# MiCOM P540 Series
# Current Differential Relays

12/01 Operation Guide P54x/E O04/C11

ALSTOM

## HANDLING OF ELECTRONIC EQUIPMENT

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling circuits can cause serious damage, which often may not be immediately apparent but the reliability of the circuit will have been reduced.

The electronic circuits of ALSTOM T&D Protection & Control products are immune to the relevant levels of electrostatic discharge when housed in their cases. Do not expose them to the risk of damage by withdrawing modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, the following precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

1. Before removing a module, ensure that you are a same electrostatic potential as the equipment by touching the case.
2. Handle the module by its front-plate, frame, or edges of the printed circuit board. Avoid touching the electronic components, printed circuit track or connectors.
3. Do not pass the module to any person without first ensuring that you are both at the same electrostatic potential. Shaking hands achieves equipotential.
4. Place the module on an antistatic surface, or on a conducting surface which is at the same potential as yourself.
5. Store or transport the module in a conductive bag.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 60147-0F.

If you are making measurements on the internal electronic circuitry of an equipment in service, it is preferable that you are earthed to the case with a conductive wrist strap.

Wrist straps should have a resistance to ground between 500k – 10M ohms. If a wrist strap is not available you should maintain regular contact with the case to prevent the build up of static. Instrumentation which may be used for making measurements should be earthed to the case whenever possible.

ALSTOM T&D Protection & Control strongly recommends that detailed investigations on the electronic circuitry, or modification work, should be carried out in a Special Handling Area such as described in BS5783 or IEC 60147-0F.

# CONTENT

# 1. SAFETY SECTION

**This Safety Section should be read before commencing any work on the equipment.**

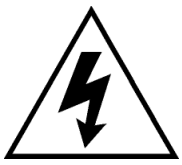
## 1.1 Health and Safety

The information in the Safety Section of the product documentation is intended to ensure that products are properly installed and handled in order to maintain them in a safe condition. It is assumed that everyone who will be associated with the equipment will be familiar with the contents of the Safety Section.

## 1.2 Explanation of symbols and labels

The meaning of symbols and labels may be used on the equipment or in the product documentation, is given below.

**Caution** : refer to product documentation



**Caution** : risk of electric shock

Protective/safety *earth terminal

Functional *earth terminal

**Note:** This symbol may also be used for a protective/safety earth terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.

*NOTE: THE TERM EARTH USED THROUGHOUT THE PRODUCT DOCUMENTATION IS THE DIRECT EQUIVALENT OF THE NORTH AMERICAN TERM GROUND.

# 2. INSTALLING, COMMISSIONING AND SERVICING

## Equipment connections

Personnel undertaking installation, commissioning or servicing work on this equipment should be aware of the correct working procedures to ensure safety. The product documentation should be consulted before installing, commissioning or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electrical shock or energy hazards.

Voltage and current connections should be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety. To ensure that wires are correctly terminated, the correct crimp terminal and tool for the wire size should be used.

Before energising the equipment it must be earthed using the protective earth terminal, or the appropriate termination of the supply plug in the case of plug connected equipment. Omitting or disconnecting the equipment earth may cause a safety hazard.

The recommended minimum earth wire size is 2.5mm$^2$, unless otherwise stated in the technical data section of the product documentation.

Before energising the equipment, the following should be checked:

– Voltage rating and polarity;

– CT circuit rating and integrity of connections;

– Protective fuse rating;

– Integrity of earth connection (where applicable)

## 3. EQUIPMENT OPERATING CONDITIONS

The equipment should be operated within the specified electrical and environmental limits.

### 3.1 Current transformer circuits

Do not open the secondary circuit of a live CT since the high level voltage produced may be lethal to personnel and could damage insulation.

### 3.2 External resistors

Where external resistors are fitted to relays, these may present a risk of electric shock or burns, if touched.

### 3.3 Battery Replacement

Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity, to avoid possible damage to the equipment.

### 3.4 Insulation and dielectric strength testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

### 3.5 Insertion of modules and pcb cards

These must not be inserted into or withdrawn from equipment whist it is energised since this may result in damage.

### 3.6 Fibre optic communication

Where fibre optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

## 4. OLDER PRODUCTS

### Electrical adjustments

Equipments which require direct physical adjustments to their operating mechanism to change current or voltage settings, should have the electrical power removed before making the change, to avoid any risk of electrical shock.

### Mechanical adjustments

The electrical power to the relay contacts should be removed before checking any mechanical settings, to avoid any risk of electric shock.

### Draw out case relays

Removal of the cover on equipment incorporating electromechanical operating elements, may expose hazardous live parts such as relay contacts.

### Insertion and withdrawal of extender cards

When using an extender card, this should not be inserted or withdrawn from the equipment whilst it is energised. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

### Insertion and withdrawal of heavy current test plugs

When using a heavy current test plug, CT shorting links must be in place before insertion or removal, to avoid potentially lethal voltages.

## 5. DECOMMISSIONING AND DISPOSAL

**Decommissioning:** The auxiliary supply circuit in the relay may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the relay (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to decommissioning.

**Disposal:** It is recommended that incineration and disposal to water courses is avoided. The product should be disposed of in a safe manner. Any products containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of lithium batteries.

## 6. TECHNICAL SPECIFICATIONS

### Protective fuse rating

The recommended maximum rating of the external protective fuse for this equipment is 16A, Red Spot type of equipment, unless otherwise stated in the technical data section of the product documentation.

| | | |
|---|---|---|
| **Insulation class:** | IEC 601010-1 : 1990/A2 : 1995<br>Class I<br>EN 61010-1 : 1993/A2 : 1995<br>Class I | This equipment requires a protective (safety) earth connection to ensure user safety. |
| **Insulation Category (Overvoltage):** | IEC 601010-1 : 1990/A2 : 1995<br>Category III<br>EN 61010-1 : 1993/A2 : 1995<br>Category III | Distribution level, fixed installation. Equipment in this category is qualification tested at 5kV peak, 1.2/50µs, 500Ω, 0.5J, between all supply circuits and earth and also between independent circuits. |
| **Environment:** | IEC 601010-1 : 1990/A2 : 1995<br>Pollution degree 2<br>EN 61010-1 : 1993/A2 : 1995<br>Pollution degree 2 | Compliance is demonstrated by reference to generic safety standards. |
| **Product Safety:** | 72/23/EEC | Compliance with the European Commission Law Voltage Directive. |
| CE | EN 61010-1 : 1993/A2 : 1995<br>EN 60950 : 1992/A11 : 1997 | Compliance is demonstrated by reference to generic safety standards. |

# CHAPTER 4
# Problem Analysis

# CONTENT

## 1. INTRODUCTION

**Before carrying out any work on the equipment, the user should be familiar with the contents of the safety and technical data sections and the ratings on the equipment's rating label.**

The purpose of this chapter of the service manual is to allow an error condition on the relay to be identified so that appropriate corrective action can be taken.

Should the relay have developed a fault, it should be possible in most cases to identify which relay module requires attention. Chapter 3, 'Commissioning and Maintenance', advises on the recommended method of repair where faulty modules need replacing. It is not possible to perform an on-site repair to a faulted module.

In cases where a faulty relay/module is being returned to the manufacturer or one of their approved service centres, completed copy of the Repair Form located at the end of this manual should be included.

## 2. INITIAL PROBLEM IDENTIFICATION

Consult the table below to find the description that best matches the problem experienced, then consult the section referenced to perform a more detailed analysis of the problem.

| Symptom | Refer to |
|---|---|
| Relay fails to power up | Section 3 |
| Relay powers up but indicates error and halts during power-up sequence | Section 4 |
| Relay powers up but Out of Service LED is illuminated | Section 5 |
| Relay reboots during normal operation | Section 6 |
| Error during normal operation | Section 6 |
| Misoperation of the relay during testing | Section 7 |

Table 1: Problem Identification

## 3. POWER UP ERRORS

If the relay does not appear to power up then the following procedure can be used to determine whether the fault is in the external wiring, auxiliary fuse, power supply module of the relay or the relay front panel.

| Test | Check | Action |
|---|---|---|
| 1 | Measure auxiliary voltage on terminals 1 and 2, verify voltage level and polarity against the rating label on front panel, under the top cover.<br>Terminal 1 is –dc, 2 is +dc | If auxiliary voltage is present and correct, then proceed to test 2. Otherwise the wiring/fuses in auxiliary supply should be checked. |
| 2 | Do LEDs/ and LCD backlight illuminate on power up, also check the N/O watchdog contact for closing. | If they illuminate or the contact closes and no error code is displayed then error is probably in the main processor board (front panel)<br>If they do not illuminate and the contact does not close then proceed to test 3. |
| 3 | Check Field voltage output (nominally 48V DC) | If field voltage is not present then the fault is probably in the relay power supply module. Consult Chapter 3 for a description of how to remove this module. The part number of this module can be checked to verify that the rating of the module conforms to the auxiliary rating printed on the relay front panel. |

Table 2: Failure of Relay to power up

## 4. ERROR MESSAGE/CODE ON POWER-UP

During the power-up sequence of the relay self-testing is performed as indicated by the messages displayed on the LCD. If an error is detected by the relay during these self-tests then an error message will be displayed and the power-up sequence will be halted. If the error occurs when the relay application software is executing then a maintenance record will be created and the relay will reboot.

| Test | Check | Action |
|---|---|---|
| 1 | Is an error message or code permanently displayed during power up. | If relay locks up and displays an error code permanently then proceed to test 2. If the relay prompts for input by the user proceed to test 4. If the relay re- boots automatically then proceed to test 5. |
| 2 | Record displayed error, then remove and re-apply relay auxiliary supply. | Record whether the same error code is displayed when the relay is rebooted.<br>If no error code is displayed then contact the local service centre stating the error code and relay information.<br>If the same code is displayed proceed to test 3. |
| 3 | Error code Identification location.<br>Following text messages (in English) will be displayed if a fundamental problem is detected preventing the system from booting:<br>Bus Fail – address lines<br>SRAM Fail - data lines<br>FLASH Fail format error<br>FLASH Fail checksum<br>Code Verify Fail<br>Other error codes relate to errors detected in hardware or software: | Refer to Chapter 3 for module<br>These messages indicate that a problem has been detected on the main processor board of the relay (located in the front panel), or in the Current Differential processor board (located within the case).<br>Refer to section 8 for a list of error codes. |
| 4 | Relay displays message for corrupt settings and prompts for restoration of defaults to the affected settings. | The power up tests have detected corrupted relay settings. It is possible to restore defaults to allow the power- up to be completed. It will then be necessary to re-apply the application- specific settings. |

| Test | Check | Action |
|---|---|---|
| 5 | Relay resets on completion of power up – record error code displayed. | Error 0x0E080000, programmable scheme logic error due to excessive execution time. Restore default settings by performing a power up with ◇ and ◇ keys depressed, confirm restoration of defaults at prompt using ↵ key. If relay powers up successfully, check programmable logic for feedback paths.<br>Refer to section 8 for a list of error codes. |

Table 3: Power-up self-test error

## 5. OUT OF SERVICE LED ILLUMINATED ON POWER UP

| Test | Check | Action |
|---|---|---|
| 1 | Using the relay menu confirm whether the Commission Test/ Test Mode setting is Enabled. | If the setting is Enabled then disable the test mode and, verify that the Out of Service LED is extinguished.<br>Otherwise proceed to test 2. |
| 2 | Select and view the last maintenance record from the menu (in the View Records). | Check for H/W Verify Fail (this indicates a discrepancy between the relay model number and the hardware). Examine the "Maint Data",(this indicates the causes of the failure using bit fields):<br>Bit Meaning<br>0 The application type field in the model number does not match the software ID<br>1 The application field in the model number does not match the software ID<br>2 The variant 1 field in the model number does not match the software ID<br>3 The variant 2 field in the model number does not match the software ID<br>4 The protocol field in the model number does not match the software ID<br>5 The language field in the model number does not match the software ID<br>6 The VT type field in the model number is incorrect (110V VTs fitted)<br>7 The VT type field in the model number is incorrect (440V VTs fitted)<br>8 The VT type field in the model number is incorrect (no VTs fitted)<br>Check for Maint Data – 1819869184. This indicates a discrepancy between the relay model number and the number of optical signalling channels fitted. |

Table 4: Out-of-service condition

## 6. ERROR CODE DURING OPERATION

The relay performs continuous self-checking. If an error is detected, then an error message will be displayed, a maintenance record will be logged and the relay will reset (after a 1.6 second delay). A permanent problem (for example due to a hardware fault) will generally be detected on the power up sequence, following which the relay will display an error code and halt. If the problem was transient in nature then the relay should re-boot correctly and continue in operation. The nature of the detected fault can be determined by examination of the maintenance record logged.

There are also two cases where a maintenance record will be logged due to a detected error where the relay will not reset. These are detection of a failure of either the field voltage or the lithium battery. In these cases the failure is indicated by an alarm message. However, the relay will continue to operate.

If the field voltage is detected to have failed (the voltage level has dropped below threshold), then a scheme logic signal is also set. This allows the scheme logic to be adapted in the case of this failure (for example if a blocking scheme is being used).

In the case of a battery failure it is possible to prevent the relay from issuing an alarm using the setting under the Date and Time section of the menu. This setting "Battery Alarm" can be set to 'Disabled' to allow the relay to be used without a battery, without an alarm message being displayed.

# 7. MIS-OPERATION OF THE RELAY DURING TESTING

## 7.1 Failure of output contacts

An apparent failure of the relay output contacts may be caused by the relay configuration and the following tests should be performed to identify the real cause of the failure. Note that the relay self-tests verify that the coil of the contact has been energised. An error will be displayed if there is a fault in the output relay board.

| Test | Check | Action |
|---|---|---|
| 1 | Is the Out of Service LED illuminated. | Illumination of this LED may indicate that the relay is in test mode or that the protection has been disabled due to a hardware verify error (see Table 4) |
| 2 | Examine the Contact status in the Commissioning section of the menu. | If the relevant bits of the contact status are operated then proceed to test 4.<br>If not, proceed to test 3. |
| 3 | Verify by examination of the fault record, or by using the test port whether the protection element is operating correctly. | If the protection element does not operate, verify whether the test is being correctly applied.<br>If the protection element does operate, then it will be necessary to check the programmable logic to ensure that the mapping of the protection element to the contacts is correct. If the mapping of the protection has been correctly configured, then the contact may be at fault. This can be verified – see test 4. |
| 4 | Using the Commissioning/Test mode function, apply a test pattern to the relevant relay output contacts and verify whether they operate (note the correct external connection diagram should be consulted).<br>A continuity tester can be used at the rear of the relay for this purpose. | If the output relay does operate then the problem must be in the external wiring to the relay. If the output relay does not operate this could indicate a failure of the output relay contacts (note that the self-tests verify that the relay coil is being energised). Ensure that the closed resistance is not too high for the continuity tester to detect. |

Table 5: Failure of output contacts

## 7.2 Failure of opto-isolated inputs

The opto-isolated inputs are mapped onto the relay internal signals using the programmable scheme logic. If an input does not appear to be recognised by the relay scheme logic the Commission Tests/Opto Status menu option can be used to verify whether the problem is in the opto-isolated input itself or the mapping of its signal to the scheme logic functions. If the opto-isolated input does appear to be read correctly then it will be necessary to examine its mapping within the programmable logic.

If the opto-isolated input state is not being correctly read by the relay the applied signal should be tested. Verify the connections to the opto-isolated input using the correct wiring diagram. Next, using a voltmeter verify that >80% of the programmed nominal battery voltage threshold is present on the terminals of the opto-isolated input in the energised state. If the signal is being correctly applied to the relay then the failure may be on the input card itself. Depending on which opto-isolated input has failed this may require replacement of either the complete analogue input module (the board within this module cannot be individually replaced without re-calibration of the relay) or a separate opto board.

## 7.3 Incorrect analogue signals

If it is suspected that the analogue quantities being measured by the relay are not correct then the measurement function of the relay can be used to verify the nature of the problem. The measured values displayed by the relay should be compared with the actual magnitudes at the relay terminals. Verify that the correct terminals are being used (in particular the dual rated CT inputs) and that the CT and VT ratios set on the relay are correct.

## 7.4 Current differential failures

The current differential board may cause the relay to report one or more of the following alarms:

Signalling Failure & CDiff Failure

The fibre optic signalling channel is not receiving valid data; it may have been disconnected or incorrectly configured at either end. As a result, current differential protection is not available and back-up protection will operate, if configured to do so. It is also possible that noise is being introduced if a RS485 electrical interface (e.g. MITZ) is being used to communicate between relays, which is corrupting the messages received.

Incompatible Relay

This occurs if the relays trying to communicate with each other are of incompatible types. Relay types P541 and P542 can be freely mixed. Relay type P543, P544, P545 and P546 can be freely mixed. However, the two groups are mutually exclusive.

## 8. ERROR CODES

Error codes (as reported by the relay via the front panel or in the Maintenance Records) can offer a considerable amount of information about the source of the error.

The Hex Code is reported on the front user interface of the relay immediately prior to a reboot sequence. If this code could not be observed, use the Maintenance Records section of the View Records column to display the corresponding Decimal Code.

| Hex Code | Decimal Code | Meaning |
|---|---|---|
| 0x0C0D0000 | 202178560 | An error has been detected in the acquisition driver. Check the input board and the opto boards |
| 0x0C0E0000 | 202244096 | An error has been detected in an output relay card. Check the relay boards. |
| 0x0C140001 | 202637313 | The serial driver failed to initialise properly. Check the serial port hardware on the power supply board and the main processor board. |
| 0x0C140002 | 202637314 | The LCD driver failed to initialise properly. Check the LCD on the main processor board. |
| 0x0C140003 | 202637315 | The Flash memory driver failed to initialise properly. Check the Flash memory on the main processor board. |
| 0x0C140004 | 202637316 | The date and time driver failed to initialise properly. Check the real-time clock and battery-backed SRAM on the main processor board. |
| 0x0C140005 | 202637317 | The data acquisition driver failed to initialise properly. Check the input board and the opto boards. |
| 0x0C140006 | 202637318 | The relay driver failed to initialise properly. Check the relay boards. |
| 0x0C140007 | 202637319 | The logs failed to initialise properly. Check the battery backed SRAM on the main processor board. |
| 0x0C140008 | 202637320 | The database failed to initialise properly. Check the EEPROM on the main processor board. |
| 0x0C140009 | 202637321 | The database took too long to commit a change. Check the EEPROM on the main processor board. |
| 0x0C14000A | 202637322 | The IRIG-B driver failed to initialise properly. Check the IRIG-B interface hardware on the IRIG-B board. |
| 0x0C160010 | 202768400 | The continuous self-checks have found an error in the RAM bus. Check the RAM on the main processor board. |

| | | |
|---|---|---|
| 0x0C160011 | 202768401 | The continuous self-checks have found an error in the RAM block. Check the RAM on the main processor board. |
| 0x0C160012 | 202768402 | The continuous self-checks have found an error in the Flash EPROM checksum. Check the Flash EPROM on the main processor board, and then try downloading a new program. |
| 0x0C160013 | 202768403 | The continuous self-checks have found an error in the code comparison. Check the Flash EPROM on the main processor board, and then try downloading a new program. |
| 0x0C160014 | 202768404 | The continuous self-checks have found an error in the battery backed SRAM. Check the battery, then the RAM on the main processor board. |
| 0x0C160015 | 202768405 | The continuous self-checks have found an error in the EEPROM. Check the EEPROM on the main processor board. |
| 0x0C1600A0 | 202768544 | The continuous self-checks have found an error on the acquisition board. Check the input board. |
| 0x0C1600B0 | 202768560 | The continuous self-checks have found an error on a relay board. Check the relay boards. |
| 0x0C1600C0 | 202768576 | The continuous self-checks have found an error on an opto board. Check the opto boards. |
| 0x0C170016 | 202833942 | Secondary initialisation tests detected a fast watchdog failure. Check the on the main processor board. |
| 0x0C170017 | 202833943 | Secondary initialisation tests detected a battery backed SRAM failure. Check the battery backed SRAM on the main processor board. |
| 0x0C170018 | 202833944 | Secondary initialisation tests detected a bus reset test failure. Check the main processor board. |
| 0x0C170019 | 202833945 | Secondary initialisation tests detected a slow watchdog failure. |
| 0x0E020000 | 235012096 | Excessive number of gates in PSL. Restore defaults and download new PSL. |
| 0x0E080000 | 235405312 | PSL excessive execution time. Restore defaults and download new PSL. |
| 0x818xxxx | -2122252288 to -2122186753 | The commissioning test module received an error code when writing to the relays. Check the relay boards. |
| 0x8182xxxx | -2122186752 to -2122121217 | The commissioning test module received an error code when writing to the LEDs. Check the processor card. |
| 0x93830000 | -1820131328 | FPGA download failed, check current differential board and the model number |

| | | |
|---|---|---|
| 0x93840000 | -1820065792 | SRAM check failed, check current differential board |
| 0x93850000 | -1820000256 | Program download failed, check current differential board |
| 0x93860000 | -1819934720 | Program failed to start, check current differential board |
| 0x93870000 | -1819869184 | Number of optical channels incorrect, check current differential board and model number. |
| 0xAC810000 | -1400832000 | Current differential program stopped, check current differential board. |

Table 6: Error Codes

Other error codes relate to problems within the main processor board software. It will be necessary to contact ALSTOM T&D P&C with details of the problem for a full analysis.

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