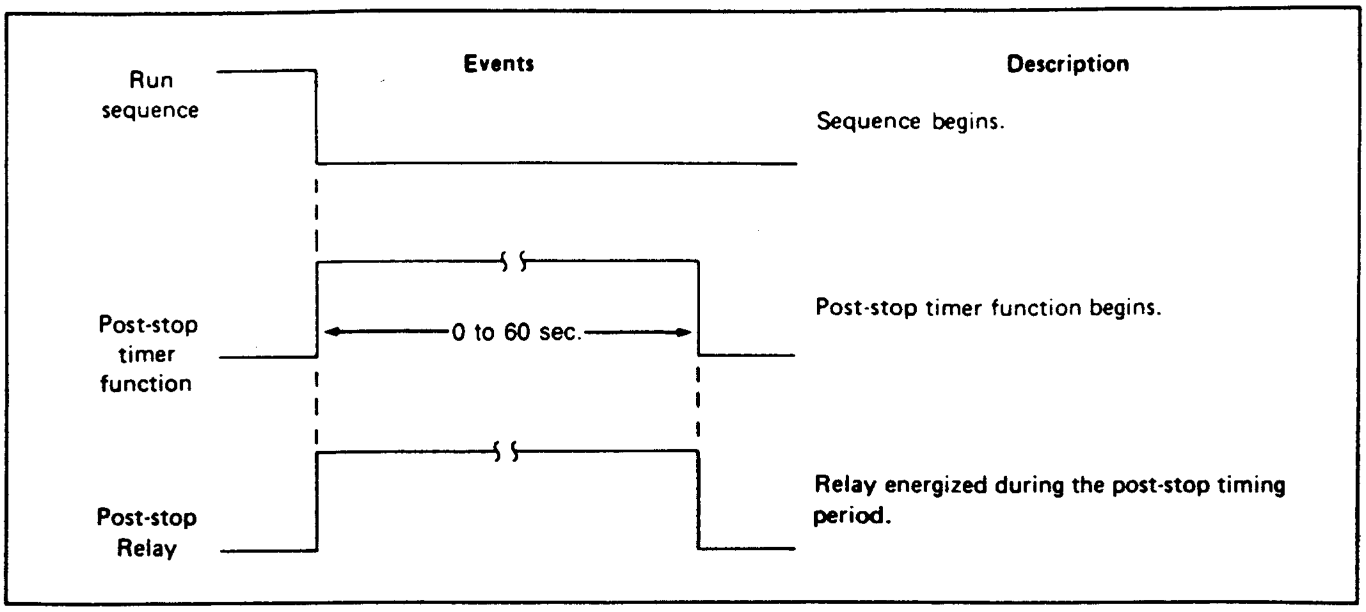



**Figure 6.8 — Post-stop Events Diagram**

If it is desired to disable the post-stop timer function, program a zero for the time value. (This action also disables the Post-stop Relay.)

**6.23 Start Counts/Hours** — The start counts/hours setpoint function limits the number of motor starts over a programmed period of time. If the number of starts within a period exceeds the setpoint, a new start cycle is inhibited until the programmed period has elapsed. Note that the function is programmed in hours, but displayed in minutes. When the limit is exceeded, the Operator Panel will display TOO MANY STARTS WAIT X MIN. Here, X is the number of minutes before a start cycle can be initiated. After the elapsed time a new start command can reinitiate a start cycle.

Setpoint values may be entered for counts and time. (The counts are entered in the TRIP window.) The function is displayed as START COUNTS/HRS.

The ranges of values are:

- Counts: 1 to 10 (in 1 count increments)
- Hours: 0 to 24 (in 1 hour increments)

If it is desired to disable the start counts/hours function, program a zero for the time value.

**6.24 Open/Unbalance Phase** — The open/unbalance phase setpoint function monitors for possible current phase unbalance of the actual motor currents. If this factor exceeds the setpoint values for the programmed time, the red ALARM LED on the Operator Panel flashes and a warning message is displayed.

(This function, however, does not cause a trip condition since the phase unbalance is already incorporated into the motor rotor protection algorithm. Should the calculated temperature become too high due to a combination of current and phase unbalance, the trip condition results, LOCKED ROTOR CUR.)

Setpoint values may be entered for the unbalance and time values. (The unbalance value is entered in the ALARM window.) The function is displayed as OPEN UNBALANCE PHASE.

The available ranges are:

- Unbalance phase: 5 to 30% of full-load motor current (in 1% increments)
- Time: 0 to 25 seconds (in 1 sec. increments)

To avoid nuisance alarming, it is recommended that the open/unbalance phase time setpoint be set one second longer than the accelerating time of the motor.

**6.25 Full-load Current** — The full-load current setpoint function monitors for the maximum continuous RMS current that can be permitted in the motor stator. (This value is the motor manufacturer's recommended full-load ampere rating.)

Primarily this function is used internally by the IQ-2000. There are no external reactions as the direct result of reaching the setpoint level. In the monitoring mode, actual current values are displayed in the VALUES windows; A, B and C each represent a single phase.

**CAUTION**

Many of the IQ-2000's protection functions, including the motor temperature protection algorithm, use the full-load current setpoint value to calculate the trip points. If this value is incorrect, motor damage can result.

A setpoint may be entered for the ampere value. (It is entered in the TIME window.) The display appears as FULL LOAD CUR-A.

The available range is:

- Amps: 1 to 1000 (in 1 amp increments)

**6.26 Current Transformer Ratio** — The current transformer (C.T.) ratio setpoint function defines the turns ratio of the C.T.

The turns ratio is entered in the TIME window, although only the first factor of the ratio is used. Thus the entry of 60 represents 60:1. The value is used internally by the IQ-2000, and thus there is no external reaction.

Available C.T. turns ratio setpoint values are:

| | | |
|---|---|---|
| 2:1 | 20:1 | 80:1 |
| 5:1 | 30:1 | 100:1 |
| 8:1 | 40:1 | 120:1 |
| 10:1 | 50:1 | 160:1 |
| 15:1 | 60:1 | 200:1 |

The turns ratio for the C.T. is listed on each application's Ampgard Schematic or outline. (See Paragraph 3.1.) A current transformer with a 5-ampere secondary is always used with the IQ-2000. Thus a 300:5 turns ratio requires a setpoint value of 60:

$$\frac{300}{5} = 60$$

Refer to the wiring plan drawings for the C.T. ratio in those applications using starters other than an Ampgard. If the current transformer must be selected, use the following criteria:

- At 100% full-load amps, the secondary of the C.T. must deliver from 2.5 to 5 amps
- Select the C.T. which supplies at close to 3.75 amps as possible at 100% full-load amps.

For example, assume an application where the motor starter delivers 300 full-load amps. A 400:5 primary-to-secondary ratio will deliver:

$$300 \times \frac{5}{400} = 3.75 \text{ amps}$$

This is within the recommended range of from 2.5 to 5.0 amps. The C.T. ratio for this example would be 80:1 (that is, 400:5).

**CAUTION**

Be careful when determining the C.T. turns ratio. An improper value can cause the IQ-2000 to receive incorrect motor current data. Motor damage could result.

**6.27 Potential Transformer Ratio** — The potential transformer (P.T.) ratio setpoint function defines the turns ratio of the optional P.T.

The turns ratio is entered in the TIME window, although only the first factor of the ratio is used. Thus the entry of 35 represents 35:1. This value is used internally by the IQ-2000, and thus there is no external reaction.

Available P.T. turns ratio setpoint values are:

| | |
|---|---|
| 0:1 | 35:1 |
| 2:1 | 40:1 |
| 4:1 | 55:1 |
| 5:1 | 60:1 |
| 20:1 | 70:1 |
| 30:1 | |

The turns ratio of the P.T. is chosen so that the rsulting secondary voltage equals 120 VAC. Thus a line voltage of 4200 requires a 35:1 ratio:

$$\frac{4200}{120} = 35$$

If a potential transformer (P.T.) is not used, program a zero in the TIME window.

**6.28 Starter Class** — The starter class setpoint function determines the actual cycling of the motor contactor(s). A total of 16 different starter classes, as listed in Table 6.C, may be chosen. Each class requires that 2 values be entered in different windows. The values are simply the class designation. For example:

11-202

ALARM window ← 11 | 202 → TIME window

The alphabetical letter preceding the STARTER CLASS depicts the firmware revision. (To be used in any correspondence with Westinghouse.)

Keep in mind that the IQ-2000 enables the motor contactor(s) by means of interposing relays. It makes use of some or all of relays C1 thru C4. Contacts from each of these relays are wired to the coil of an interposing relay. (See Figure 6.9.) These, in turn, are wired to the main contactor(s). Selecting the starter type determines the operations of the contactor(s). Table 6.D shows the relationship between each of the possible starter classes and relays C1 thru C4.

Table 6.C

STARTER CLASSES

| Starter Class | Description |
|---|---|
| 11-202 | Across-the-line, non-reversing |
| 11-212 | Across-the-line, reversing |
| 11-502 | Primary reactor, reduced-voltage, non-reversing |
| 11-512 | Primary reactor, reduced-voltage, reversing |
| 11-602 | Auto-transformer, reduced-voltage, non-reversing |
| 11-612 | Auto-transformer, reduced-voltage, reversing |
| 11-902 | Reserved for future use |
| 11-912 | Reserved for future use |
| 13-202 | Wound-rotor, non-reversing |
| 13-212 | Wound-rotor, reversing |
| 14-202 | Synchronous, full-voltage, non-reversing |
| 14-212 | Synchronous, full-voltage, reversing |
| 14-502 | Synchronous, primary reactor, reduced-voltage, non-reversing |
| 14-512 | Synchronous, primary reactor, reduced-voltage, reversing |
| 14-602 | Synchronous, auto-transformer, reduced-voltage, non-reversing |
| 14-612 | Synchronous, auto-transformer, reduced-voltage, reversing |

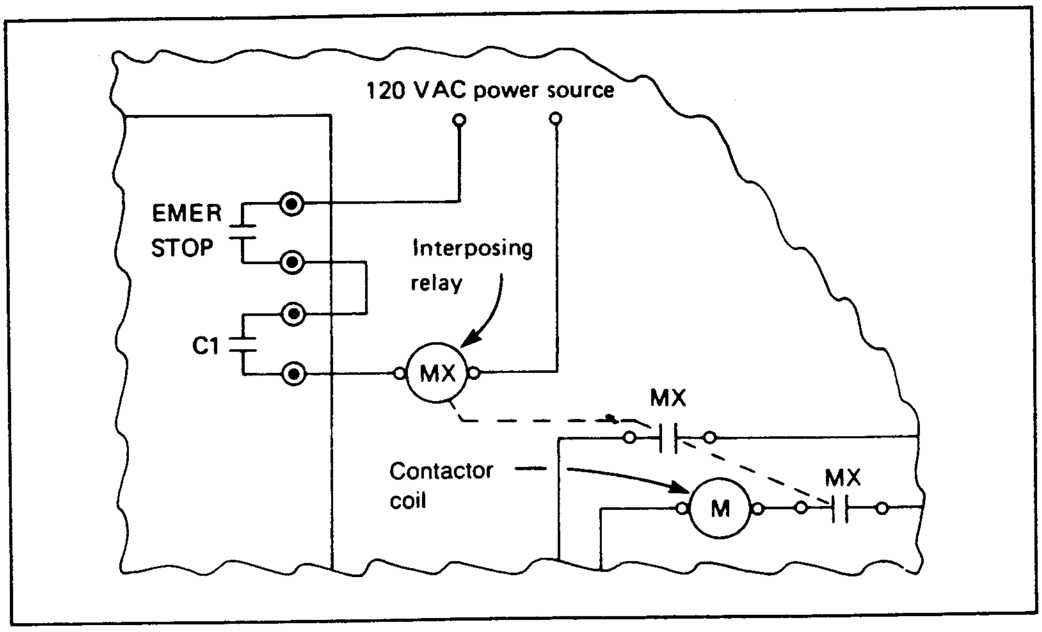



Figure 6.9 — Interposing Relay Wiring (typical)

Table 6.D

RELAY C1 THRU C4 FUNCTIONS

| Starter Class | C1 | C2 | C3 [1] | C4 [2] |
|---|---|---|---|---|
| 11-202 | FWD | - | - | - |
| 11-212 | FWD | RVS | - | - |
| 11-502 [3] | FWD | - | FWD MOM | - |
| 11-512 [3] | FWD | RVS | FWD/RVS MOM | - |
| 11-602 [3] | FWD | - | FWD MOM | FULL VOLTAGE |
| 11-612 [3] | FWD | RVS | FWD/RVS MOM | FULL VOLTAGE |
| 11-902 [4] | - | - | - | - |
| 11-912 [4] | - | - | - | - |
| 13-202 | FWD | - | - | - |
| 13-212 | FWD | RVS | - | - |
| 14-202 | FWD | - | - | - |
| 14-212 | FWD | RVS | - | - |
| 14-502 [3] | FWD | - | FWD MOM | - |
| 14-512 [3] | FWD | RVS | FWD/RVS MOM | - |
| 14-602 [3] | FWD | - | FWD MOM | FULL VOLTAGE |
| 14-612 [3] | FWD | RVS | FWD/RVS MOM | FULL VOLTAGE |

[1] The closure time of the Forward Momentary (C3) relay is determined by the pre-run timer setpoint function. See Paragraph 6.15.

[2] The Post-start Relay, when used, is energized immediately after the pre-run timer function times out.

[3] When used with a reactor or autotransformer, the pre-run timer setpoint should be set 2 seconds longer than the longest possible time required for the motor to accelerate to full speed at reduced voltage. When the pre-run timer is completed, the starter switches from reduced voltage to full voltage.

[4] For future use.

Section 7

# MONITORING AND TROUBLESHOOTING

**7.0 General** — This Chapter is designed to assist maintenance personnel to carry out monitoring operations and troubleshooting procedures. It is divided into 2 general areas of information:

- Operator Panel monitoring procedures (Par. 7.1)
- Isolating a malfunction (Par. 7.2)

> DANGER
>
> All maintenance procedures **must** be performed only by qualified personnel who are familiar with the IQ-2000 and its associated controlled motor and machines. Failure to observe this caution can result in serious or even fatal personal injury and/or equipment damage.

> DANGER
>
> The following procedures at times involve working in equipment areas where the hazard of fatal electrical shock is present. Live parts are exposed. Personnel must exercise extreme caution to avoid injury, including possible fatal injury.

> CAUTION
>
> To avoid static discharge to internal components of the IQ-2000, always make contact with the metal shell of the IQ-2000's chassis before handling the Modules. In addition, avoid touching components in the IQ-2000 as much as possible. Failure to comply with this caution can result in damage to the IQ-2000.

All correspondence with Westinghouse, whether verbal or written, should include the "firmware revision" alphabetical letter preceding the STARTER CLASS setpoint display. This alphabetical letter appears in the FUNCTION window when the starter class setpoints are displayed, as described in Paragraph 7.1.2.

**7.1 Panel Operations** — The following functions are carried on by means of the Operator Panel:

- Normal operational reporting (Par. 7.1.1)
- Programming setpoint values (See Par. 4.3)
- Reviewing setpoint values (Par. 7.1.2)
- Monitoring electrical characteristics (Par. 7.1.3)
- Internal diagnostics (Par. 7.1.4)

**7.1.1 Normal Operational Reporting** — The FUNCTION window of the Operator Panel provides a reporting function that occurs during the normal operation of the IQ-2000. Commands such as START SEQUENCE and POST STOP are used to report the various sequences involved with starting, running and stopping the motor. Figure 7.1 shows the relationship among the displays and the various operations of the IQ-2000.

**7.1.2 Reviewing Setpoints** — The setpoint value reviewing operation allows maintenance personnel to observe programmed values while the IQ-2000 is in the run mode. This function gives maintenance personnel the ability to examine or determine setpoints without entering a cycle stop condition that shuts down motor operation. The following steps assume the keyswitch is in the RUN position.

**Step 1** — Depress the SET POINTS pushbutton. Then depress the STEP pushbutton. At this time WINDING TEMP is displayed in the FUNCTION window. (See Figure 7.2.) Also, all values related to this function are displayed.

**Step 2** — Depress the STEP pushbutton. The next setpoint function along with its value(s) will be displayed. (Functions appear in the same order as those listed in Table 6.B.)

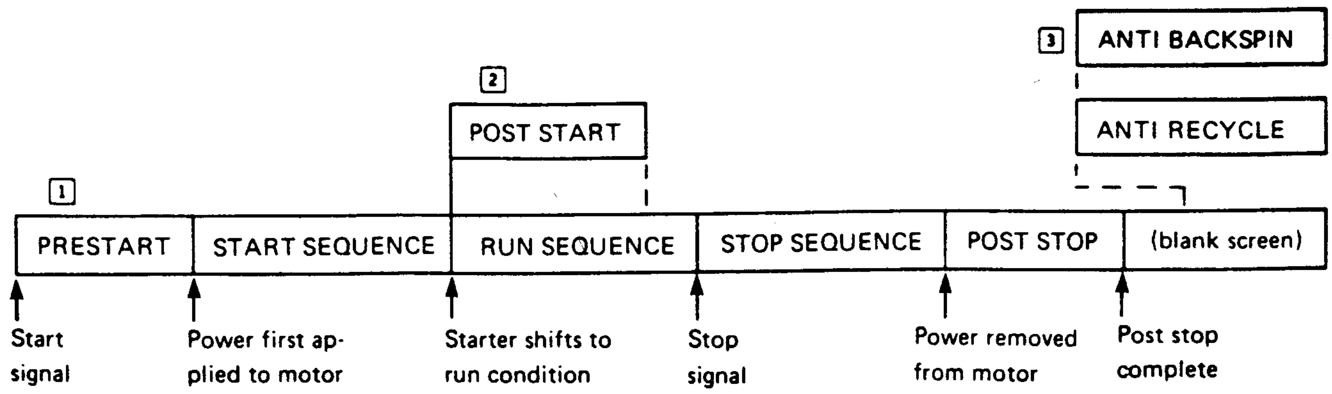
**Step 3** — Depress the STEP pushbutton repeatedly to sequence through the functions. (Note: if the STEP pushbutton is not depressed every 4 seconds, the reviewing operation automatically terminates. The display then returns to the message shown just before the reviewing of setpoints was begun.)

Note: setpoints can be reviewed "automatically"; each setpoint is sequentially displayed for 4 seconds, in the run mode. To initiate this automatic setpoint review:

- Depress the SET POINTS pushbutton
- Depress the CYCLE/SELECT pushbutton

When all the setpoints have been displayed once, the automatic sequencing will end. The FUNCTION window may then go blank. Depress the STEP pushbutton and the IQ-2000 will display the Monitoring Operation listed in Table 7.A.

**7.1.3 Monitoring Characteristics** — The electrical characteristics monitoring operation allows maintenance personnel/operators to observe selected parameters associated with




1 Messages—such as PRESTART, START SEQUENCE—for each of the conditions shown are displayed on the Operator Panel at the start and stop cycle times shown here.

2 POST START is displayed only if the post-start timer function is active, as described in Par. 6.21.

3 After the post stop timer function is complete, the FUNCTION window displays READY until the next start signal. The antibackspin or antirecycle condition occurs and the display is as shown if either of these functions, as defined in Par. 6.18 and 6.19, respectively, occurs.

**Figure 7.1 — Display/Run Sequence Relations**

the motor and motor starter. A listing and complete description of these electrical characteristics is given in Table 7.A.

> **NOTE**
>
> As long as the RESET pushbutton is not reset, the state of the metering functions just prior to the occurrence of the trip are retained by the IQ-2000 for diagnostic purposes. Even if AC power is removed, the last states of the metering functions are retained for a minimum of 12 hours, upon restoration of control voltage.

The metering functions are performed by the IQ-2000 as time permits in contrast to the almost instantaneous reponse to certain trip conditions such as:

- Instantaneous overcurrent
- Ground fault
- Emergency trip

For this reason the monitoring of the metering functions, such as % full-load amps and motor current, are performed as a secondary function when time permits. As a result, the metering function data retained may be the data which occurred between 2 and up to 10 seconds before the trip occurred.

The monitoring operation can be performed in one of 2 ways:

- **Manual Stepping.** Individual displays of electrical

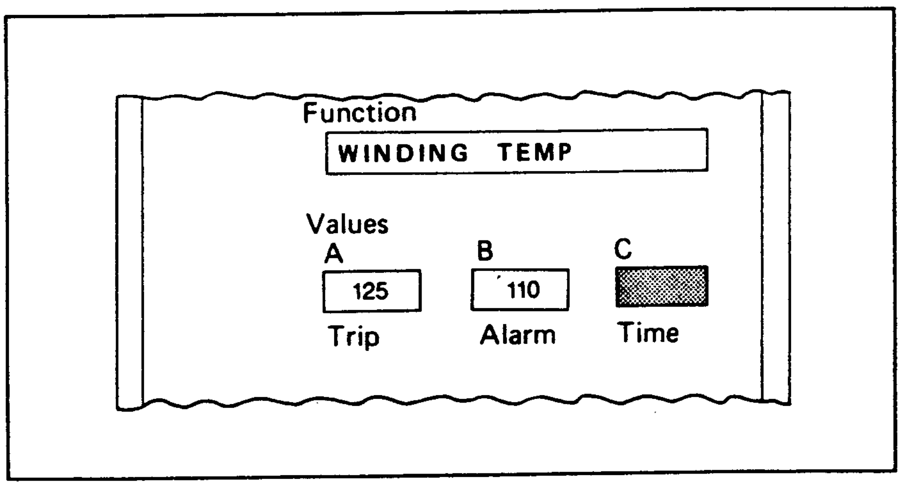



**Figure 7.2 — Reviewing Message**

Table 7.A

MONITORING OPERATION

| Function [1] | Description |
|---|---|
| LINE VOLTAGE [2] | All 3 phases are displayed in the A, B and C windows of the Operator Panel. |
| MOTOR CURRENT-A | All 3 phases are simultaneously displayed in the A, B and C windows of the Operator Panel. |
| MOTOR CURRENT-% | The percents of the full-load current of all 3 phases are displayed in the A, B and C windows of the Operator Panel. |
| GROUND CURRENT-A | The actual ground leakage current of a grounded wye system is displayed in amperes in the A window of the Operator Panel. |
| WINDING TEMP-C [3] | The highest reading from the 6 possible motor RTDs is displayed in the A window of the Operator Panel. |
| MOTOR BRG TEMP-C [3] | The readings from the 2 motor bearing RTDs is displayed in the A and B windows of the Operator Panel. |
| LOAD BRG TEMP-C [3] | The readings from the 2 load RTDs is displayed in the A and B windows of the Operator Panel. |
| KILOWATTS [2] | The actual kilowatts of power being used is displayed in the A window of the Operator Panel. |
| KILOVARS [2] | The instantaneous kilovars is displayed in the A window of the Operator Panel. Note: Kilovars is displayed as a negative value (with a - prefix) whenever the power factor is lagging. |
| POWER FACTOR-% [2] | The actual power factor, ranging from 0 to ±100%, is displayed in the A window of the Operator Panel. Note: When the power factor is lagging, the value displayed will be negative and the display will be prefixed with a dash symbol (-). |
| FREQUENCY-HZ | The frequency of the incoming AC line is displayed to the closest whole number of Hertz/second. |
| MEGAWATT HOURS [2] [4] | The actual megawatt hours total accumulated to date. This data is retrieved from a non-volatile memory storage area and displayed in the A window of the Operator Panel. |
| RUN TIME [4] | The actual run time of the IQ-2000 to date. This data is retrieved from a non-volatile memory storage area and displayed in the A window of the Operator Panel. |
| OPERATIONS-COUNT [4] | The total start cycles to date regardless of AC power interruptions. This data is retrieved from a non-volatile memory storage and displayed in the A window of the Operator Panel. |

[1] As displayed in the FUNCTION window of the Operator Panel.

[2] If the optional potential transformer (P.T.) is not present, zeroes will be displayed in the value windows.

[3] If the optional RTD Module is not present, zeroes are displayed in the value windows.

[4] These values are updated in non-volatile memory once each 24 hours. Note: the IQ-2000 must be on continuously (AC power applied) for a full 24 hours before the new information is stored.

characteristics can be manually called up and/or advanced according to the operator's needs. To initiate the characteristics display and to continue stepping through the list, depress the STEP pushbutton. (This assumes the run mode.)

- **Automatic Stepping.** All electrical characteristics can be displayed on a sequential basis. Each function is displayed for approximately 4 seconds. Once all functions have been shown, the automatic monitoring operation is terminated.

  To initiate this operation, depress the CYCLE/SELECT pushbutton. (This assumes the run mode.)

NOTE

The display of the starter class selection is preceded by an alphabetical character (displayed in the FUNCTION window). This is the firmware revision level. Always state this firmware revision level in any correspondence with Westinghouse.

**7.1.4 Internal Diagnostics** — The IQ-2000 performs an internal diagnostics check approximately every 2 minutes when the Keyswitch is in the RUN position. If a malfunction is detected during the diagnostic check, any of the following messages can be displayed in the FUNCTION window:

- ROM CKSUM ERROR
- CHECKSUM
- REPROGRAM EE ROM

Table 7.D contains the suggested corrective actions to be taken for each of the messages.

**7.2 Malfunction Isolation Of The Starter** — In the event that a malfunction occurs, certain troubleshooting procedures can be used to assist in localizing its cause. This troubleshooting approach is divided into 2 broad situations:

- Monitoring operations can be performed (Par. 7.2.1)
- Operator Panel is inoperative (Par. 7.2.2)

**7.2.1 Panel Operating** — The Operator Panel continues to operate after a trip, alarm or stop condition, and it can provide valuable information. Information obtained from it can be divided into 2 groups:

- Alarm conditions (Par. 7.2.1.1)
- Trip conditions (Par. 7.2.1.2)

**7.2.1.1 Alarm Conditions** — An alarm condition occurs when one of the electrical characteristics exceeds the programmed setpoint value. Note, however, that some alarm characteristics must exceed the setpoint value for a programmed time value **before** the alarm condition occurs.

When this condition happens, the red ALARM and SETPOINT LED lights. Also, a message is displayed in the FUNCTION window to assist with the isolation process. If the application has external devices connected with the IQ-2000's internal Alarm Relay, those devices could give additional warning.

**Table 7.B**

**TROUBLESHOOTING: ALARM CONDITIONS**

| FUNCTION Window Display | Probable Cause | Solution |
|---|---|---|
| OVERLOAD WARNING | The rotor temperature monitoring exceeded 75% of the maximum allowable value. [1] | Monitor electrical characteristics to further isolate the malfunction to an area such as the incoming AC line, or motor/load.<br>Note: If a trip or restart condition occurs and the OVERLOAD WARNING message is still displayed after the RESET pushbutton is depressed, wait until the motor cools before restarting. |
| WINDING TEMP<br>MOTOR BGR TEMP<br>LOAD BGR TEMP<br>GROUND FAULT<br>OPEN/UNBALANCE PHASE | In each case the actual electrical value monitored has exceeded the alarm setpoint value for the function displayed. In addition, the SET POINT LED illuminates to indicate that the numbers displayed in the VALUE windows are the programmed setpoints. | In each of the 5 different displays perform a monitoring function to further isolate the malfunction. Note: If the actual temperature of one or more of the RTDs does not correspond to the reading (in degrees Centigrade), suspect the RTDs, RTD wiring or the RTD Module. |

[1] The Alarm Relay is not tripped when an overload warning condition occurs.

Alarm conditions all have the following in common:

- The internal Alarm Relay is energized when the condition occurs.
- The form C relay contacts, available at the interface (TB-A26 thru A28), are brought out from the Alarm Relay.
- The condition is automatically cleared, the ALARM LED and Alarm Relay resets, if the characteristic causing the condition falls below the setpoint.
- The SET POINT LED remains on until another condition overrides the previous ALARM condition.

All possible alarm conditions are listed in Table 7.B. Related probable cause and solutions are also shown.

**7.2.1.2 Trip Conditions** — A trip condition is a situation that causes the main contactor to open and motor to stop. These conditions fall into 2 groups:

- When the selected characteristics exceed the programmed setpoint values, including, at times, a time setpoint.

  When a trip condition occurs, the red TRIP and SETPOINT LED lights and a message is displayed in the FUNCTION window to assist the operator.

- When the IQ-2000 detects a malfunction. These may be external to the control — such as a broken report-back signal wire from the machine or process. There also are conditions which may be internal to the control — such as an opto-coupler failure.

Trip conditions have these characteristics in common:

- A picture of the metering functions just prior to the occurrence of a trip is stored in memory and can be recalled by depressing the STEP pushbutton. The order of the electrical characteristics displayed will be identical to the listing in Table 7.A.

  Note: The picture of the metering function data is retained by the IQ-2000, as described in Paragraph 7.1.3.

  Note: Depressing the RESET pushbutton clears the electrical characteristics stored when the trip condition occurred. If after depressing the RESET pushbutton the OVERLOAD WARNING message appears, wait until the motor cools before restarting.

- The internal Trip Relay is actuated when the condition occurs.
- The form C relay contacts, available at the interface (TB-A23 thru A25), are brought out from the Trip Relay.
- The condition must be manually reset. (Use the RESET pushbutton.)

All possible trip conditions are listed in Table 7.C. Related probable causes and solutions are also shown.

**Table 7.C**

**TROUBLESHOOTING: TRIP CONDITIONS**

| FUNCTION Window Display | Probable Cause | Solution |
|---|---|---|
| LOCKED-ROTOR CURRENT-A | The rotor winding temperature storage, as directed by the rotor algorithm, has exceeded the maximum allowable value of the $I^2T$ protection curve (motor overload curve). The actual locked-rotor current setpoints are displayed in the VALUES windows of the Operator Panel. | Monitor the electrical characteristics associated with the motor current to further isolate a malfunction to areas such as the AC line or motor overload. |
| WINDING TEMP<br>MOTOR BGR TEMP<br>LOAD BGR TEMP<br>GROUND FAULT ⊡<br>INST OVERCURRENT<br>JAM<br>UNDERLOAD<br>OVERVOLTAGE<br>UNDERVOLTAGE | In each case the actual electrical value monitored has exceeded the trip setpoint value for the function displayed. In addition, the SET POINT LED illuminates to indicate that the numbers displayed in the VALUES windows are the programmed setpoints. | Monitor the associated electrical characteristics (as listed in Table 7.A) to further isolate the malfunction.<br>Note: If the actual temperature of one or more of the RTDs does not correspond to the reading (in degrees Centigrade), suspect the RTDs, RTD wiring, or the RTD Module. |

Table 7.C

TRIP CONDITIONS (Cont.)

| FUNCTION Window Display | Probable Cause | Solution |
|---|---|---|
| INC SEQ RESET | The INCOMPL SEQ REPORT-BACK terminal (TB-A14) was not energized at the appropriate time during the start cycle, or continuously energized during the run cycle. | Monitor terminal TB-A14 during an actual start cycle. Check functions that are being monitored by TB-14 (Incomplete sequence, Field loss, Pull out protection, etc.). |
| BAD REPORT BACK | The report-back contacts from the main contactor relay did not open or close in response to the commands to the Processor Module Relay(s) C1, C2, C3 and C4. | Verify that the control wires associated with the interposing relay and power contactor are properly connected.<br>Refer to the Ampgard Schematic, or equivalent, and examine the main contactor's (or contactors') interlock contacts functioning as follows:<br>• C1 Report Back — TB-A15 [2]<br>• C2 Report Back — TB-A16<br>• C3 Report Back — TB-A17<br>• C4 Report Back — TB-A18 |
| BAD STOP RESET | The PRE-STOP REPORT-BACK terminal (TB-A8) failed to be energized at the correct time in the stop cycle. | Monitor terminal TB-A8 during an actual stop cycle. |
| BAD START RESET | The PRE-START REPORT-BACK terminal (TB-A10) failed to be energized at the correct time in the start cycle. | Monitor terminal TB-A10 during an actual start cycle. |
| REMOTE TRIP | The REMOTE TRIP terminal (TB-A13) was energized. | Monitor terminal TB-A13. |
| PHASE ERROR | 1. Check to see if voltage is available between TB-B11 and B12, B12 and B10, and B10 and B11. Either a blown fuse or single phase condition exists. | Determine why voltage is not present. |
| | 2. During initial start-up the start cycle was prevented because an incoming AC line out-of-phase condition existed. | Rotate 2 of the incoming power leads L1, L2 or L3. Check for proper motor rotation.<br>Alternately, change the IQ-2000 control wiring by rotating the following:<br>• Voltage TB-B11 exchanged with TB-B12<br>• Do not change the wiring to TB-B10<br>• Current TB-B4 exchanged with TB-B8<br>In either case clearly mark the new wiring and update the drawings for future reference. |
| | 3. P.T. ratio setpoint is set other than 0 when no potential transformers are supplied in the application. | Set the P.T. ratio setpoint to 0. Required when testing starter with external 120 volt control. |

Table 7C
TRIP CONDITIONS (Cont.)

| FUNCTION Window Display | Probable Cause | Solution |
|---|---|---|
| OPEN/UNBAL PHASE | 1a. If the value of the negative sequence current is 50% or more of the positive sequence current, a trip condition is initiated.<br>1b. Single phasing of motor. | Monitor the incoming AC line. |
| | 2. During initial start-up an out-of-phase condition exists. | Rotate 2 of the incoming power leads L1, L2 or L3. Check for proper motor rotation.<br>Alternately, change the IQ-2000 control wiring by rotating the following:<br>• Voltage TB-B11 exchanged with TB-B12<br>• Do not change the wiring to TB-B10<br>• Current TB-B4 exchanged with TB-B8<br>Clearly mark the new wiring and update the drawings for future reference. |
| KVAR Reads 0 | The calculated lagging KVAR is greater than -999 | On large horsepower motors that are lightly loaded, it is possible to have a value larger than -999 KVAR. The IQ-2000 is programmed to display 0. Monitor the lagging power factor and percent of full-load amps. |
| POWER FACTOR AND KILOWATTS READS 0 | Phasing between the Voltage & Current signal is wrong | The IQ-2000 is similar to a Wattmeter. Only one possible combination of wiring from the Current Transformers and Potential Transformers is Correct.<br>The use of a Phasing meter to determine proper phase relationship is recommended.<br>Without such an instrument, it is possible through trial and error to correct. Leave the Potential Transformer Connections as is and "roll" the Current Transformer connections.<br>Example TB-B4 to B6, B6 to B8 and B8 to B4. This may have to be tried twice, "two rolls" to obtain proper phase relationship. Make a final calculation check reviewing the Volts, Amps, Power Factor, KVAR and Kilowatts. |
| ILLEGAL INPUT | Two or more simultaneously input contacts gave contradictory commands. | Check all possible start and stop inputs. |
| TOO MANY STARTS [3] | Too many start cycles have been attempted for the programmed setpoint value. | Verify that the start commands have been occurring legally. (See Table 5.C for a description of possible input terminals that can initiate start commands.) |
| EMERGENCY STOP | LOCK-OUT STOP switch was pushed, thereby energizing the E-STOP terminal TB-A21 [4] | Depress the RESET pushbutton which opens the LOCK-OUT STOP switch, thereby de-energizing TB-A21. |

[1] Ground fault trips can be caused by either motor suppression or power factor correction devices. (See Paragraph 6.4 for details.)

[2] See Paragraph 6.28 and Table 6.D for a description of the C1, C2, C3 and C4 relays' operation.

[3] The message WAIT XXX MIN will be displayed in the VALUES windows of the Operator Panel at the same time. Here, XXX represents an actual number of minutes.

[4] Not all motor starters have this optional switch.

**7.2.2 Panel Inoperative** — If the Operator Panel is inoperative, either the LEDs and displays are off, or they are not responding properly. In this case use the procedures listed in Table 7.D. When using the list, keep in mind that:

- The most probable problems or the simplest to verify are listed first. For this reason, always follow the order of the Table's suggestions.
- If the Processor Module, RTD Module or main chassis requires replacement, refer to Chapter 8 for recommended procedures.

DANGER

If a Processor Module is replaced, it is necessary to reprogram all setpoint values that apply to the specific IQ-2000 application. **Do not** attempt to restart the motor until all values are entered and validated. (Use the application's Setpoint Record Sheet and Paragraph 4.3.) Damage to equipment and/or personnel may occur if this procedure is not followed.

**Table 7.D**

**TROUBLESHOOTING: OPERATOR PANEL INOPERATIVE**

| Symptom | Probable Cause | Solution |
|---|---|---|
| All LED's and display windows off or unintelligible | Incoming AC deficient | Verify that 120 VAC (±15%) exists between terminals TB-P2 and TB-P3. (Refer to the Ampgard Schematic or equivalent to further isolate a deficient AC line.) |
| | Blown fuse | Check the fuse located on the Processor Module. |
| | Processor Chassis or Operator Panel malfunction | • Verify that all connections to the terminal blocks are secure and that the connectors are installed properly.<br>• Turn Keyswitch to the PROGRAM position for 5 seconds. Then return to the RUN position.<br>• If all connections and connectors are OK and the Operator Panel is still inoperative, then replace the Processor Chassis. [1] |
| Display windows blank RUN LED on | A display sequence, as described in Par. 7.1.2, is completed | When in the run mode, press the STEP pushbutton to display line voltage. This also verifies that the Operator Panel is functional. |
| CHECKSUM or REPROGRAM EE ROM is displayed in the FUNCTION window | Data transfer loss | Turn the Keyswitch to the PROGRAM position for 10 seconds. Then return the Keyswitch to the RUN position. After 15 seconds the message READY will be displayed. |
| ROM CKSUM ERROR is displayed in the FUNCTION window | Processor Module malfunction | Replace the Processor Chassis. [1] |
| OPTO COUPLER BAD is displayed in the FUNCTION window | Processor Module malfunction | Replace the Processor Chassis. [1] |

[1] If the malfunction persists after the Processor Chassis is replaced, the Operator Panel of the IQ-2000 should be replaced.

Section 8

# UNIT REPLACEMENT

**8.0 General** — This Chapter lists a step-by-step approach to be followed when replacing the following items:

- Processor Module (Par. 8.1)
- RTD Module (Par. 8.2)
- IQ-2000 Chassis (Par. 8.3)

Before replacement, refer to the information on isolating a malfunction in Chapter 7 to make sure that possible malfunctions external to the Processor and RTD Modules have been eliminated.

Always conform to the following cautions when performing any maintenance functions.

> DANGER
>
> The following procedures **must** be performed only by qualified personnel who are familiar with the IQ-2000 and its associated controlled motor and machines. Failure to observe this caution can result in serious or even fatal personal injury and/or equipment damage.

> DANGER
>
> If a Processor Module is replaced, it is necessary to reprogram all setpoint values that apply to the specific IQ-2000 application. **Do not** attempt to restart the motor until all values are entered and validated. (Use the application's Setpoint Record Sheet and Paragraph 4.3.) Personnel injury and/or damage to the equipment may occur if this procedure is not followed.

**8.1 Processor Module Replacement** — The following procedure lists the steps needed to replace the Processor Module:

Step 1 — Remove AC power at the main disconnect or the isolation switch of the starter. Verify that all "foreign" power sources to the starter cabinet are disconnected.

Step 2 — Gain access to the Chassis of the IQ-2000 by pulling the draw-out panel as far forward as it will travel.

Step 3 — Remove the screw securing the Chassis door of the IQ-2000, and open the door. (See Figure 8.1.)

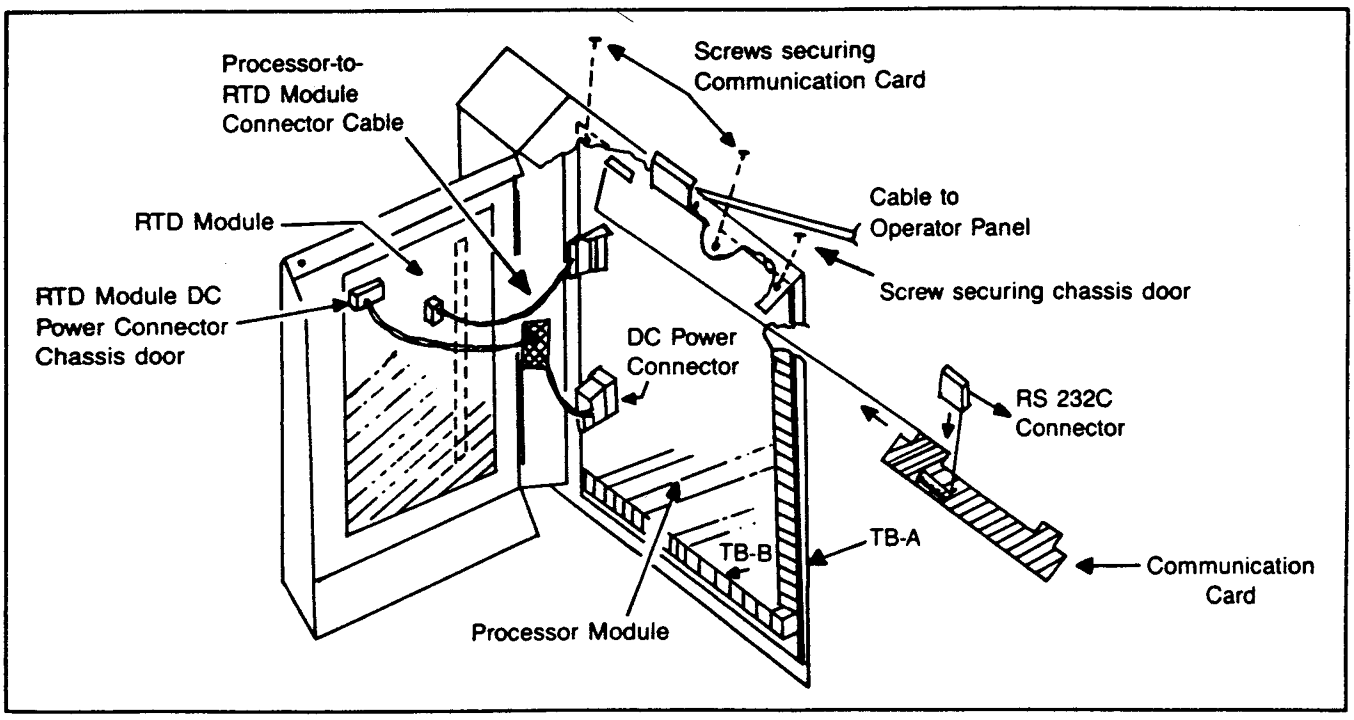



**Figure 8.1 — IQ-2000 Chassis**

Step 4 — Verify that all wires connecting to the terminals of the terminal blocks TB-A, TB-B and TB-P are marked and that it is apparent which designations relate to which terminals.

Step 5 — Loosen each screw terminal and remove the wires from the terminal blocks.

Step 6 — Unscrew the 2 flat-head screws securing the cable connected between the Processor Module and the Operator Panel. (See Figure 8.1.) Note: alternately turn each screw a few turns CCW to prevent the connector from being skewed and damaging the pins.

Step 7 — Remove the connector of the Operator Panel Cable.

Perform Steps 8 and 9 if the optional Communication Card is contained in the application.

Step 8 — Remove the 2 screws securing the connector of the Communication Card. Note: Alternately, turn each screw a few turns CCW to prevent the connector from being skewed and damaging the pins.

Step 9 — Remove the 2 screws securing the Communication Card to the chassis of the IQ-2000. (See Figure 8.1.)

Step 10 — Unplug the DC power connector of the Processor Module.

Step 11 — If the optional RTD Module is contained in the application, unplug the Processor-to-RTD Module Connector Cable at the Processor Module end.

Step 12 — Remove the 4 screws located in each corner of the Processor Module to remove the Module from the chassis.

Step 13 — Reverse the procedure listed in Steps 2 thru 12 to install a replacement Processor Module.

**8.2 RTD Module Replacement** — The following procedure lists the steps needed to replace the RTD Module:

Step 1 — Remove the AC power at the main disconnect switch.

Step 2 — Gain access to the IQ-2000 chassis by pulling the draw-out panel as far forward as it will travel.

Step 3 — Verify that all wires connecting to the terminals of terminal block TB-R are clearly marked and it is clear which terminal relates to the designations. (See Figure 8.1.)

Step 4 — Loosen each screw terminal and remove the wires from them.

Step 5 — Remove the screw securing the chassis door of the IQ-2000 and open the door.

Step 6 — Remove the Processor Module-to-RTD Module Connector Cable at the RTD Module end.

Step 7 — Remove the DC Power Connector of the RTD Module.

Step 8 — Remove the 6 screws securing the RTD Module.

Step 9 — Reverse Steps 2 thru 8 to install a replacement RTD Module.

**8.3 IQ-2000 Chassis Replacement** — The following procedure lists the steps needed to replace the Chassis of the IQ-2000:

Step 1 — Remove AC power at the main disconnect or the isolation switch of the starter. Verify that all "foreign" power sources to the starter cabinet are disconnected.

Step 2 — Refer to Processor Module, Paragraph 8.1, Steps 2, 4, 5, 6, and 7.

Step 3 — If the optional RTD Module is contained in the application, remove it as described in Paragraph 8.2.

Step 4 — If the optional Communication Card is contained in the applicator, remove as described in Paragraph 8.1, Steps 8 and 9.

Step 5 — Verify that all wires connected to the incoming AC terminal block, TB-P1, P2 and P3, are marked and that it is apparent which designations relate to which terminals.

Step 6 — Remove the 4 screws securing the main chassis of the IQ-2000 to the mounting panel.

Step 7 — Reverse the procedure listed in Steps 2 thru 5 to install a replacement IQ-2000 Main Chassis.

**8.4 Terminal Identification** — Identification for the external terminals of the IQ-2000's TB-A, -B, and -P are shown in Figure 8.2. For terminal identification on the RTD Module's TB-R, refer to Figure 3.3.

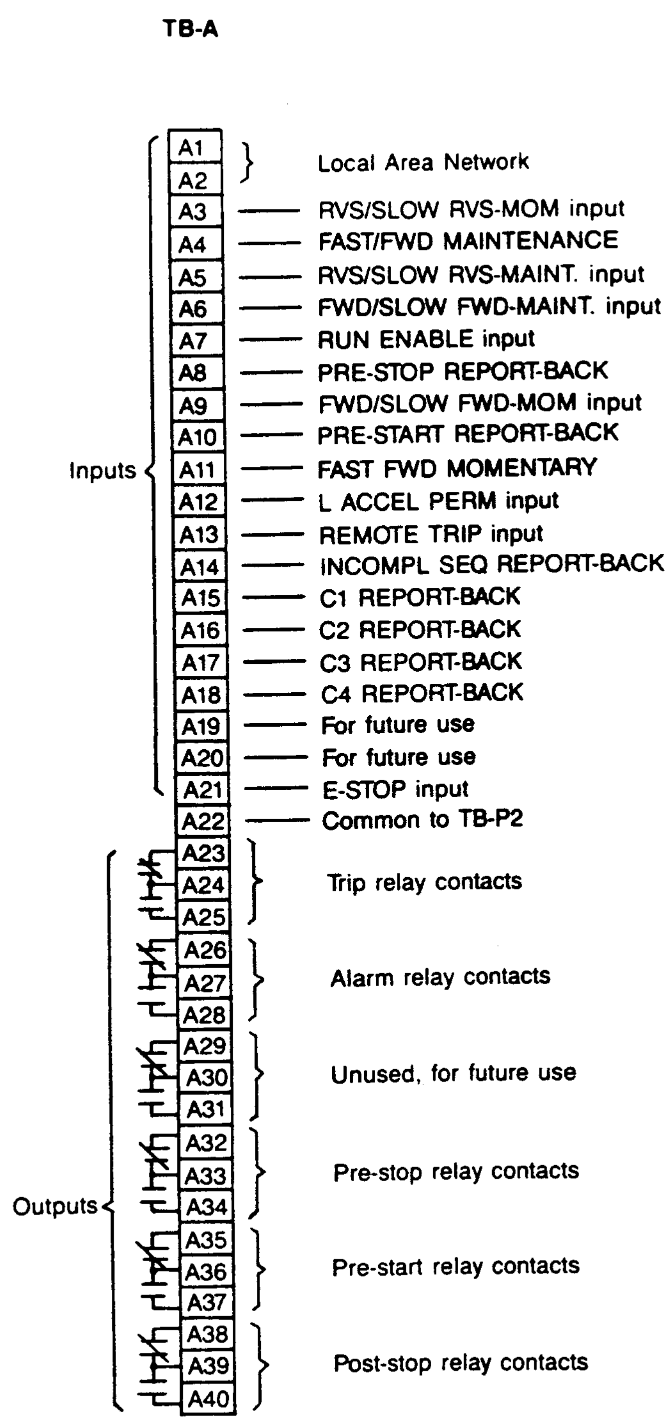



**Figure 8.2 — Terminal Designations**

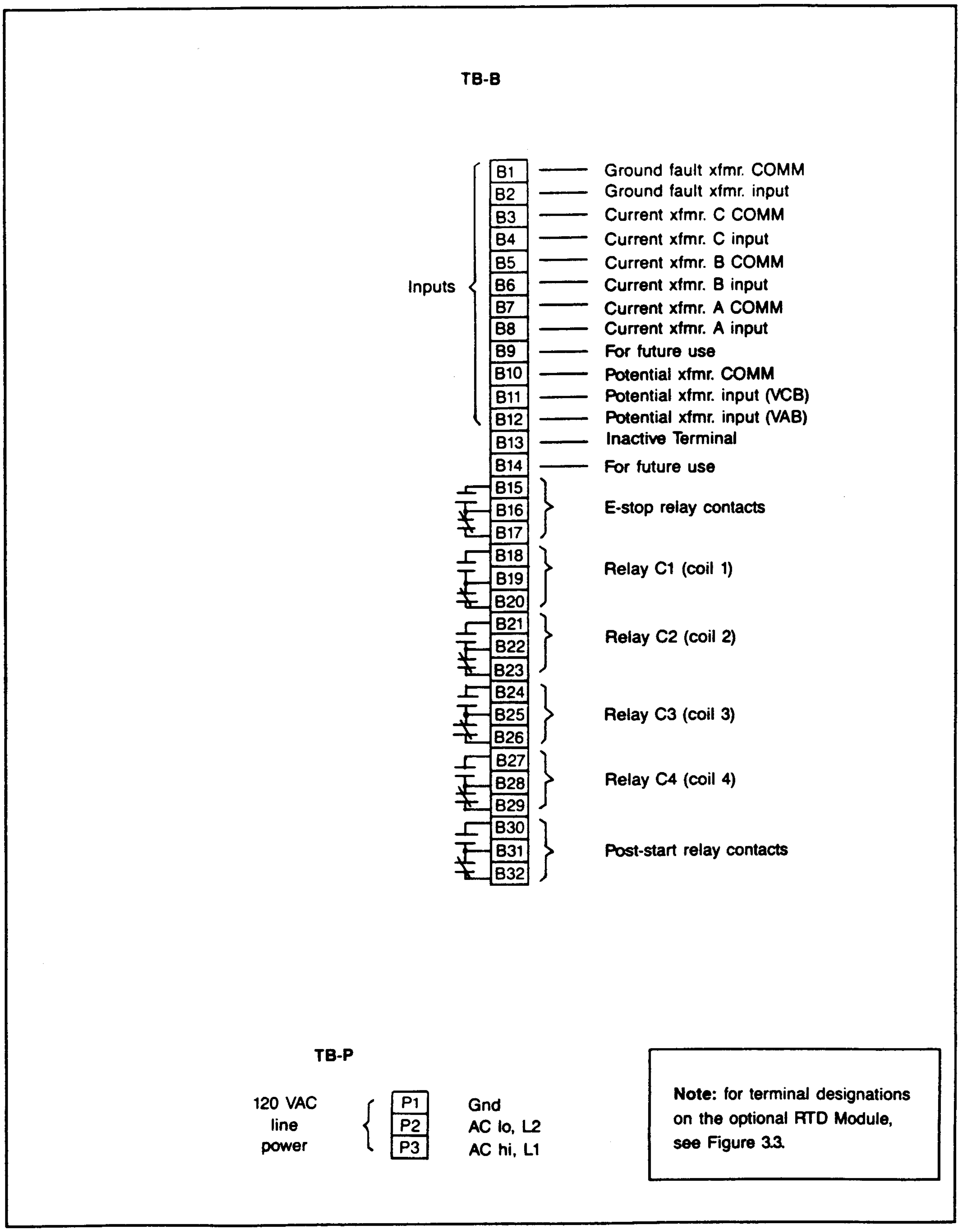



**Figure 8.2 — Terminal Designations**