IPM V2

INTEGRATED PROTECTION RELAY

User Manual

Revision: 16, MARCH 2020

Designed and manufactured in Australia by Ampcontrol Pty Ltd

AMPCONTROL®

WARNING!

The **warning** symbol highlights a potential risk of **injury or death**.

Please share these warnings with other operators.

CAUTION!

The **caution** symbol highlights a potential risk of **damage to equipment**.

Please share these cautions with other operators.

NOTE

The **note** symbol highlights **key information**.

Please share these notes with other operators.

ENVIRO

The **enviro** (environmental) symbol highlights areas which may have an impact on the surrounding **fauna and/or flora**.

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Before You Begin

Thank you for purchasing the Ampcontrol IPM V2 Integrated Protection Relay.

WARNING!

In the interests of **safety and correct equipment operation**, please take the time to read and understand the content in this manual.

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 SAFETY AND OTHER WARNINGS

For safety reasons, the relay must be installed, operated and serviced only by competent personnel. Please read and understand this instruction manual completely before installing, operating or servicing this equipment. Failure to install or operate this instrument in accordance with the instructions contained in this manual may create hazardous operating conditions.

1.1 Safe Use of Equipment

The equipment supplied has been designed and manufactured to ensure safe operation. The equipment must only be used within the design parameters.

The instructions within this manual must be observed as an aid towards achieving the safest possible installation.

Persons responsible for installation, maintenance, or operation, must observe the following instructions:

1.1.1 Changes to Equipment

Changes in the design and modifications to the equipment are not permitted. Unauthorised changes made to the hardware or operating firmware will void the manufacturer's warranty, and may compromise the integrity of the system into which it is installed and other connected equipment.

1.1.2 Equipment Knowledge

Experience with, or understanding of, this equipment is essential for the safe installation and removal of the equipment. Therefore, please read and understand this manual prior to use. Competency based training courses are recommended and are available on request.

1.1.3 Manual Handling

Precautions have been taken to ensure all equipment is safe to handle and free from sharp edges. However, care should always be taken when handling enclosures and gloves should be worn.

1.1.4 Installation

Correct operation and safety depend on the relay and associated equipment being installed correctly. Mechanical and or electrical installation and maintenance of plant and equipment must only be carried out by appropriately qualified personnel and must be tested thoroughly prior to operation.

1.1.5 Operation

As safety depends on the relay functioning correctly it is highly recommended that all safety functions of the relay be periodically tested to ensure correct operation.

2 RECEIVING AND STORAGE

2.1 Receiving

All possible precautions are taken to protect the equipment against damage or losses during shipment, however before accepting delivery, check all items against the packing list or bill of loading. If there is evidence of physical damage, notify Ampcontrol immediately.

Notify Ampcontrol immediately in case of any discrepancies to the packing list. Keep a record of any claims and correspondence. Photographs are recommended.

Where practicable do not remove protective covers prior to installation unless there are indications of damage. Boxes opened for inspection and inventory should be carefully repacked to ensure protection of the contents or else the parts should be packaged and stored in a safe place. Examine all packing boxes, wrappings and covers for items attached to them, retain and store any approval documentation for your safety file as applicable prior to wrapping being discarded.

2.2 Inspection

Equipment that is found to be damaged or has been modified away from its published specification must not be used. Please contact Ampcontrol if the equipment is suspected to be different than that ordered or if it does not match the published specifications.

2.3 Storage after Delivery

When the equipment is not to be installed immediately, proper storage is important to ensure protection of equipment and validity of warranty.

All equipment should be stored indoors between 0-40˚C, preferably on shelves and protected from moisture and sunlight.

2.4 Unpacking of Equipment

The method of packing used will depend on the size and quantity of the equipment. The following cautions should be interpreted as appropriate.

CAUTION!

Take care when unpacking crates as the **contents may have shifted during transport**.

ENVIRO

The disposal of packaging materials, replaced parts, or components must comply with environmental restrictions without polluting the soil, air or water.

Ensure that any timber and cardboard used as **packaging is disposed of in a safe and environmentally responsible manner**.

Where possible, dispose of all waste products i.e. oils, metals, plastic and rubber products by using an approved recycling service centre.

3 PRODUCT OVERVIEW

3.1 IPM V2 Relay

The Ampcontrol IPM V2 Integrated Protection Relay is an intelligent protection relay based on microprocessor technology. The IPM Integrated Relay provides the necessary functions required for protecting electrical outlets supplying underground mining machinery, powered by reeling or trailing cables, in the metalliferous industry. The relay can also be used to provide optimum overload protection of motors used on conveyors, pumps, fans and compressors. All of the protection functions are combined into a compact, plug-in unit, which can be easily changed out to minimise down time in the event of a problem with the relay.

The IPM provides protection and control functions for:

- Earth Leakage
- Earth Continuity
- Insulation Testing
- Contactor Fail
- Under Voltage
- Overcurrent
- Short Circuit
- Under Current (Pump Snore Protection)
- Fan “Burp” Control

The IPM Integrated Protection Relay can provide Machine Data Transfer through the use of a Remote Termination Module (RTM) connected between the pilot and earth at the machine end of the trailing cable. Through the use of the RTM Remote Termination Module the relay parameters are automatically uploaded from a remote machine when a cable is inserted into a power outlet. The RTM also allows for remote control (starting) of the IPM output.

Figure 3.1: IPM Integrated Protection Relay

A RS485 Modbus communication port is available that can be connected to a PLC or a central monitoring system for continuous monitoring and fault-finding.

The IPM Relay provides an isolated 4-20mA analogue output that can be configured to continuously represent Average Current, Overload, Earth Leakage and the Insulation level of the relay.

The IPM Integration Protection Relay has 6 digital inputs (Lock, Reset, Aux, Ex-Stop, Ex-Start and MCI), which feed into a microprocessor unit to be interpreted. The microprocessor has been programmed to control three output relays, MCR (Main Contactor Relay), CBR (Circuit Breaker Relay) and ALM (Alarm Relay).

All of the tripping logic and outlet control is performed by the microprocessor, so that virtually no external control is required.

A four-line 20 character backlit LCD display combined with a keypad provides an easy to operate user interface. The display provides easy access to all available information. A simple procedure allows adjustment of the relay's settings.

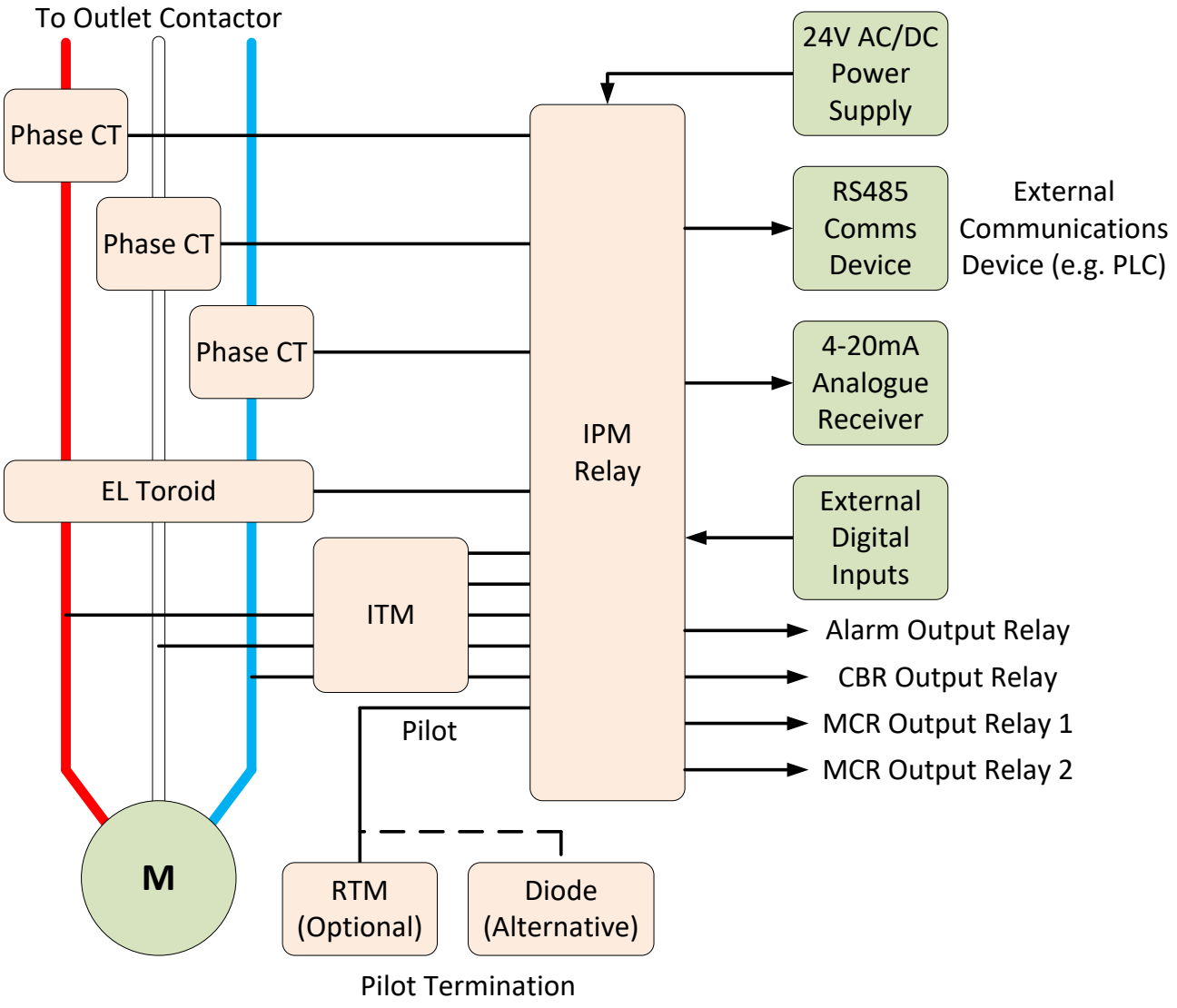


Figure 3.2: IPM Block Diagram

3.1.1 Earth Leakage Protection

The IPM monitors the outlet's earth leakage current through the use of an approved core balance toroid. A Residual Current Device (RCD) operating characteristic is provided with adjustable trip sensitivity and time delay. When a trip is initiated, the IPM will open its MCR output relay, opening the outlet's contactor.

For detailed information on the operation of the Earth Leakage protection function, refer to Section 6.1.

3.1.2 Earth Continuity Protection

The Earth Continuity function tests for the continuity of the earthing between the outlet and the machine, via the pilot core in the trailing cable. The pilot core is also used to transfer data when a Remote Termination Module (RTM) is used to achieve machine communication.

For detailed information on the operation of the Earth Continuity protection function, refer to Section 6.3.

3.1.3 Insulation Testing

The insulation testing function tests the resistance of the 3 phase lines to earth by applying a high voltage DC signal to the phase conductors, via the Insulation Test Module (ITM). This test is initiated once all starting conditions are met.

If the result of the Insulation Test is above the pre-set resistance level, the IPM's MCR relay energises, which in turn closes the main contactor. A manual "Insulation Test" is also provided as a maintenance/fault finding tool. (When this test is performed the MCR relay does not close at completion of a healthy test). The Insulation Test allows cable insulation levels to be trended as an aid to preventative maintenance.

For detailed information on the operation of the Earth Fault Lockout protection function, refer to Section 6.2.

3.1.4 Frozen / Failed Contactor Protection

The IPM relay provides failed contactor protection, initiating a back-trip to an upstream circuit breaker if the contactor is deemed to have failed to open when required. The position of outlet's contactor is monitored via the Main Contactor Input (MCI). The state of the contactor is then compared to the state of the IPM's output relay. If the contactor is closed whilst the MCR is in the open position, a failed contactor trip will be initiated.

The IPM also monitors the voltage on the load side of the outlet's contactor, via the ITM module, whilst the contactor is in the open position. If this voltage exceeds 10% of the rated line voltage, a failed contactor trip will be initiated. When a trip is initiated, the IPM will open its CBR output relay, opening the upstream circuit breaker.

For detailed information on the operation of the Frozen/Failed Contactor protection function, refer to Section 8.1.

3.1.5 Overcurrent / Overload Protection

The IPM relay monitors the outlet phase currents via three current transformers (CTs). The measured current allows the IPM to implement overcurrent, thermal motor overload and phase imbalance protection. When a trip is initiated, the IPM will open its MCR output relay, opening the outlet's contactor.

For detailed information on the operation of the Overcurrent and Overload protection functions, refer to Section 0.

3.1.6 Short Circuit Protection

In addition to the overload protection functions, the IPM relay uses the currents measured from the three phase CTs to provide short circuit protection. The IPM opens its CBR output when a short circuit

trip is initiated. In typical installations the CBR output is used to trip a circuit breaker upstream from the outlet's contactor.

For detailed information on the operation of the Short Circuit protection function, refer to Section 7.2.

3.1.7 Pump Snore Function

The IPM relay has a Pump Snore function that provides additional control functionality for pump installations. The Snore function automatically stops the output upon detection of a low current condition, avoiding damage to the pump components due to overheating. The outlet will be restarted after a fixed or automatically adjustable time delay.

For detailed information on the operation of the Pump Snore function, refer to Section 11.

3.1.8 Fan Burp Function

The IPM relay has a Fan Burp function that provides additional control functionality for fan installations. The Burp function allows for the progressive inflation of ventilation bags (tubes) by pulsing the motor contactor controlling a ventilation fan, several times at start-up.

For detailed information on the operation of the Fan Burp function, refer to Section 10.

3.2 Accessories

The IPM relay requires a number of accessories to perform its protection functions. These accessories will be introduced in the following subsections. Some accessories are marked as optional and are not required for the IPM to perform its basic protection functions. Purchasing these optional items will, however, expand the capabilities of the installation.

3.2.1 Insulation Test Module (ITM)

The IPM is connected to the outlet's phase conductors via a high impedance Insulation Test Module (ITM). This allows the IPM to perform a high voltage DC insulation test prior to the closing of the outlet's contactor. The IPM also uses the ITM to monitor the magnitude of the phase voltages. This is used during the frozen contactor testing to ensure that when the outlet's contactor opens, voltage is removed from the outlet. The ITM is available in a 415V model or a 1kV model.

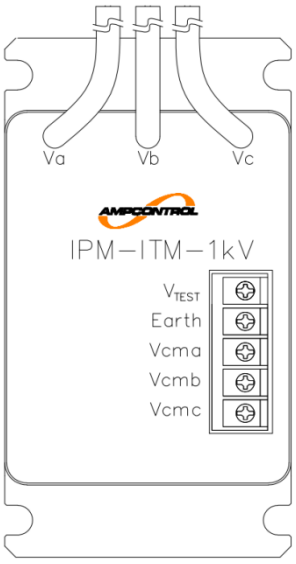


Figure 3.3: Insulation Test Module

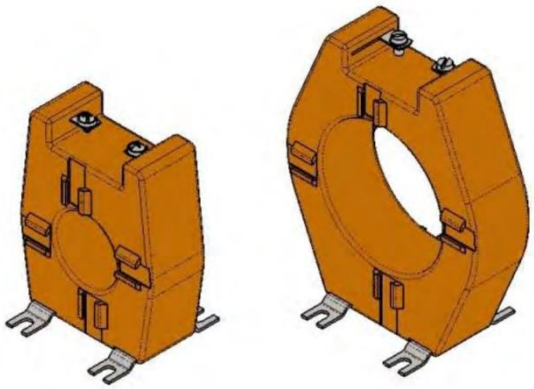


Figure 3.4: Phase Current Transformers

3.2.2 Phase Current Transformers (CTs)

The IPM relay measures the phase currents from all three of the outlet's phases. Using these measured current values, the IPM is able to implement its overload and short circuit protections functions. The IPM requires three (3) current transformers to measure the phase currents. The phase current transformers are available in two standard sizes: 45mm inner diameter (1000:1 & 500:5) and 88mm inner diameter (1000:1 only). The current transformers are panel mounted units.

3.2.3 Earth Leakage Toroid

The IPM requires a summation toroid to be installed around the outlet's three phase conductors. This toroid allows the IPM to measure the magnitude of outlet's earth leakage current. Only one (1) earth leakage toroid is required per IPM. The IPM's earth leakage toroids are 1000:1 and have an 88mm inner diameter.

Figure 3.5: Earth Leakage Toroid

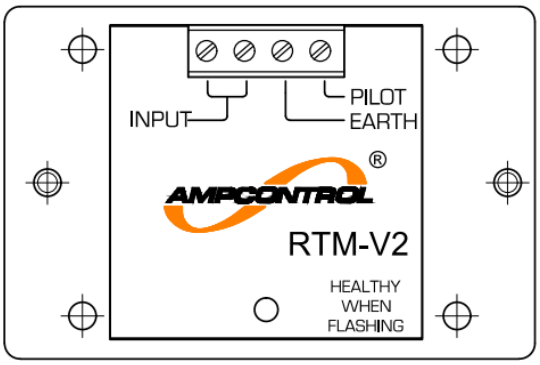


Figure 3.6: Remote Termination Module

3.2.4 Remote Termination Module (RTM) (Optional)

The RTM is an optional component in the IPM system. It is used to terminate the pilot cable in the motor enclosure instead of a diode. When used, the RTM stores the IPM's Group 2 protection settings for that particular motor. This means that the cable supplying the motor can be moved to another outlet without the need to re-configure all of the IPM's protection settings. The RTM also offers a remote start input.

4 INSTALLATION

4.1 General Warnings

These instructions have been designed to assist users of the relay with installation.

Before the relay can be installed, there are a number of things that need to be considered and understood to prevent incorrect or unsafe operation of the relay or the system into which it is installed.

Along with relevant competence, and an understanding of the target application, the following points should be considered.

4.1.1 Ensure that the information provided in this user manual is fully understood.

It is extremely important that the limitations and functionality of the relay are understood to prevent incorrect installation and use from creating a potentially dangerous risk. If in doubt as to the nature of the limitations or their implication, consult a competent authority such as a supervisor or Ampcontrol technical representative.

4.1.2 Ensure that the application into which the relay is being installed has been properly defined, designed and approved.

Any system intended to mitigate the risk of injury needs to be properly designed and implemented. Such a system must be the result of structured risk analysis with the outcomes used to define the system requirements. These requirements, in turn, will guide the choice of instrumentation, logic solvers and actuators needed to implement the system. Understanding the needs of the system will ensure proper selection of equipment.

4.1.3 Ensure that the relay will properly perform the required functions within the system design.

It is important to understand how the relay is intended to interact with other equipment within a system. For safe and reliable use, it is crucial that neither the relays logical operation nor its signalling be compromised by incompatibilities with connected equipment.

4.1.4 Modifications of any form to the relay or accessories are prohibited.

The relay, as supplied, has been designed and manufactured to comply with the requirements of protection standards. If modifications of any form are made to the relay, the equipment may no longer be fit for use. If any modifications or damage to the relay is evident, do not use the equipment and contact Ampcontrol for advice.

4.2 Mandatory Installation Practices

The following information must be adhered to when installing the relay. Failure to adhere to this information may give rise to unsafe operation.

Using the relay in a manner that exceeds its electrical, functional or physical specifications, or in a way that is contrary to its operating restrictions, may create risks to personnel and/or equipment resulting in injury or death.

- The relay must be powered within the specified voltage range.
- The installation of the relay must be carried out by suitably trained and qualified personnel.
- Identification labels fixed to the relay must not be damaged, removed or covered.
- The installation is to be in accordance with the relevant installation Standards/Codes of Practice.
- Modifications must not be made to any part of the relay. As supplied, the unit is built to, and complies with the relevant standards. Modifications to its construction will render the unit non-compliant.
- Complete and accurate records of the installation must be kept as part of the site installation.

4.3 Mechanical Installation Information

4.3.1 IPM V2 Integrated Protection Relay

The IPM relay is a panel mounted relay that requires a 135mm x 135mm square cut out.

There are four mounting brackets and four M5 screws that are supplied with the relay. These brackets slide into the side of the relay after it has been inserted into the cut out. The screws are inserted into the bracket and tightened to secure the IPM to the panel.

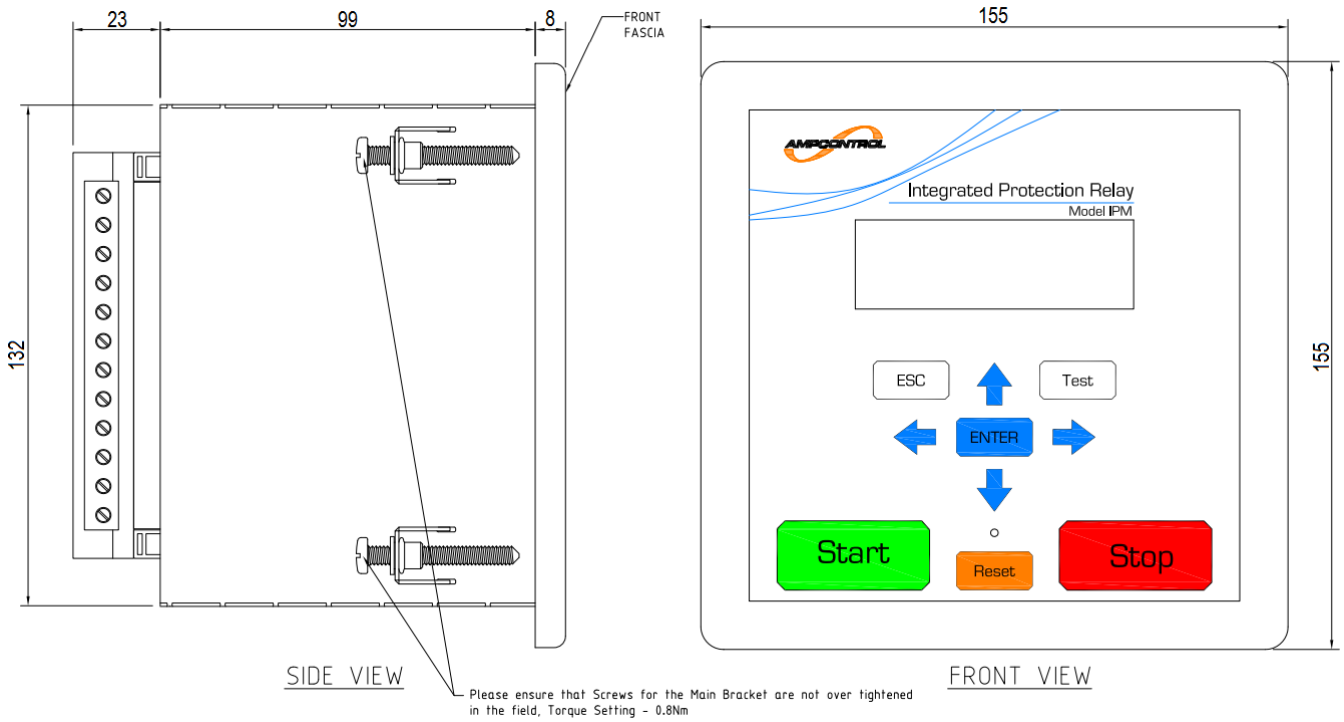


Figure 4.1: IPM Relay Dimensions

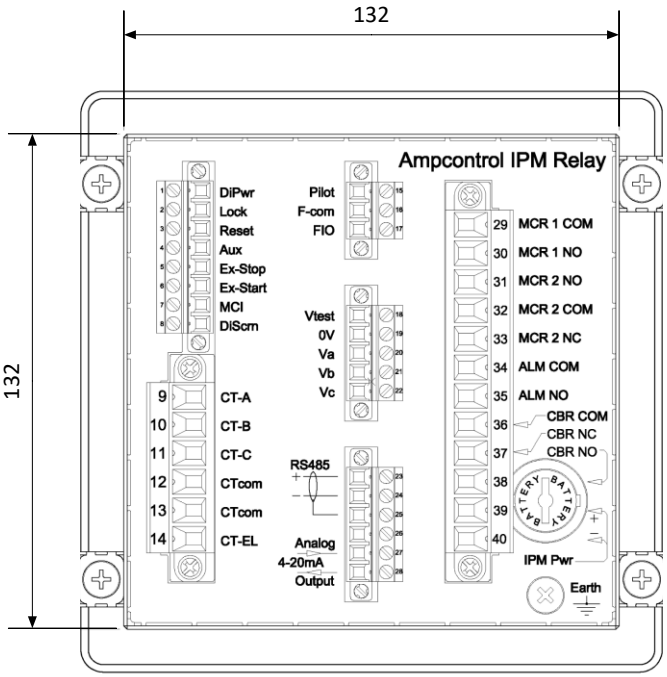


Figure 4.2: IPM Relay Rear Panel Details

4.3.2 Phase Current Transformers (CTs) & EL Toroid

The IPM uses 1000:1 or 500:5 current transformers to monitor the phase current of the outlet.

The IPM uses a 1000:1 current transformer installed around all three phases to monitor the earth leakage current of the outlet.

These current transformers are panel mounted.

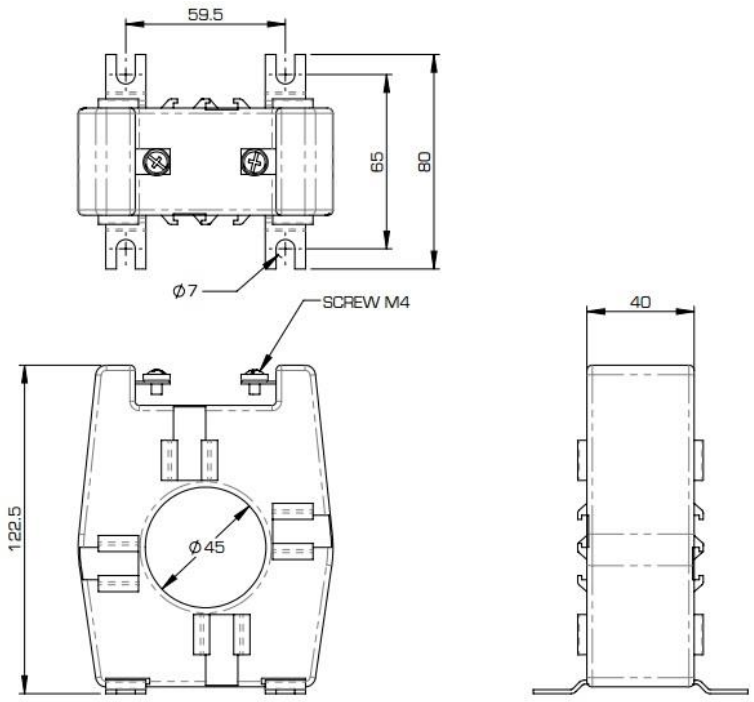


Figure 4.3: Current Transformer 45mm I.D. (Part: 101272) Dimensional Details

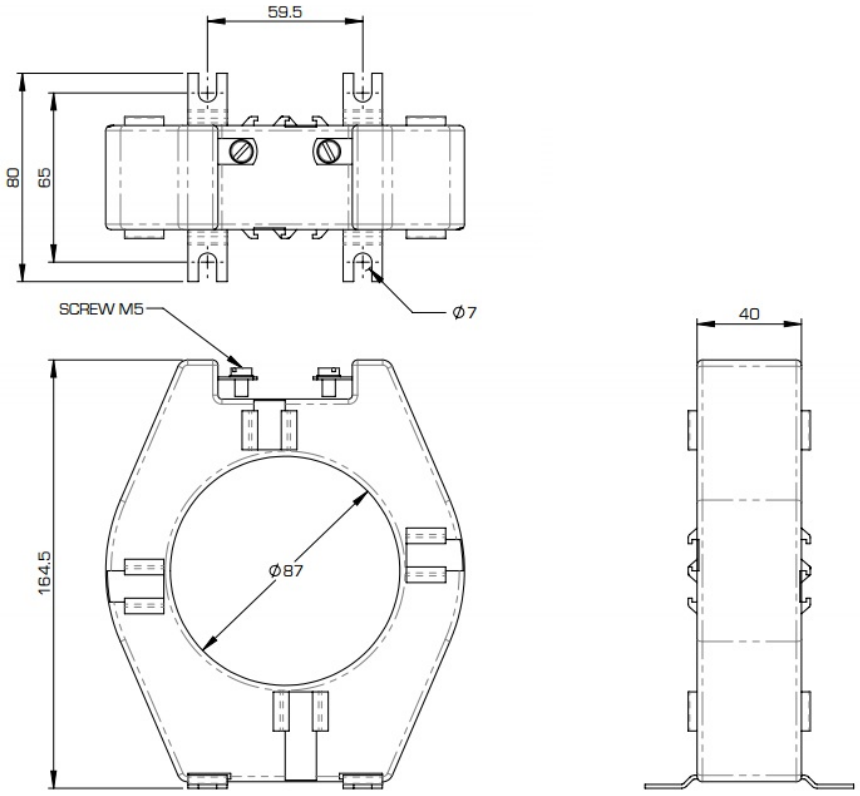


Figure 4.4: Current Transformer 88mm I.D. (Part: 101703) Dimensional Details

4.3.3 Remote Termination Module (RTM)

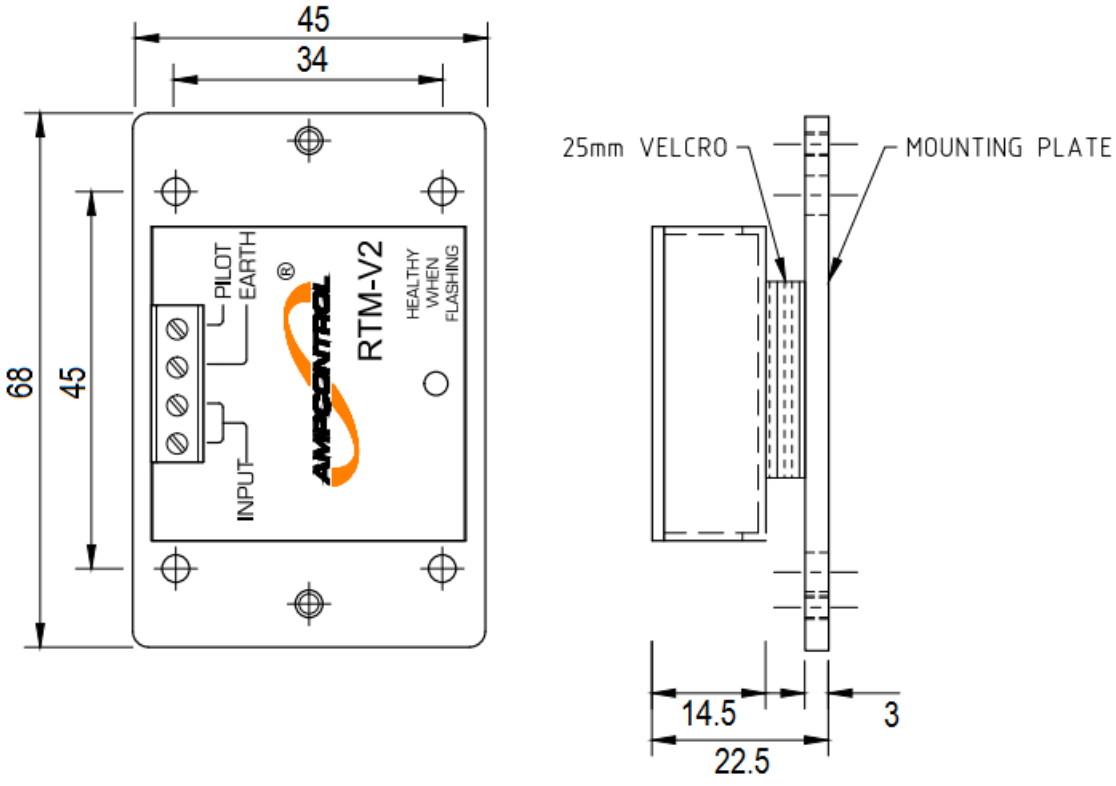


Figure 4.5: RTM Dimensions

4.4 Electrical Installation Information

The IPM relay provides several protection functions and, due to this, has a number of different types of electrical connections. This section will provide details on the wiring and terminations for each of these different types of connections.

The following sub-sections are arranged as per the terminal numbering on the rear of the unit (refer to Figure 4.2 for terminal arrangement).

For an alternate representation of the wiring for the IPM, refer to drawing IPM2E002 in APPENDIX 6: Drawings.

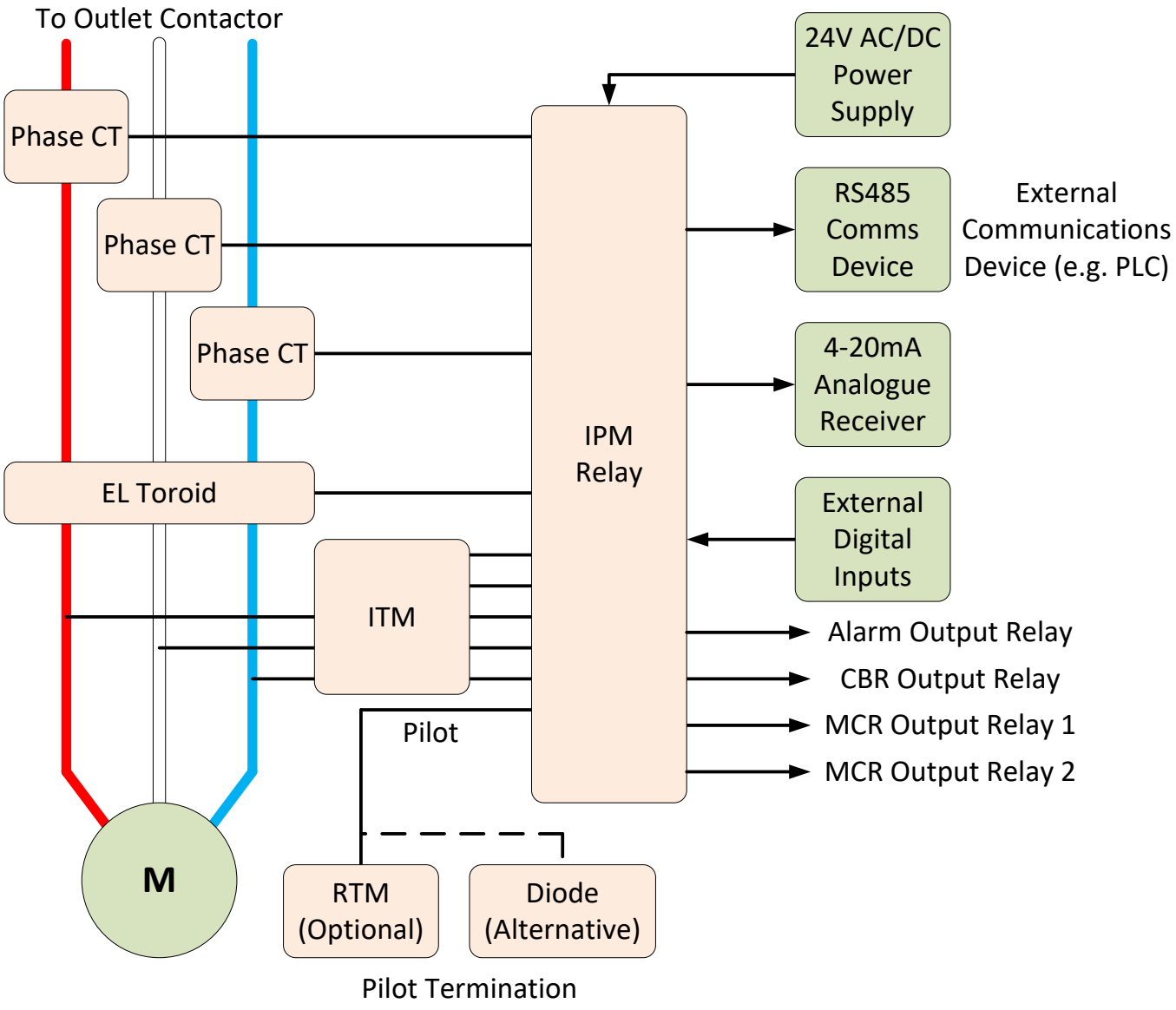


Figure 4.6: IPM Connection Block Diagram

4.4.1 Digital Inputs (Terminals 1, 2, 3, 4, 5, 6, 7 & 8)

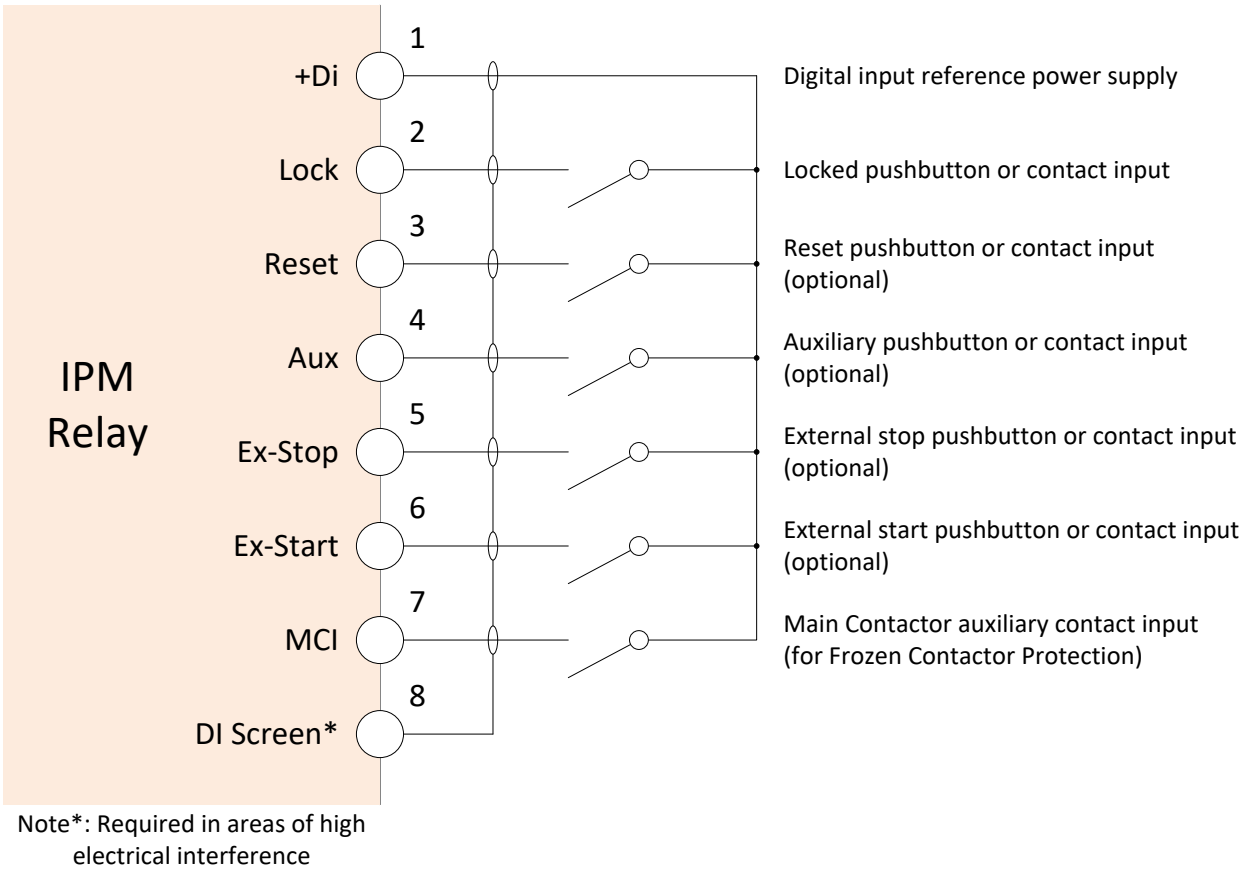


Figure 4.7: IPM Relay Electrical Connections: Digital Inputs

The IPM has a number of digital inputs to allow external devices to interact with the relay. Each of these inputs is activated when it is shorted to the DI+ terminal (1) by a normally open contact or pushbutton.

The MCI input is a special input that is used to monitor the state of the outlet's main contactor for the IPM's frozen contactor protection. Wire a normally open auxiliary contact from the main contactor to this input to allow this function to operate correctly.

For a detailed explanation of the functions of each of these inputs, refer to Section 12.6.1.

The Digital Input (DI) Screen terminal is used to terminate the screens of the cables that are used for the digital inputs.

NOTE

If the IPM is to be installed in areas of high electrical interference, it is recommended that the wiring for the digital inputs be run in **screened cables**.

4.4.2 Phase Current Transformers (Terminals 9, 10, 11 & 12)

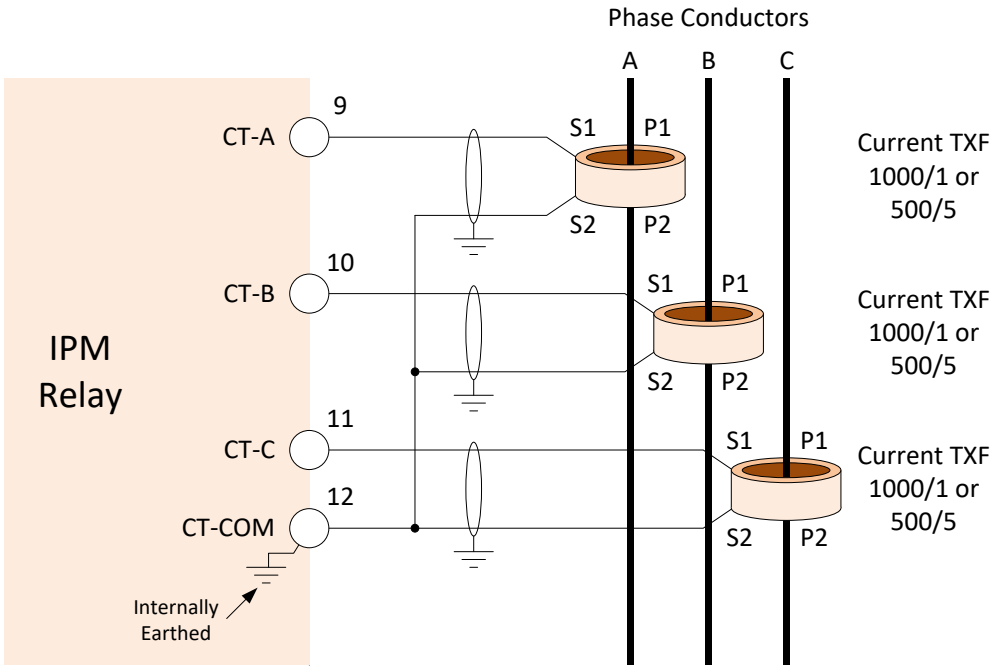


Figure 4.8: IPM Relay Electrical Connections: Phase Current Transformers

The IPM relay measures the individual phase currents of the outlet, using current transformers, to provide input for a number of its protection functions. Current transformers should be wired to the IPM in twisted pairs with an overall screen.

Current transformers are not ideal devices and if correct procedures are not followed during installation, nuisance tripping can result. An ideal CT would have all the flux from the wire contained in the core and so would accurately detect any change in current. A real CT has “leakage fluxes”. That is, a very small proportion of the total flux is not contained in the core, but in the space outside it and as result reduces sensitivity of the CT. The positioning of the cables also plays a part in this effect.

The size of the error will vary from CT to CT, even those of the same type and size because of slight differences in the core and symmetry of the windings.

To avoid nuisance tripping and false readings, consider the following during installation:

1. Keep cables as close to the centre of the toroid as possible. Do not tie them to one side of the toroid. Remember to aim at symmetry.
2. Do not bring the cables back past the toroid within one diameter of the CT, trying to cram cables into a small space reduces symmetry and may lead to problems, which are difficult to solve.
3. Avoid placing the CT near any device, which produces magnetic fields - whether it is a transformer or other cables. Try to maintain several CT diameters clearance.
4. Many small cables tend to be worse than say three large ones. Try to position the CT in the circuit with this in mind.
5. Select the smallest internal diameter CT to suit the cable size.

NOTE

The two CT-COM terminals (12 & 13) are internally connected and are joined to earth.

4.4.3 Earth Leakage Toroid (Terminals 13 & 14)

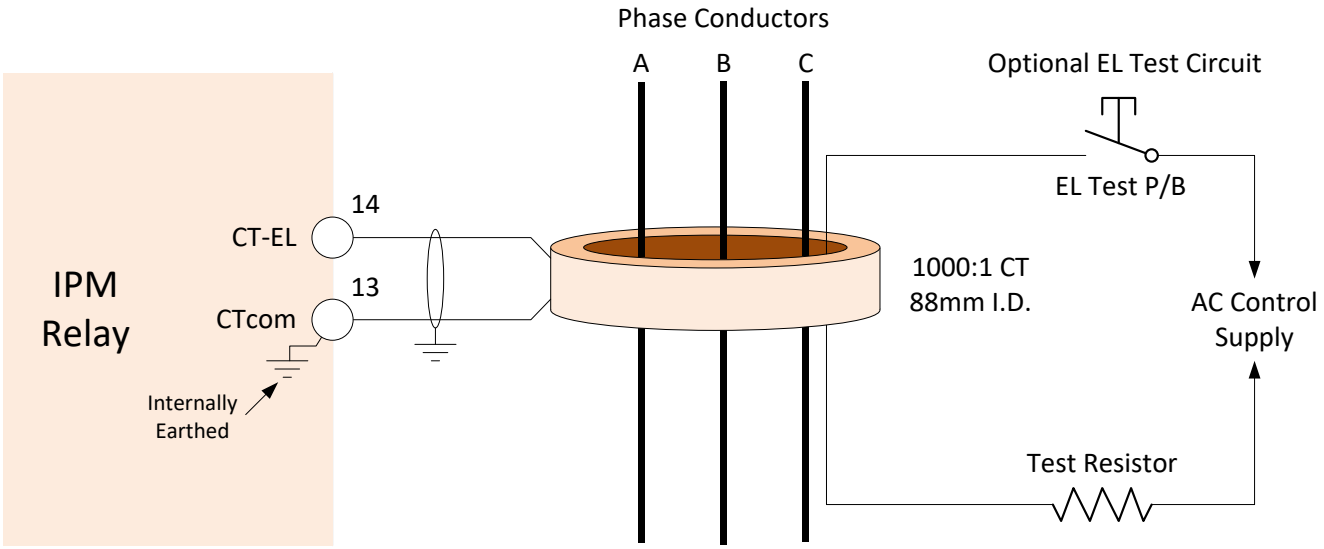


Figure 4.9: IPM Relay Electrical Connections: Earth Leakage Toroid

The IPM relay measures the earth leakage current using a summation toroid to provide input for the earth leakage protection function. The toroid should be wired to the IPM using a twisted pair cable with an overall screen.

NOTE

For general information on the installation of CTs and earth leakage toroids, **refer to Section 4.4.2**.

The earth leakage protection function can be tested by connecting an **AC supply** through the earth leakage toroid, via a test pushbutton and a resistor. The resistor must be selected to ensure that the earth leakage protection trips as required.

4.4.4 Earth Continuity (Terminal 15)

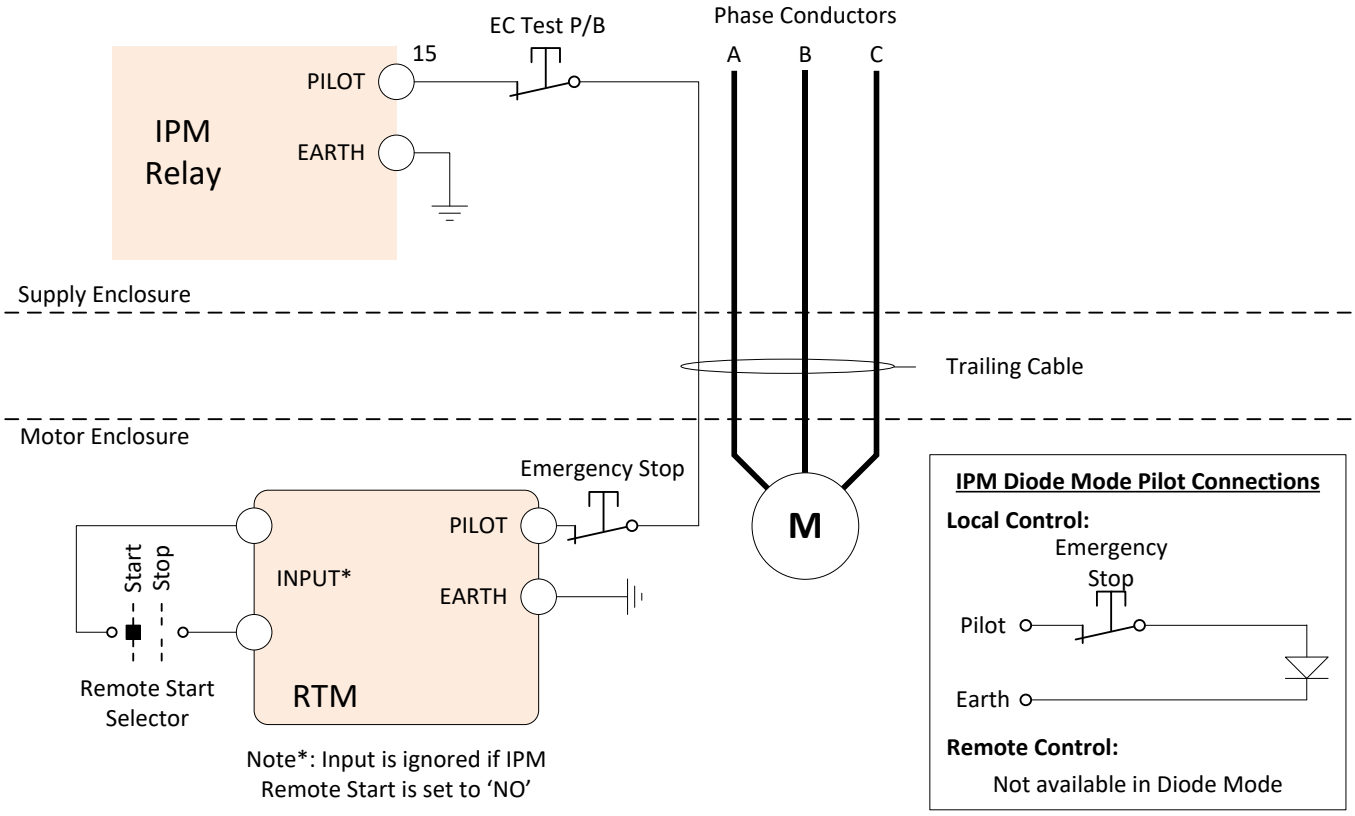


Figure 4.10: IPM Relay Electrical Connections: Earth Leakage Toroid

The Pilot terminal (15) is to be wired to the pilot core of the outlet's cable. The IPM monitors the presence of either a termination diode, or an RTM, that is installed in the motor enclosure to ensure that there is a continuous earth connection between the supply enclosure and the motor enclosure via the outlet cable. The magnitude of the pilot/earth return loop impedance is also monitored via this terminal.

In order for the earth continuity protection to function correctly, ensure that the earth connection is correctly installed to the IPM.

If an RTM is connected, and the IPM set to remote start mode, then a remote start can be requested by closing the input on the RTM. The input must remain closed whilst the motor is running. A stop will be initiated if this input becomes open circuit.

WARNING!

The Remote Input on the RTM is not to be used for an emergency stop function. **Emergency stop pushbuttons should be wired into the pilot circuit**. A normally closed contact with a contact monitoring block should be considered.

NOTE

Remote Start is not available if the IPM is used in Diode Mode.

4.4.5 Terminals 15 & 16

Do not connect. These terminals are unused in this version of the IPM relay.

4.4.6 ITM Interface (Terminals 18, 19, 20, 21 & 22)

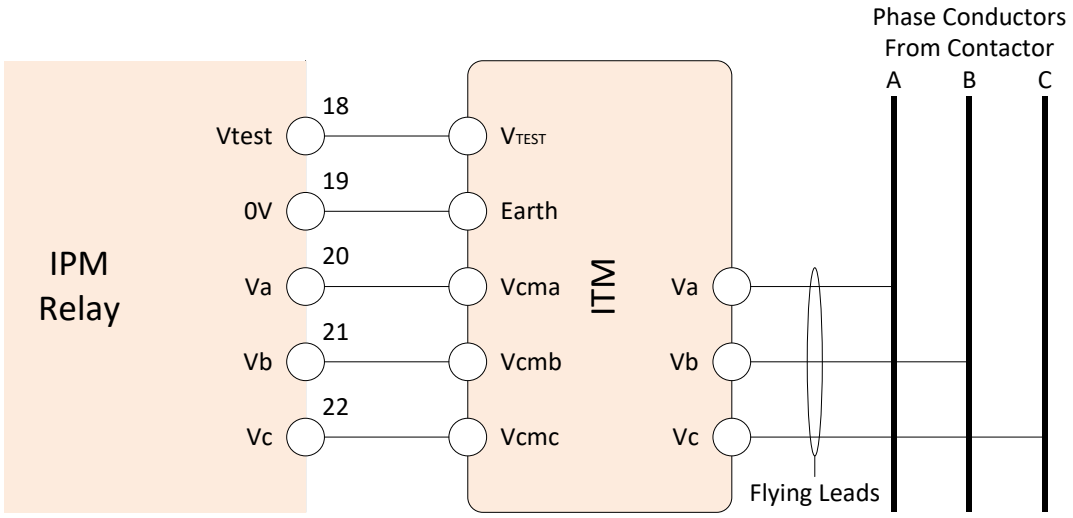


Figure 4.11: IPM Relay Electrical Connections: ITM

The Insulation Test Module (ITM) is a resistor barrier, which interfaces between the power circuit and the IPM relay. It also provides a manual and automatic High Voltage DC 'Insulation Test'. The ITM is housed in an encapsulated module.

Terminals 20, 21 and 22 provide the voltage measurement feedback for the IPM relay from the power circuit.

Terminal 19 provides the earth connection between the IPM and the ITM.

Terminal 18 on the IPM is the 'Vtest' output of the IPM relay. The IPM will energise this output when the high voltage DC insulation test is being undertaken, providing a source for the high voltage generation in the ITM.

4.4.7 RS485 Communications Port (Terminals 23, 24 & 25)

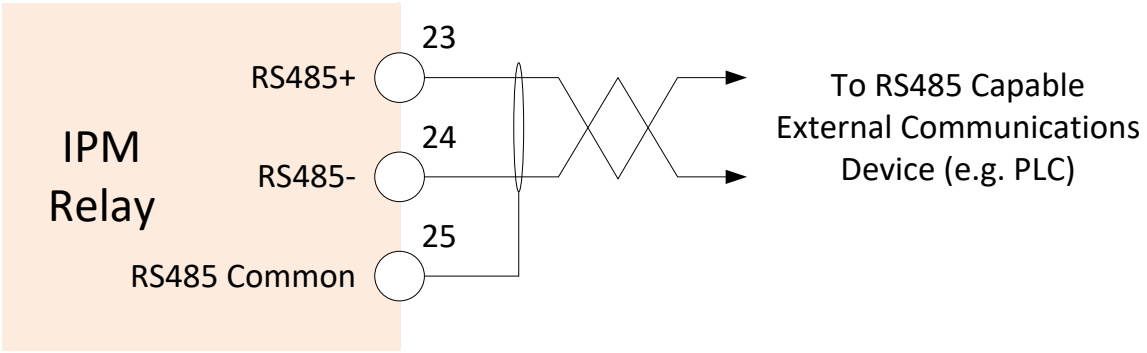


Figure 4.12: IPM Relay Electrical Connections: RS485 Connections

RS485 connections should be wired in screened twisted pair. The screen of the twisted pair cable should be terminated into terminal 25 of the IPM relay.

4.4.8 Terminal 26

Do not connect. This terminal is unused in this version of the IPM relay.

4.4.9 Analogue Output (Terminals 27 & 28)

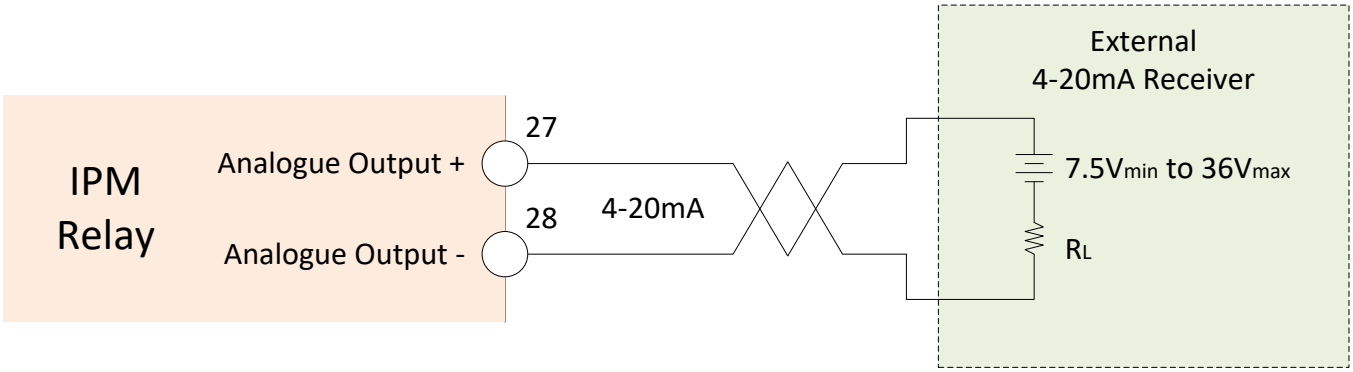


Figure 4.13: IPM Relay Electrical Connections: Analogue Output

The IPM relay is provided with a 4-20mA analogue output. It is provided with a wide ranging DC voltage input at 7.5VDC to 36VDC.

4.4.10 Output Relays (Terminals 29, 30, 31, 32, 33, 34, 35, 36, 37 & 38)

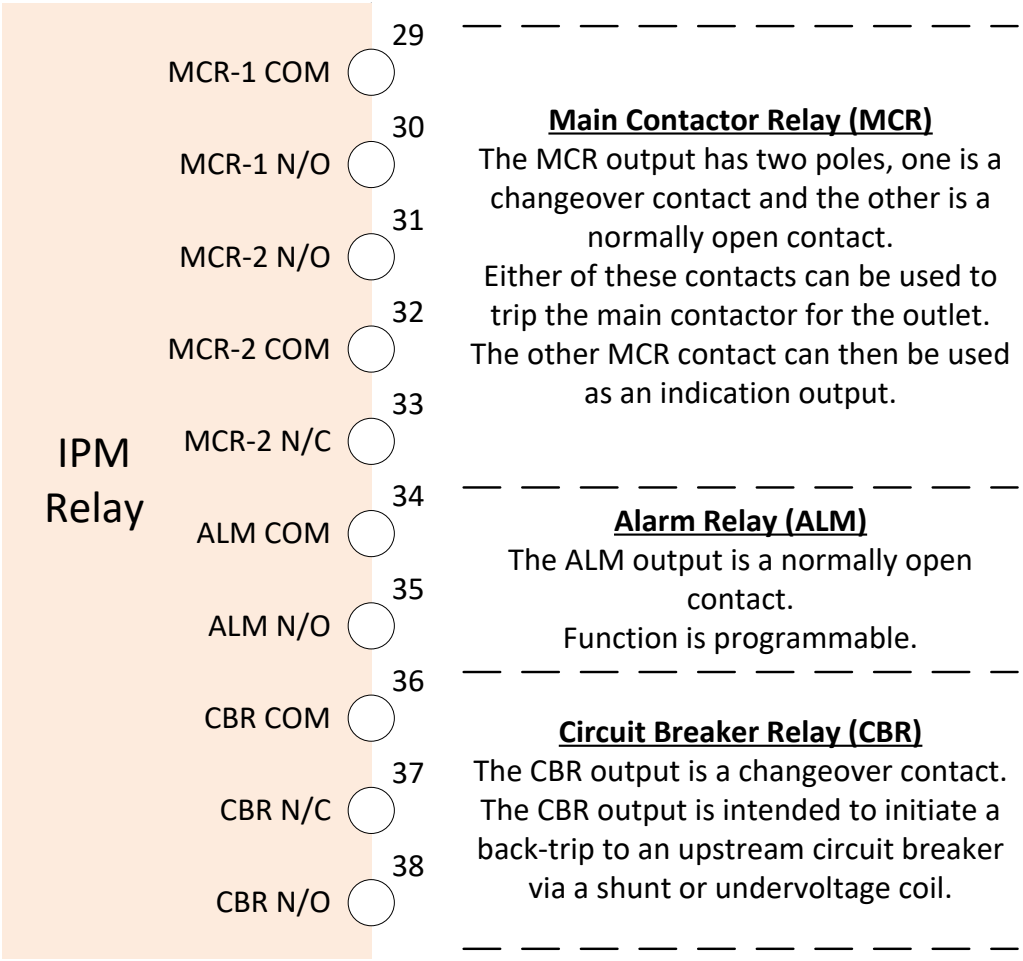


Figure 4.14: IPM Relay Electrical Connections: Output Relays

The IPM relay has three (3) different types of output relays. The Main Contactor Relay (MCR) is intended to open and close the outlet's contactor as part of its control and protection functions. The Alarm Relay (ALM) can be programmed to close at specified alarm points for different protection functions. The Circuit Breaker Relay (CBR) is intended to provide a back-trip to an upstream circuit breaker for faults such as frozen contactor and short circuit.

4.4.11 Power Supply (Terminals 39 & 40)

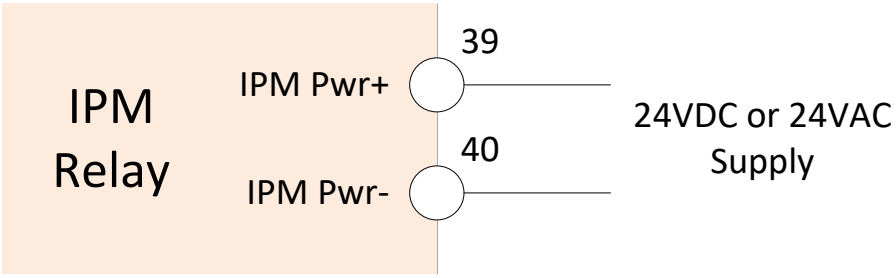


Figure 4.15: IPM Relay Electrical Connections: Power Supply

The IPM can be supplied by either 24VAC or 24VDC.

4.4.12 Chassis Earth Connection

The earth connection on the rear of the IPM relay is a bolted connection. An earth conductor should be secured to the chassis of the IPM using a ring lug.

5 COMMISSIONING AND CALIBRATION

Prior to being put into service, the electrical protection system must be correctly commissioned. This manual does not cover system commissioning; the full scope of commissioning tests should be determined during the risk assessment or FMEA covering the design of the electrical protection system.

The following tests can provide guidance on checking the correct operation of the relay during commissioning. This is not intended to provide an exhaustive commissioning checklist, but should be considered to be a minimum set of tests.

5.1 Earth Leakage

Test the correct operation of earth leakage circuits by injecting a fault current through the toroid. Ensure that all relevant tripping circuits operate successfully and that latched trips may be reset in the appropriate manner.

5.2 Earth Continuity

Test that the Earth Continuity protection is operational by creating an open circuit on the pilot wire. Ensure that all relevant tripping circuits operate successfully and that latched trips may be reset in the appropriate manner.

Repeat with a short circuit between the pilot and earth.

5.3 Insulation test

Ensure that a manual insulation test can be successfully conducted via the IPM.

Also check that an automatic insulation test is initiated by the IPM when a START signal is generated.

5.4 Over Current / Motor Overload Current Injection

Test the Over Current / Motor Overload protection by carrying out secondary injection on the CT terminals of the IPM.

Where Over Current protection is employed, inject 2x FLC (Full Load Current) into one of the CT terminals and ensure that all relevant tripping circuits operate successfully, in the time expected according to the settings employed, and that latched trips may be reset in the appropriate manner. Repeat on the second set of CT terminals and the third set of CT terminals.

If Motor Overload is used, check that all relevant tripping circuits operate successfully, in the time expected according to the settings employed, and that latched trips may be reset in the appropriate manner.

5.5 Short Circuit Current Injection

Test the Short Circuit protection by carrying out secondary injection on the CT terminals of the IPM.

Inject a current value relevant for the settings employed into one of the CT terminals and ensure that all relevant tripping circuits operate successfully, in the time expected, and that latched trips may be reset in the appropriate manner. Repeat on the second set of CT terminals and the third set of CT terminals.

5.6 Current Detection in CTs

Ensure the integrity of the current-detection CTs by injecting primary current into the CT aperture and validating the reading on the IPM screen.

5.7 Main Contactor Fail (MCF)

Validate the correct operation of the ITM and MCF protection by applying a voltage on the load side of the contactor. The voltage must be >10% of the rated voltage of the ITM. Ensure that a CBR trip is initiated by the IPM which can only be reset by performing a locked reset.

5.8 Voltage Measurement

Validate the voltage measurement function of the IPM by checking the measured voltages on the IPM screen when the main contactor is closed.

5.9 RS485 Interface

The correct operation of the RS485 interface is determined by polling the IPM relay from a RS485 capable device.

5.10 RTM (if Installed)

Validate the correct operation of the RTM by making changes to Group 2 settings, moving the machine to a different outlet and ensuring that the correct settings are available on the new outlet.

5.11 Lock, Reset, Aux, Ex-Stop, Ex-Start & MCI Inputs

Ensure that the digital inputs to the IPM are operating correctly by operating each of the inputs and ensuring that the IPM functions as expected.

6 EARTH PROTECTION FUNCTIONS

The IPM relay provides the following earth protection functions:

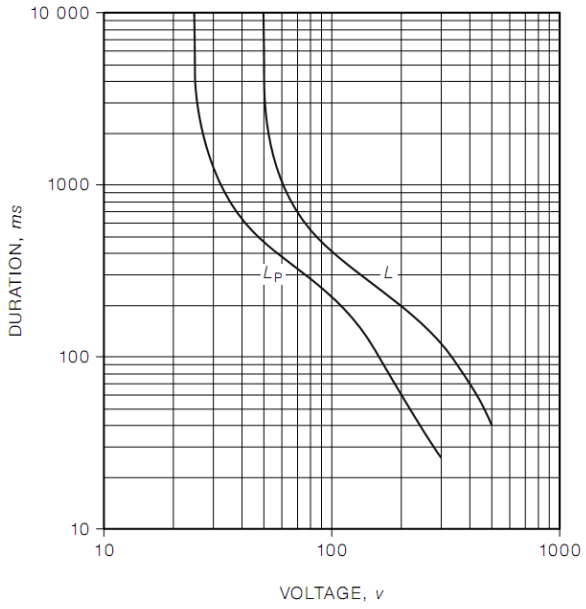
- Earth Leakage
- Insulation Test
- Earth Continuity

6.1 Earth Leakage

6.1.1 Introduction

Protection systems are defined in AS/NZS 2081 for use in fault limited systems. This standard describes the requirements of Earth Leakage protection to initiate a trip of the circuit interrupting device when a selected value of earth fault current is exceeded for a certain amount of time.

All protection systems must comply with this standard as stated in AS/NZS 4871, which sets out the general requirements for the design, construction and testing of electrical equipment directly associated with mining and quarrying activities. Part of these requirements includes designing for electrical faults, and the standard outlines the safe touch potential which must be considered in electrical protection design. Acceptable touch potential levels are described using a series of curves as shown in Figure 6.1.



L	for normal conditions	touch voltage limit 50 V
L_P	for wet conditions	touch voltage limit 25 V

NOTE: This curve is derived from AS/NZS 3000 and is based on a typical set of conditions and body resistance values.

Figure 6.1: AS/NZS 4871 Safe Touch Potential Levels (Figure C1 from the standard)

The IPM V2 relay's earth leakage protection function has been designed in accordance with AS/NZS 3190 – Approval and Test Specification – Residual Current Devices (current-operated earth-leakage devices). Given this, it is important to consider the performance of the earth leakage protection provided by the IPM V2 and assess how the relay's performance compares with the requirements of AS/NZS 2081. Testing was completed to assess the ability of the IPM V2 relay to trip within acceptable levels.

The results for the earth leakage tripping times of the relay are detailed in APPENDIX 1: IPM Earth Leakage Tripping Curves. These results show that the tripping times are well within those specified by the relevant standards. The tripping times reduce for higher fault currents, improving the performance of

the relay.

Figure 6.2 summarises the trip times which can be expected when the trip time is set to be ‘Instantaneous’, for increasing fault currents at different trip levels.

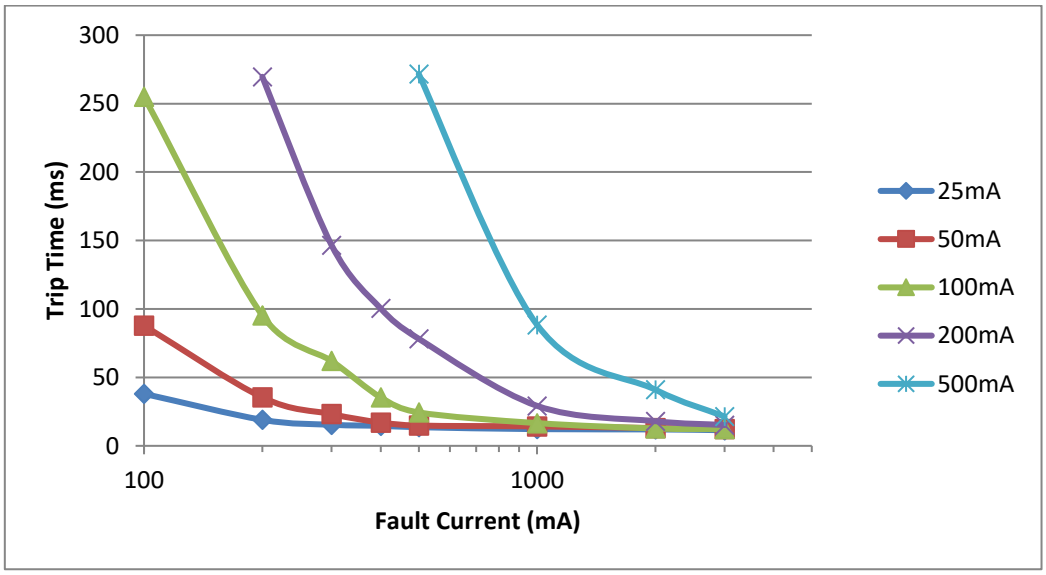


Figure 6.2: Instantaneous trip times for a selection of device trip level settings

6.1.2 Earth Leakage Protection Function

The earth leakage protection function uses a 1000:1 core balance toroid to measure the earth fault current. A Residual Current Device (RCD) operating characteristic is provided with adjustable trip sensitivity and time delay.

The % leakage current is displayed on the 'Current and Voltage Information’ page (Level 2, Screen 2) as ‘Ie’ shown as a % of the selected trip level. When the leakage reaches 100% a trip occurs. For timing of the trip refer to APPENDIX 1: IPM Earth Leakage Tripping Curves. As discussed above, the higher the fault current measured the faster the trip response.

To reset the relay depends on the RCD Reset Lock setting (in group 1 settings page 8). If off, the user can reset the relay by operating the reset key/digital input. If the setting is on, the user is required to activate the lock input before operating the reset key/digital input.

The trip level is selected via the ‘RCD Trp. Level’ setting (Level 6, Screen 13) and is adjustable between 25mA and 500mA and off.

The time delay is selected via the ‘RCD Trp. Time’ setting (Level 6, Screen 14). Settings are instantaneous and adjustable between 50ms and 150ms.

6.2 Insulation Test

The IPM Relay can provide an automatic High Voltage ‘Insulation Test’. A manual ‘Insulation Test’ is also provided.

An Insulation Test Module (ITM), which is a resistive isolation device, is used to interface the power conductors to the IPM Relay. Modules are selected in the Group 1 Settings ‘ITM Module’ (Level 5, Screen 2) for rated line voltages of 415V and 1000V.

The ITM is the preferred isolation module and must be used when the ‘Insulation Test’ function is required.

When “None” is selected the IPM Relay does not provide ‘Insulation Test’, or voltage functions.

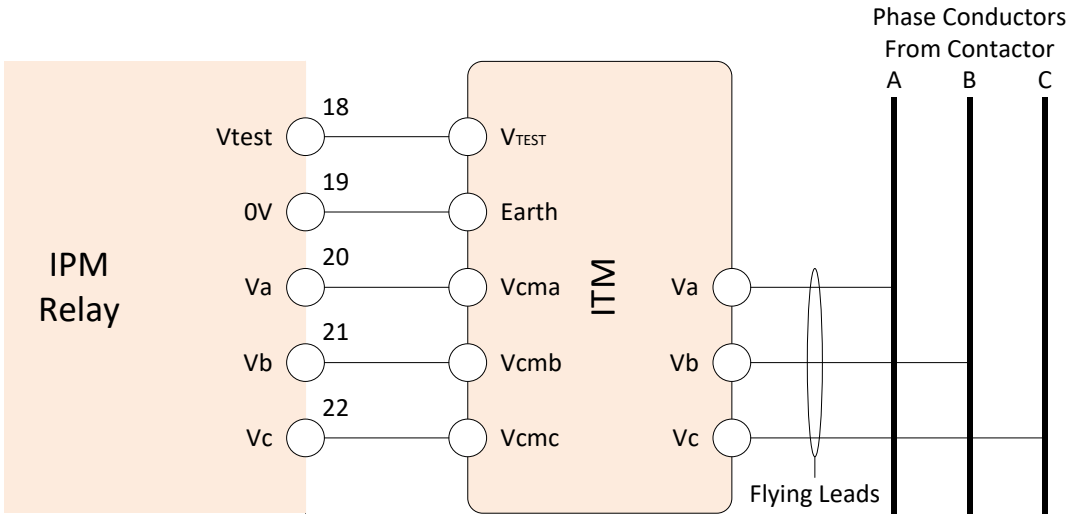


Figure 6.3: ITM Insulation Test Connections

6.2.1 Automatic Insulation Test

If an ITM Module has been selected, in the adjustable Group 1 Settings and a trip level has been set in the adjustable Group 2 settings, then an automatic High Voltage DC 'Insulation Test' is initiated by operation of the start button once all starting conditions are met.

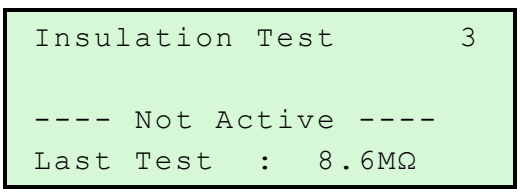
The HV DC 'Insulation Test' commences when the IPM Relay applies voltage to the 'Vtest' terminal of the relay for a period of 2 seconds. This applies 30VDC to the ITM Module. A HV DC voltage is generated in the ITM Module, which applies a voltage of 500V for 415V operation and 820V for 1000V systems, between each phase and earth.

The IPM Relay measures the resistance to earth for all phases in parallel. At the end of the test the result is stored in the Event Log as 'It:X.XMΩ' If the resistance value is above the pre-set threshold the MCR Relay picks up allowing the outlet to be energised. Additionally, if the result is equal to or below an Alarm Level (typically 1.5 times the selected trip level) the status message 'Insulat.Test Alarm' is displayed on the Status Page (Level 1, Screen 1).

Table 1: Pre-set Resistance and Alarm Thresholds

Ins. Tst. Level: Selection MΩ	Alarm Level MΩ
1.0	1.5
2.0	3.0
5.0	7.5
10	15
20	30
None	None

If the value is less than the pre-set trip level a trip occurs and is latched and saved in a non-volatile memory. To reset the relay following an insulation test fail trip, operate the reset button.



- L3: Indicates the status of the insulation test.
- L4: Displays the insulation resistance as a result of the test and is retained in memory until the next test is carried out.

The trip level is set at 'Ins.Tst.Level' page (Level 6, Screen 18) and is selectable.

If the 'Insulation Test' is not selected by setting the 'ITM Module' value to "None" then the MCR Relay closes by operation of the start button.

6.2.2 Manual Insulation Test

A manual "Insulation Test" is provided as a maintenance/fault finding tool. The manual test can only be carried out when the load is not energised. A manual insulation test is also prevented when operating in snore mode.

Before a manual Insulation Test can be performed the following conditions must apply:

1. The Insulation Test page being displayed. This is located on the 'Insulation Test' screen (Level 3, Screen 2).
2. Pilot must be healthy (and any previous trips reset).
3. Insulation Test function must not be tripped.
4. Outlet must not be running.
5. Outlet must not be in the process of 'closing'.
6. Outlet must not be 'Paused'.

When the above conditions are met the <TEST> key must be pressed and held (for the duration of the test). After 3 seconds the manual insulation test is initiated. The test voltage is applied to the outgoing feeder while ever the above conditions are held (including holding the <TEST> key). The test results are continuously calculated and displayed. The operator should maintain the test at least long enough for the readings to stabilise, this being a function of the cable length. Once the test is completed (usually by releasing the <TEST> key) the results are held in memory until another insulation test is commenced either manually or as part of the starting sequence, or IPM control power is lost.

If the 'ITM Module' has been set to "None" then the manual test will not function.

The status of the manual insulation test is shown on the Insulation Test Screen (Level 3, Screen 2).

The three functions shown on the screen are 'Not Active', 'Arming Man.Ins.Test' and 'Manual Insulat. Test'.

The display will show the last measured value.

6.3 Earth Continuity

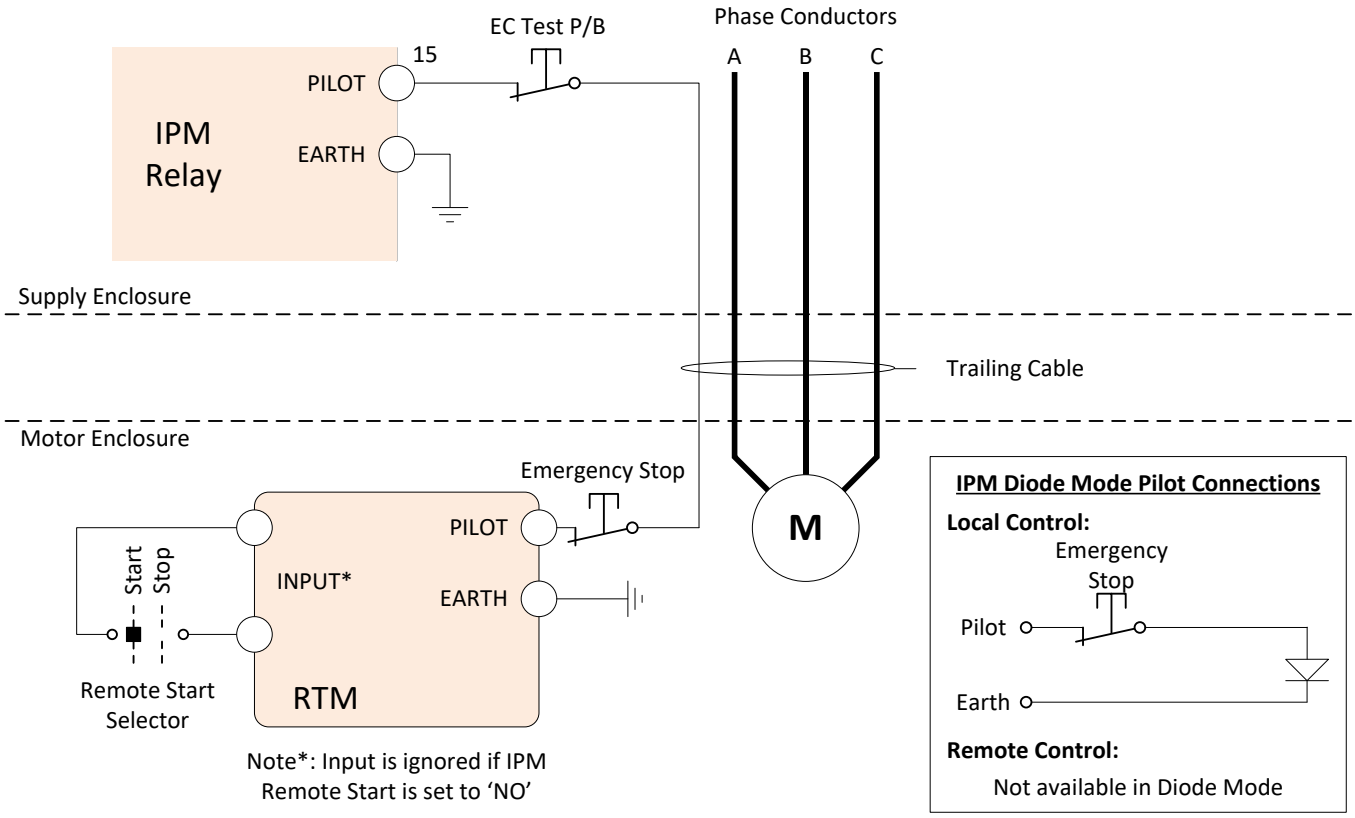


Figure 6.4: Earth Continuity Connections

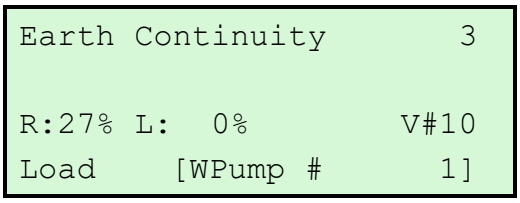
The Earth Continuity function tests for the continuity of the earthing between the outlet and the machine, via the pilot core in the trailing cable. The pilot core is also used to transfer data when a Remote Termination Module is used to achieve Machine Data Transfer.

The IPM relay can be configured to operate in either diode or RTM mode. The mode is selected in 'EC Pilot Mode' (Level 5, Screen 1) and determines what terminating device the relay is looking for on the pilot.

NOTE

The Remote Termination Module will only be recognised by an IPM Relay and will not be seen as a diode by other earth continuity devices.

The relay measures the resistance of the pilot - earth loop and the leakage between the pilot and earth conductors. The leakage measurement ensures that pilot to earth faults are detected. If the pilot - earth loop resistance exceeds 45Ω a trip occurs which in turn opens the main contactor control circuit. The fault can be configured as latching or non-latching. This allows the user to determine if the fault is manually or automatically reset once the pilot - earth loop resistance is less than 45Ω. The selection is either 'EC Trip Latch: On' or 'Off" (Level 6, Screen 17). To manually reset the relay, operate the reset button.



- L3: Shows the earth continuity resistance (R) of the pilot – earth loop and the leakage (L) between the pilot and earth conductors as a % of the trip levels. When either value reaches 100% a trip occurs. The version of the software is also indicated.
- L4: Shows the Load Type and Number (from the connected RTM unit).

Pilot Trip Time is adjustable to allow for operation in noisy electrical environments. The trip times can be selected at 'Pilot Trip t' (Level 6, Screen 15) and can be set to 80, 120, 160, 200, 300, 400 and 500ms.

The leakage trip setting is fixed at 1850Ω.

Clause 5.3 of AS/NZS 2081 requires total clearance trip times <500mS, this includes interposing relays, contactors and circuit breaker opening times. An EC trip time of up to 500mS is entirely appropriate where touch potentials are managed appropriately, however in all cases the EC trip time should be as low as is reasonably practical.

The purpose of earth continuity protection is to continuously monitor the integrity of the return earth resistance. The earth continuity protection relay cannot explicitly monitor the return earth resistance alone, and instead monitors the resistance of the pilot-earth loop. In all cases, the resistance of the pilot-earth loop will be higher than the return earth resistance itself, and so is conservative. That is, the return earth resistance can be no higher than the trip setting of the earth continuity relay.

There are two aspects to earth continuity monitoring:

(1) To actively remove power from an outlet in case of live uncoupling, and;

(2) To monitor incremental changes in the resistance of the earth return path to ensure that leakage currents under both normal and fault conditions do not result in dangerous touch voltages.

The IPM relay meets the requirements of AS/NZS2081 which sets a limit on the maximum clearance time that can be utilised for earth continuity protection of 500ms. This specifically addresses the risk associated with live uncoupling. That is, in restrained receptacles suitable for mining applications the pilot pin disengages before the earth connection and the upper limit of 500ms removes power before a user can practically complete disconnection and inadvertently come into contact with live exposed connections or generate a hazardous electrical condition.

Similarly, incremental changes in the return earth resistance can occur over time through the normal process of coupling and uncoupling electrical connections and the ingress of dust and contaminants as mining progresses. The electrical distribution system will be designed so that the worst case touch potential under fault conditions is developed with the upper limit of return earth resistance set by the earth continuity trip resistance. It should be noted that a modest increase (even an increase above the trip setting) of earth return resistance is not immediately dangerous in the majority of situations – a touch potential is normally only generated in case of an earth fault. Unlike an earth leakage clearance time, there is no requirement that the earth continuity trip time be instantaneous, nor is there a defined link between EC clearance time and significantly improved safety outcomes. Under Australian Standards earth continuity protection trip times <=500ms are generally acceptable and will normally meet the requirements of (1) & (2) for most applications.

The trip time for earth continuity should be chosen in the same way as an earth leakage trip current setting. In all cases, the earth leakage trip current should be as close as possible to the normal (non-fault) EL current that does not cause a nuisance tripping. Similarly, the earth continuity trip time should be as low as practical to not cause a nuisance trips. In low noise applications (eg: simple DOL motors

and linear loads) practically achievable clearance times will be less than 200ms. In higher noise applications (eg: Soft starters, variable speed drives and non-linear loads) higher clearance times up to 500ms may be necessary and can be shown to be safe.

Please note, excessive noise on the pilot-earth loop (as monitored by the EC protection relay) can be indicative of a standing touch potential or another undiagnosed operating difficulty. Where EC trip settings above 200ms are required to avoid nuisance tripping Ampcontrol recommends the source of noise (and so the electrical distribution system design) is properly investigated to ensure the system is safe.

7 CURRENT RELATED FUNCTIONS

The IPM relay uses a current transformer on each of the three phases to monitor the line currents. The measured currents are used to implement the following protection functions:

- Overload Protection
- Short Circuit Protection
- Phase Current Balance
- Residual Current Balance
- Under Current Trip

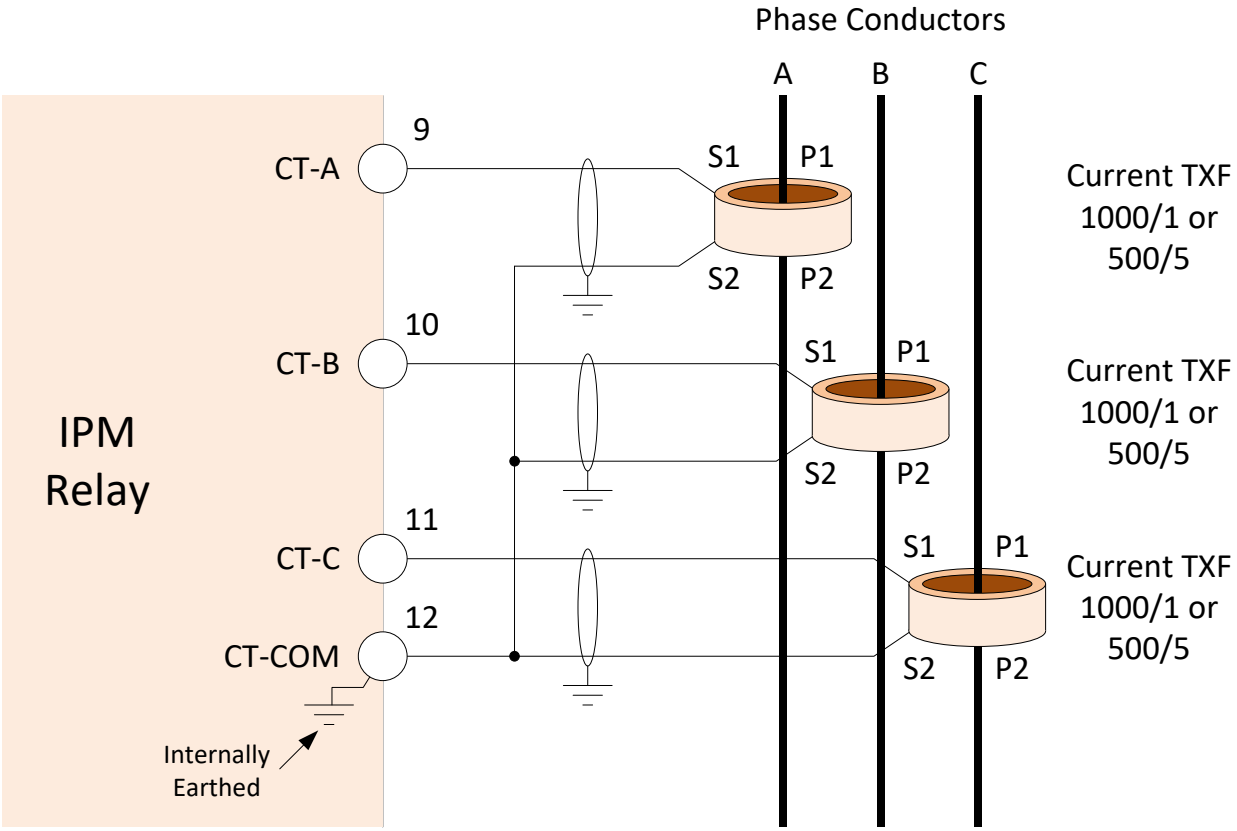


Figure 7.1: IPM Phase CT Connections

7.1 Overload Protection

The motor overload function is based on a thermal model of the motor. The three phase currents are squared to provide the I^2R heating input to the motor model. The selected 'Stopped Cooling Ratio' determines the cooling output for the model.

The state of the thermal model is shown by the 'Thermal Accumulator', which can be viewed on the 'Current/Volts Information' level on the display. The thermal accumulator represents the motor temperature. When the accumulator reaches 100%, a Motor Overload Trip occurs.

The full load current is selected via the '100% Current' setting (Level 6, Screen 2) and can be set between 0.5125A and 640A in 448 steps. See the Appendix section of this manual for the respective Full Load Current Selection tables for a 100:1 CT or 1000:1 CT.

The trip time is selected via the 'O/L Trp t @ 6x' setting (Level 6, Screen 6). It is a function of the current and the selected trip time curve. Refer to APPENDIX 6: Drawings for details of the motor overload and short circuit trip times.

The fifteen (15) motor overload curves allow trip settings from 3 to 40 seconds at six (6) times FLC and are shown for both cold and hot conditions. The hot curve corresponds to the trip time after the motor has been running at the selected full load current indefinitely.

The trip time can be calculated as follows:

$$Trip\,Time = C\ x\ 31.53 \times \ln\left[\frac{I^2 - \frac{1.1238A\%}{100}}{I^2 - 1.1238}\right]$$

Where:

C = Curve Selected

I = Current (FLC = 1)

A% = Initial Thermal Accumulator Value

NOTE

For Cold Start A = 0% and on Hot Start, A = 89%.

The motor manufacturer's data should always be consulted to select the appropriate settings for the motor being protected. Typically, the capacity of a cold motor is given at six times its rated current.

The IPM Relay's trip curves can then be used to select the trip time curve, which best suits the motors overload capacity.

The motor overload trip latches once the thermal accumulator reaches 100% and can only be reset once the thermal accumulator falls below a pre-set value. The pre-set value is selected via the 'O/L Rst Level' setting (Level 6, Screen 8) and can be set to 30%, 40%, 50%, 60%, 70%, 80%, 90%, A-30%, A-40%, A-50%, A-60%, A-70%, A-80%, A-90%. The "A-"settings automatically reset a motor overload trip once the thermal accumulator falls below the set value. Otherwise the trip has to be reset manually by pressing the keypad 'RESET' button or activating the 'RESET' digital input once the thermal accumulator has fallen below the set value.

An emergency restart on a hot motor can be achieved by zeroing the thermal accumulator memory. This is done by closing the Lock input and Reset key/digital input simultaneously for 1.5 seconds.

CAUTION!

Repeated restart attempts in this condition may damage the motor

The 'Stopped Cooling Ratio' modifies the cooling output of the thermal model when the motor is stopped. This can be used to account for reduced cooling capacity of the motor when it is not running (motor run status monitored via MCI digital input).

The ratio is selected via the 'O/L cool mult' setting (Level 6, Screen 7) and is adjustable from 1.0 to 5.0. A cooling multiplier of 1 means the cooling is independent of whether the motor is running or not – for example, a water-cooled motor. Protection for a fan-cooled motor is based on a setting of 2.5, however, for the best protection consult the motor manufacturer.

7.2 Short Circuit Protection

The short circuit function has a definite time characteristic. If the current exceeds the selected level for the pre-set time then a trip occurs. The short circuit function trips the CBR relay (the CBR relay is normally energised, and drops out when tripped).

The short circuit trip level is selected via the 'Short Cct.Trip' setting (Level 6, Screen 4) and is a multiple of the selected full load current, from 3.0 to 10 times FLC, in steps of 0.5. The trip time is selected via the 'Short Cct. t' setting (Level 6, Screen 5) and is adjustable from 20ms to 160ms.

To reset the relay following a short circuit trip it is necessary operate the reset key/digital input.

7.3 Phase Current Balance

The current balance measurement 'Ib' is displayed on the 'Voltage and Current Information' page, Level 2, Screen 2.

If Iave is <100% the difference between the average current and each phase current is calculated. The maximum difference is used as the current balance percentage.

If Iave is >= 100% then the current balance is calculated as:

$$Ibal = \frac{\text{MAX } \Delta\text{I x } 100\%}{Iave}$$

Where:

Iave = Average of the 3 phase currents

MAX Δ I = The maximum deviation of a phase current from the average

Phase current balance protection is selected via the 'Cur.Bal.trip' setting (Level 6, Screen 9).

The trip level is selectable at 5%, 10%, 20%, 50%, and OFF.

The phase current balance protection is inhibited until the average current exceeds both 20% of the selected full load current and the selected balance trip level.

If any phase drops below the selected trip setting for a period of 2 seconds then the outlet is stopped. To reset the relay following a current balance trip, operate the reset key/digital input.

I	A	B	C 2
Cur:	0%	0%	0%

```
Ave:    0 Amp  Ir:   0%
Ibal:   0%     Iel:  0%
```

7.4 Residual Current Signal

The three phase current signals are summed electronically in the IPM to produce a residual current signal that can be used to detect earth fault currents. If the residual current signal exceeds the trip level for the selected trip time, a trip occurs, tripping the MCR relay. The fault is latched.

To reset the relay following a residual current trip, operate the reset key/digital input.

- L2: Displays the 3 phase currents as a % of the FLC
- L3: Displays the average current and the % residual current as 'Ir'
- L4: Displays the current balance and the % of leakage current

The trip level is selected via the 'Residual iTrp' setting (Level 6, Screen 11) and is adjustable from 10% to 250% FLC and 'off'. The trip time is selected via the 'Res.trip time' setting (Level 6, Screen 12) and is adjustable from 100ms to 5 seconds. Setting the trip level to 'off' disables this function.

NOTE

The residual current function can be used even if a core balance toroid is used for earth leakage protection. It can be used to provide some detection of wiring/CT/internal relay faults.

7.5 Undercurrent Trip

Undercurrent protection is enabled as soon as the main contactor is closed (indicated by closing the MCI input). Selecting a value of "None" will inhibit this function. If any phase drops below the selected trip setting for a period of 4 seconds then the outlet is stopped. This raises the "Under Current Trip" alarm and is recorded in the event log as "Und.I Trp". To reset the relay, operate the reset button.

The trip level is selected via the 'Under I Level' setting (Level 6, Screen 10). The trip level is selectable at 32%, 40%, 48%, 56%, 64%, 72%, 80%, 88%, and 96%. Setting the trip level to "None" disables this function.

NOTE

This function is used when in snore mode and must be set to an appropriate level – note that there is a 4 second delay before a trip.

8 VOLTAGE RELATED FUNCTIONS

The IPM relay uses the Insulation Test Module (ITM) to monitor the magnitude of the voltage on the load side of the outlet's main contactor. The voltage measurement is used to implement the following functions:

- Main Contactor Fail Protection
- Undervoltage Trip
- Voltage Metering

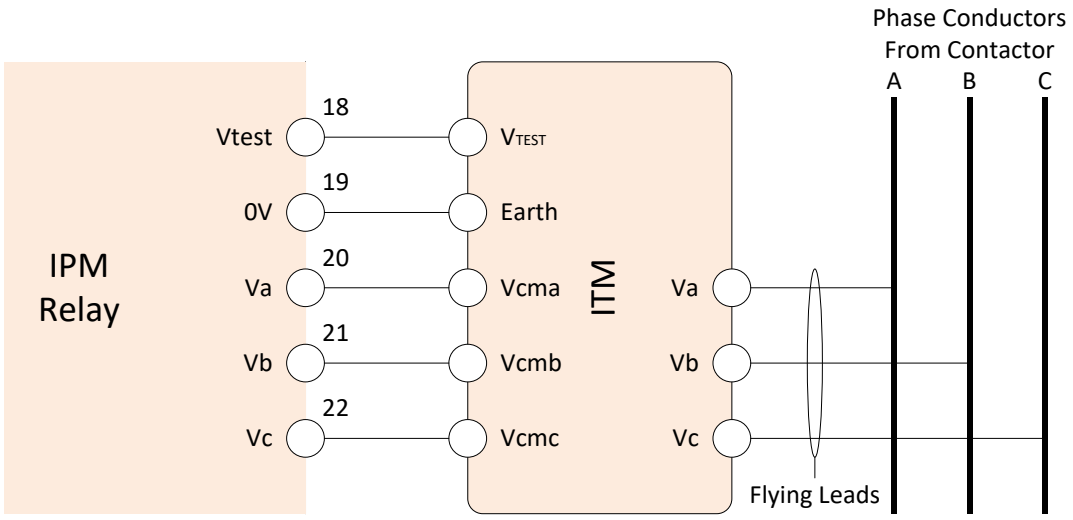


Figure 8.1: IPM Voltage Monitoring Connections

8.1 Main Contactor Fail Protection

The Main Contactor Fail (MCF) protection operates if the Main Contactor (MC) fails to function by either:

1. Failing to open when required. This is achieved by comparing the state of the main contactor (via the Main Contactor Input MCI) against the state of the MCR relay output. This test provides "Frozen Contactor Protection".
2. Failing to maintain insulation across the contacts when the contactor is open. The Insulation Test Module (ITM) is used to measure the voltage on the load side of the contactor. If this exceeds 10% of the rated line voltage, a trip will occur. This test provides "Loss of Vacuum Protection". This function is inhibited immediately after the main contactor opens to allow for back EMF voltages generated by some motors to dissipate. The inbuilt time is selected via the 'back EMF time' setting (Level 6, Screen 20). The settings are adjustable from 2 to 20 seconds.

A main contactor fail trip operates the CBR relay, which trips the circuit breaker.

To reset the relay following a main contact failure trip, operate the reset key/digital input.

The status of the MCI input can be viewed on the 'IPM Relay and Keys' screen, (Level 4, Screen 2).

8.2 Undervoltage Trip

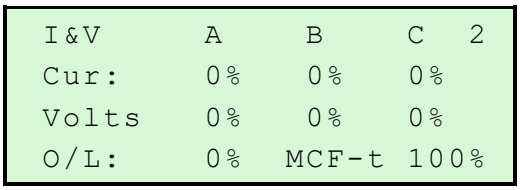
The undervoltage protection is enabled as soon as the main contactor is closed (indicated by closing the MCI input). If any of the phase voltages drop below the selected trip setting of the nominal line voltage for 800ms then the MCR relay is de-energised.

To reset the relay following an undervoltage trip, operate the reset key/digital input.

The trip level is selected via the 'U/V Trp level' setting (Level 6, Screen 19) and is adjustable between 40, 50, 60, 70, 75, 80, 85, 90, 95 & OFF. Setting the trip level to 'OFF' disables this function.

8.3 Voltage Metering

The Insulation Test Module (ITM) is also used to provide line voltage metering.



- L2: Displays the line current for each of the 3 phases.
- L3: Displays the line voltages for each of the 3 phases.
- L4: Displays the thermal accumulator and main contactor fail timer that counts down when a main contactor fault is detected.

Line voltages of 415V and 1000V are configured when the appropriate Insulation Test Module is selected in the ‘Group 1 Settings’ (Level 5, Screen 2).

9 MACHINE COMMUNICATION

The IPM provides the option of using the Remote Termination Module (RTM) to provide machine communication. See Section 6.3 for connection diagram.

9.1 Remote Termination Module

The Remote Termination Module is a microprocessor based fully encapsulated module that replaces the diode at the end of the pilot conductor of the trailing cable. It is powered by and communicates via the pilot line. Its non-volatile memory stores the parameters to configure the outlet as appropriate for that machine.

This allows the motor to be supplied from different outlets without the need for re-programming the protection settings into the IPM each time.

Machine type and machine number are displayed on the Default and Earth Continuity Screens (Levels 1 and 3).

9.2 Machine Type Codes

There are fourteen (14) selectable machine type codes available for use in the Remote Termination Module. The descriptive code is transmitted to the IPM Relay to identify the type of machine connected to the outlet. The codes are programmed at the 'RTM Mach. Type' page (Level 6, Screen 1).

- J-bo Face Boring Machine
- Fan Ventilation Fan
- Drill Drill
- Pump Pump
- Hpmp Hydraulic Pump
- Wpmp Water Pump
- DCB Distribution Control Box
- Bolt Bolter
- HRMr Hard Rock Miner
- Belt Conveyor Belt
- Winc Winch
- Crsh Crusher
- Dplg Dummy plug
  Spare

9.3 Machine Type Number

Machine numbers 1 to 40 can be assigned to machines. These numbers are programmed at the 'RTM Mach. Num.' page (Level 6, Screen 2).

10 FAN BURP FUNCTION

The Burp Function of the IPM relay allows the progressive inflation of ventilation bags (tubes) by pulsing the motor contactor, controlling the ventilation fan, several times at start up (see Section 12.6.5 for operational sequence).

There are three configurable parameters that control the Burp Function at start up, 'Burp Number of Pulses', 'Burp Pulse On Time' and 'Burp Pulse Off Time'.

Selectable Settings:

- '# Burp Pulses' (Level 6, Screen 25) - selectable at none and 1 to 6 (selection of "none" disables the Burp Function).
- 'Burp On Time' (Level 6, Screen 26) and 'Burp Off Time' (Level 6, Screen 27) - selectable at 0.6, 0.8, 1.0, 1.2, 1.5, 2.0, 2.5 and 3.0 seconds.

11 PUMP SNORE FUNCTION

The purpose of the IPM Snore Function is to (optionally) add a timed re-start to the IPM Relay after an undercurrent trip has been detected. Refer to Section 7.5 for more information on the operation of the undercurrent trip function.

11.1 Basic Operation

The basic operation of the snore function is illustrated using the following scenario:

Assume a pump is the load device of the relay, which pumps a dam. When the water level drops below the pump pickup, the load current will drop significantly enough to be detected as an undercurrent trip (as set in the settings level 6) by the IPM.

The Snore Function (Snore-Process) will operate only after configuration and activation via the IPM menus. The snore function will operate after undercurrent is detected and will permit the pump to restart after a time delay (tSnoreDelay). After this off period the pump will restart. During the first 4 second ON period (tSnoreOn) the pump will run, and only if the pump remains in an undercurrent state, the IPM will extend tSnoreDelay by 1.5 times and switch off the output relay for the new setting of tSnoreDelay. This process will continue until the time reaches a maximum of tSnoreDelay x 8.

The initial setting for tSnoreDelay is obtained from a menu configuration setting (tSnoreSet). The available initial settings are OFF, 5, 10, 15, 20, 8F, 15F, 20F, 30F, 60F **minutes** (the "F" represents a fixed delay that does not extend tSnoreDelay as described above. If a load is detected during tSnoreOn (that is, no undercurrent is detected), the pump will remain on, but tSnoreDelay will be reduced to ¾ of its present setting; but not below tSnoreSet (this does not apply to the "F" settings). In the case where the new tSnoreDelay is less than tSnoreSet, then tSnoreDelay shall be set to tSnoreSet.

When in tSnoreDelay mode, and if a 'Start' is initiated from:

a) The 'Start' key (on the relay), or,
b) A pulse from the External Start input is detected

Then the relay will immediately abort the running tSnoreDelay and proceed through a power-on sequence.

If a power failure occurs when the IPM is operating in Snore Mode, it will resume operating in Snore Mode when power is restored. If Aux is open, or there is an EL fault on Power Up, the snore function will wait for up to 15 seconds to start.

11.2 Setup Procedure for Snore Function

Setup of the Snore Function is done by settings throughout the menu structure. The additional settings required to enable the Snore Function include:

- Start Mode must be set to 'Snore'
- The Snore Delay parameter must not be set to none
- The 'Under Current' trip level must not be set to none
- The AUX External Digital input must be active

11.2.1 Relay Snore Mode Starting Procedure

When the 'Snore' start mode is selected, the relay can be initially started from different sources:

- Start key on facia, if and only if the aux input is closed,
- External start button, if and only if the aux input is closed.

Each operation of the 'Start' key will cause the relay to proceed through a power-on sequence regardless of the status of the snore function.

11.2.2 Relay Stop Procedure

The relay will be stopped whenever the Stop key or the external Stop is actioned – regardless of the Snore process. This will reset the snore delay timer.

If the AUX input opens at any time during operation in Snore mode, then a start is required to restart the snore function. The Message 'Snore – Need Aux' will be displayed on the screen when in Snore mode with the AUX open. This will reset the snore delay timer.

12 PRODUCT OPERATION

12.1 Basic Display Operation

The fascia of the IPM Integrated Protection Relay has a four line 20 character backlit Liquid Crystal Display (LCD), Status LED and a tactile keypad. Figure 1 gives an overview of the fascia of the relay.

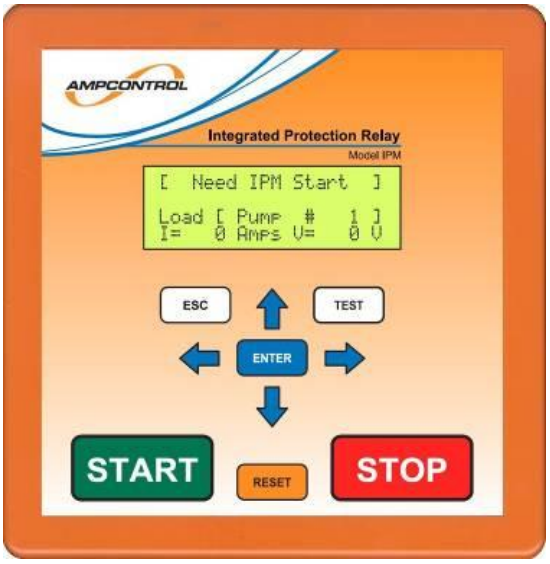


Figure 12.1: IPM Relay Fascia and Display

The layout of the display structure is shown on the 'IPM Display Map', APPENDIX 4: IPM Menu Structure. The display level is changed with the Up/Down arrow keys and the Left/Right arrow keys control the various display screens.

The ENT and ESC keys are used to modify settings and provide hyper jump access to the display structure.

The Reset key allows a reset following a trip condition.

The Test key is used to activate a manual insulation test.

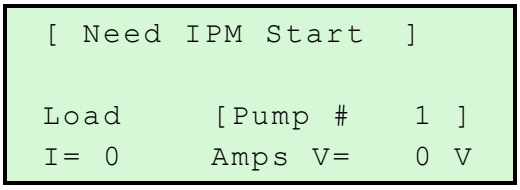
Start and Stop keys are provided for controlling the IPM which in turn controls the MC and MCB

The Status LED is a single bi-coloured LED that can be viewed some distance from the relay. Status indication is as follows:

Table 2: Status Indication

IPM Status	LED Colour	LED Flash
OK (Run)	Green	4Hz
OK (Stopped)	Green	1Hz
Alarm	Red	4Hz
Trip	Red	1Hz

The IPM status display is one of the most useful features of the relay's display system and should be viewed as the first step in fault finding. The 'Relay Status Page' is the default screen on power up and shows the current status of the IPM Protection Relay.



- Line 1: A one-line status message is displayed and if more than one message is active the display cycles through all active messages at 1 second intervals.
- Line 2: IPM Software version appears here while the UP arrow key held.
- Line 3: Shows the Load Type and Number (from the connected RTM unit).
- Line 4: Shows the Load Current (3ϕ average) and Load Voltage (average ϕ - ϕ.)

Through the use of the Modbus communications port, PLC's and SCADA systems can be configured to display the same messages that appear on the display. This helps to provide consistent information to operators.

12.2 Trip/Status Messages

The following table shows a list of the forty (40) status messages and the category (type) of the messages. Messages are cleared according to their message category.

- Type 1: Messages are latched for display and are cleared by either pressing the <ENT> key while on the Status Display Page or by starting a new starting sequence.
- Type 2: Messages are enabled and cleared automatically.
- Type 3: Messages are triggered by the respective trip functions and are cleared by resetting the trip function.
-

Table 3: Trip/Status Message

Message and Type		Comment
Tripped No Volts	1	Voltage on load side of contactor is too low
MC Close Fail	1	MCI input did not close within 5 sec of MCR relay closing
External MC Open	1	IPM detected (via MCI input) that MC was opened – not initiated by the IPM relay
Burp MCI Fail	1	MCI input fails to follow MCR relay output during burp phase
Under Current Trip	1	Under Current function tripped
Last T:--------	1	Shows 'Last Trip' record
OTS Mode Exit Stop	1	IPM has exited the OTS Test Mode

Message and Type		Comment
Outlet Paused	2	IPM waits 5 sec between running (or testing) and re-testing
Need IPM Start	2	Awaiting IPM start digital input
Testing Insulation	2	In process of Insulation Test (2 seconds)
Closing Main Cont.	2	MCR closed, waiting on MCI feedback (5 sec max.)
Burp: MCR Closed	2	Burp Phase is on MCR closed
Burp: MCR Open	2	Burp phase is active – MCR is open
Running	2	Outlet closed
Snore	2	Snore function active
Snore – Close AUX	2	Aux digital input must be closed for Snore to function
High Current Alarm	2	High Current Alarm triggered
Thermal Trip Alarm	2	Thermal Trip Alarm triggered
Cur. Balance Alarm	2	Current Balance Alarm triggered
Under Cur. Alarm	2	Under Current Alarm triggered
Earth Leakage Alarm	2	Earth Leakage Alarm triggered
UnderVoltage Alarm	2	Under Voltage Alarm triggered
Insulat. Test Alarm	2	Insulation Test Alarm triggered
Need RTM Start	2	Shown when the digital input is closed but the IPM is stopped
OTS Testing Mode	2	IPM operating in OTS Test Mode
Earth Leakage Trip	3	Earth Leakage function tripped
Earth Cont. Trip	3	Earth Continuity function tripped
Insulat. Fail Trip	3	Insulation Test function tripped
Over Current Trip	3	Over Current function tripped
Short Circuit Trip	3	Short Circuit function tripped
I Balance Trip	3	Phase Current Balance function tripped
Residual Cur. Trip	3	Residual Current function tripped
Main Contactor Fail	3	Main Contactor Fail function tripped
RTM-Offline Trip	3	IPM cannot communicate with RTM
IPM Memory Error (see Note 1)	3	Corrupted memory in relay's stored settings

Message and Type		Comment
RTM Memory Error (see Note 1)	3	IPM detected errors in set up data received from RTM
Stopped - IPM	3	IPM Stop digital input activated (closed)
RTM CT Ratio Error (see Note 2)	3	The attached RTM was set up using a different CT ratio than that of the IPM in use
RTM Version Error	3	The attached RTM does not support 100:1 CT operation
Remote Stop	3	Shown whenever RTM's digital input is open
Configuration Error	2	Present when: Start is set to Modbus. In snore mode; the delay or undercurrent trip level is not set. Also if the remote start is set to 'yes' or 'aux' whilst in snore mode.
Stopped – Ext Stop	3	IPM Stop digital input externally activated (closed).

NOTE

1. It is normal to see the IPM Memory Error Message when switching between Diode/RTM Mode or when the RTM is first connected to the pilot.
2. If the CT Ratio is changed the current setting must also be reset (otherwise an Error Message of "RTM CT Ratio Error" will be displayed).

12.3 Last Trip Status Messages

The IPM Relay has several functions, which can stop/trip the outlet and then self-clear. The IPM Relay therefore saves the non-latched trip codes in a register and displays the 'Last Trip' messages in the Status Message Page (note that the stop/trip function also appears in the Event Log).

Messages that are displayed at Last T: ---------

Table 4: Last Trip Messages

Message and Type	Comment
EC Leak T	E/C Leakage Trip that provides additional information for E/C Trip
EC Ω Trip	E/C Ohms Trip that provides additional information for E/C Trip
MC Opened	Main contactor opened – opening not initiated by the IPM Relay

RTM Off L	RTM Off Line – IPM cannot communicate with RTM
Und. I Trp	Under Current trip caused outlet to stop
Stopped	IPM Stop Input Tripped Locally
Ext. Stop	IPM Stop Input Tripped Externally

12.4 Communications

The IPM Relay provides an industry standard RS485 Slave Modbus communication port. This allows connection to a PLC or a SCADA system. APPENDIX 5: IPM Modbus Address Table provides detail on Modbus addresses.

The baud rate is selected via the 'Modbus:Baud /P' setting (Level 5, Screen 4) and is selectable between 1200 and 19200 Baud, with even, odd, or no parity. One stop bit is used in conjunction with parity, while two stop bits are used with no parity.

The half-duplex 3-wire RS485 communications interface allows up to 31 devices to be multi-dropped onto a single master communication line. The IPM's Modbus Slave address is selected via the 'ModBus Addr:' setting (Level 5, Screen 3) and is adjustable between 1 and 31.

12.4.1 Modbus Commands

The following Modbus commands are supported:

Table 5: Modbus Commands

Modbus CMD	Comment
03	Read Holding Registers
06	Store Single Register

Valid read registers are in the range from 1 to 96. An attempt to read a register outside this range will result in an exception scan. Currently, only the first 78 registers contain valid data. Supported Modbus exception responses are:

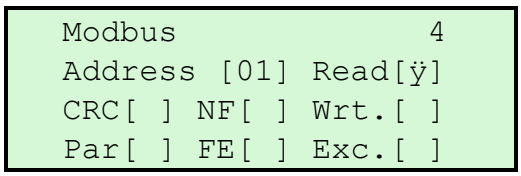
Table 6: Modbus Exception

Modbus Exception	Comment
01	Illegal Function
02	Illegal Data Address
03	Illegal Data Value

12.4.2 Modbus Status

Table 7: Modbus Status

Status	Comment
Address	The Modbus slave address the IPM is set to
Read	A solid block when a READ command is received
Wrt	A solid block when a WRITE command is received
Exc	A solid block when an unsupported Modbus command is received
CRC	A solid block when a checksum error is detected
Par	A solid block when a parity error is detected
NE	A solid block when noise is detected
FE	A solid block when a framing error is detected



The Modbus Status can be viewed on Level 4, Screen 4.

12.5 Remote IPM Control

The IPM and RTM software have been changed to allow for the RTM digital input to be used to control the IPM. This functionality is similar to that of the IPB/C/D.

The remote start can be set in two modes. In one mode it is always active and in the other mode it is active only when the auxiliary digital input is closed. Remote start can also be disabled.

12.5.1 Function Overview

A previously unused parameter called ‘remote start’, originally intended to implement the remote start functionality, is used to enable the remote start function. Setting it to ‘yes’ enables remote start. Setting it to ‘no’ will disable remote start. Setting it to ‘Aux’ enables remote start only when the auxiliary digital input is closed.

The remote input (on the RTM) is edge sensitive. This ensures that if there is an upstream trip, the IPM will not restart automatically once the power is restored. It also allows the keypad and external digital input stops to work sensibly so that if the IPM is stopped locally, it will not restart immediately after any of the stop are released.

When remote start is active, the remote input is closed to start the IPM and must remain closed while the IPM is running. The remote input is opened to stop the IPM.

12.5.2 Operating Modes

NOTE

The external digital stop input and the keypad stop will always stop the IPM regardless of the start mode.

There are two modes in which the IPM relay can operate:

- Diode Mode- The remote start parameter has no effect when the IPM is set to diode mode.
- RTM Mode- The Remote start parameter has three possible options; ‘no’, ‘yes’ and ‘aux’.

12.5.2.1 Remote start - ‘no’

The remote input will be ignored. Starting the relay will depend on whatever start mode is selected as per the existing operation.

12.5.2.2 Remote start - ‘yes’

1. Start mode - ‘K/Ext’ (Keypad or External)
   Keypad and External start inputs are ignored. Remote input controls the IPM. Local stop input will still stop the IPM. Local stop inputs will override the remote start if they are held closed while a remote start is signalled.
2. Start mode - ‘Ext’ (External only)
   As per ‘K/Ext’
3. Start mode - ‘K&Ext’ (Keypad and External)
   As per ‘K/Ext’
4. Start mode - ‘Modbs’ and ‘Snore’
   These modes will not operate when remote start is set to ‘yes’. The status display will show “Configuration Err”.

12.5.2.3 Remote start - ‘Aux’

When an appropriate start mode is selected, changing the Auxiliary digital input will switch between local (keypad or external digital start input) and remote (RTM digital input). It is allowable to change the state of the Auxiliary input while the IPM is running.

If the RTM input is open and the IPM is running while the Auxiliary input is closed, the IPM will immediately stop. If the RTM input is closed and the IPM is running while the Auxiliary input is closed, the IPM will continue to run.

1. Start mode - ‘K/Ext’, ‘Ext’ and ‘K&Ext’
   The IPM will change between remote start mode and local start mode depending on the state of the ‘Aux’ digital input. When the input is closed the IPM will be controlled via the RTM as described in Section 4.4.4.
   When the ‘Aux’ digital input is open the control will revert to local mode. The start signal required will depend on the Start mode parameter.
2. Start mode - ‘Modbs’ and ‘Snore’
   These modes will not operate when remote start is set to ‘yes’. The status display will show “Configuration Err”.

12.5.3 IPM/RTM Software Compatibility

NOTE

A ‘New IPM’ is considered to be version 9 or earlier; An ‘Old RTM’ is version 2 or earlier (reported as ‘20’ on the IPM display).

- New RTM and New IPM - Nothing to consider.
- New RTM and Old IPM - The Old IPM will ignore the remote start setting.
- Old RTM and New IPM - The new IPM will check the version of the RTM (this is transmitted in the pilot protocol). If the RTM has the ‘remote start’ parameter set, but the RTM version is too old, the IPM will display “RTM Version Error”.
- Old RTM and Old IPM - Nothing to consider.

12.5.4 Status Messages

There are two new status messages - “Need RTM Start” and “Remote Stop”.

When in remote start mode, whenever the RTM’s digital input is open, the display will show “Remote Stop”. If the digital input is closed but the IPM is stopped the display will show “Need RTM Start” to indicate that the RTM’s digital input needs to be opened and then closed to generate a new edge.

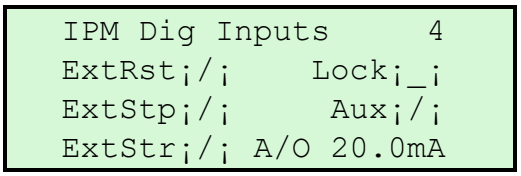
NOTE

This is most likely to happen if the RTM’s digital input is closed to allow the IPM to run and then a local stop is used to stop the IPM. Because of the edged triggered nature of the RTM digital input, the IPM will not automatically restart.

12.6 System Control

12.6.1 Digital Inputs

The IPM provides six (6) voltage free digital inputs for correct operation. To activate an input a connection needs to be made from '+DiPwr' terminal to the respective digital input's terminal.



- L2: Displays the status of the external reset and the lock inputs.
- L3: Displays the status of the external stop and the auxiliary inputs.
- L4: Displays the external start input and the analogue output in mA.

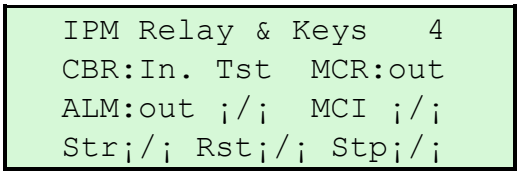
The function of each input is as follows:

1. Lock: The lock input needs to be closed whenever changes to the relay settings are being made. If the lock input is not closed then the settings cannot be changed.
   The lock input must also be closed to reset the thermal memory to allow an emergency restart. To perform a reset, the motor must be stopped (MCI open) and both the reset key and the lock input must be held closed for 1.5 seconds. This will reset the 'Thermal Accumulator' and allow the motor to be started immediately.
2. Reset: The reset digital input performs the same function as the keyboard reset allowing for external/remote resetting of trips. To reset a trip, an open to close transition on the reset input (or reset key) is required.
3. MCI: The Motor Contactor Interlock input provides the IPM relay with the status of the motor contactor. Its status is used by the thermal modelling to activate the 'Cooling Multiplier' and also provides the basis for Motor Contactor Fail (MCF) monitoring.
4. Digital: This is an auxiliary digital input.
5. Ex-Start: This input allows the installation of an external start button.
6. Ex-Stop: This input allows the installation of an external stop button.

12.6.2 Output Relays

The IPM provides three relay outputs for correct operation. All relay contacts are rated at 5A/190VAC.

1. MCR: (Main Trip Relay). This relay energises when there are no trips, and drops out whenever a trip occurs. A normally open and a changeover set of contacts are provided.
2. ALM: (Alarm Relay). This relay energises whenever there are alarms active and drops out when all alarms are clear. One changeover set of contacts is provided.
3. CBR: (CBR Relay). This relay is normally energised and drops out if there is a short circuit trip or a motor contactor fail trip. One changeover set of contacts is provided.



- L2: Displays the status of the CBR and MCR Relays.
- L3: Displays the status of Alarm Relay, the Test key and the Main Contactor input.
- L4: Displays the status of the Start, Reset and Stop Keys.

12.6.3 Outlet Control

The outlet can be energised by local or remote operation depending on the 'Remote Start' option. The selection is "Yes" or "No" (Level 6, Screen 16).

If "Yes" is selected the relay ignores the local start input thus allowing operation of the outlet from the remote machine. Both the external and local stop buttons will turn off the outlet.

If "No" is selected the local start/stop buttons control the outlet.

12.6.4 Start Mode

The Start Mode is selected at (Level 5, Screen 3). The possible settings are K/Ext, Ext, K&Ext, Modbus and Snore. The start/stop logic operates as follows:

1. The external stop digital input and the front keypad stop button will always stop the relay, regardless of the settings for 'Start Mode'. In all cases only one of the stop inputs needs to be active to stop the relay.
2. K/Ext mode – Relay can be started with either an external start or the keypad.
3. Ext mode – Only the external start is used. The keypad start is disabled.
4. K&Ext mode – Both the external start and the front panel keypad start button needs to be active to start the relay.
5. Modbus mode – Not implemented.
6. Snore mode – The parameters for Under Current Trip, Start Mode and the Snore time delay need to be set for your application. Extra protection against accidentally selecting this mode is provided by requiring the external digital input to be closed before this mode will start.

12.6.5 Operational Sequence (Insulation Test and Burp Function selected)

Before an outlet can be energised there should be no protection faults present.

Once the start button is operated an insulation test is performed. If the result of this test is satisfactory the Burp Phase is initiated. When the Burp Phase is completed the IPM Relay goes into the run mode.

A time delay of 5 seconds is allowed for the Main Contactor Interlock (MCI) to close. If it does not close within this time, then the run mode is exited.

If a stop input is closed while the relay is in run mode, the run is cleared, and the MCR relay de-energises. The event log reads "Stopped".

While the main contactor is closed, the MCI input is continuously monitored. If it opens, the run is cleared and the MCR relay de-energises. In this case the event log records "MC Opened" which indicates that the outlet was turned off by something other than the IPM Relay, for example, open circuited main contactor coil or control supply.

It should be noted that if the main contactor does not close when the MCR relay closes and the start/stop conditions are maintained, then the IPM will cycle through the following start sequence: testing, run, stopped, pause then repeat the sequence while ever the start input is closed.

12.7 Analogue Output

The IPM Relay provides an isolated 4-20mA analogue output. The output continuously monitors Average Current, Overload, Earth Leakage and the Insulation Level of the relay. The Monitor Output settings can be selected at '4-20mA Output' (Level 6, Screen 28). Settings available are O/L (0-100%), Iave (0-250%), E/L (0-100%) and MΩ (0-40MΩ). The analogue output status in milliamps is shown on the 'IPM Relay and Keys' screen, (Level 4, Screen 2).

12.8 IPM Alarm Functions

The IPM has several standard alarm functions. If any are triggered, the Alarm Relay (ALM) picks up. Each has a selectable alarm level, and can be disabled. Generally the alarms are self-resetting once the alarm condition is removed.

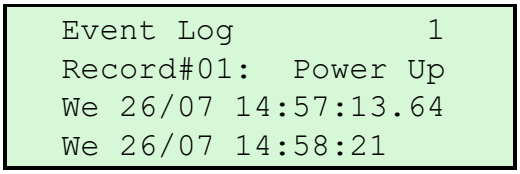
1. High Current Alarm - Is activated by the phase currents exceeding the selected threshold. It is selected via the 'High I alarm' setting (Level 6, Screen 21) and is adjustable from 100% to 600% FLC and 'off'. The highest of the three phase currents is used. Time delay = 1 sec. Setting the alarm level to 'off' disables this function.
2. Overload Alarm - Is activated by the thermal accumulator exceeding the selected threshold. It is selected via the 'O/L Alarm Lev' setting (Level 6, Level 22) and is adjustable from 50% to 95% and 'off'. Time delay = 2 s. A motor overload trip overrides this alarm. Setting the alarm level to 'off' disables this function.
3. Under Cur. Alarm - Is activated by the phase current falling below the selected threshold. It is selected via the 'Under I Alarm' setting (Level 7, Screen 10) and is adjustable from 32% to 96% and 'off'. This alarm is only activated when the motor is running (MCI input closed). Time delay = 2 sec. Setting the alarm level to 'off' disables this function.
4. Earth Leakage Alarm - Is activated when the earth leakage current exceeds a set level. The alarm level is selected via the 'E/L Alarm Lev' setting (Level 6, Screen 24) and can be set to 20%, 50%, 80% and 'off'. The earth leakage alarm has a time delay of 1 second and auto resets when the earth leakage current falls below the selected level. Setting the alarm level to 'Off' disables this function.
5. Insulat. Test Alarm - Is activated when the meg-ohm resistance of each phase to earth, as a result of an insulation test, equals or falls below the alarm level. The alarm level is set at 1.5 times the trip setting.

The alarm message is displayed until a new test is initiated or the <ENT> key is pressed while displaying the alarm message. The 'Insulat. Test Alarm' is also recorded in the Event Log.

12.9 Event Log

A real time clock/calendar is included in the IPM Relay. This combines with the non-volatile memory to provide a data-logging feature. This log sequentially records the time, date and details of the most recent event. A chronological list of the previous 50 events is stored.

The event log can be viewed by using the right or left arrow keys to scroll the log.



A typical display shows:

- L2: Displays the event.
- L3: Indicates the time that the relay powered up on Wednesday, 26 July.
- L4: Indicates the present time.

Log 1 is always the most recent event. Each time a new log is recorded, the 50th log is removed from the list.

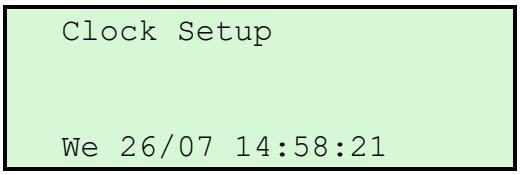
The following events are logged:

Table 8: Events

Event	Description
Power Up	The instant that power is applied to the relay
Pwr Down	Removal of power from the relay
MCR Close	Closure of the Main Contactor Relay
Stopped	Stopping of the outlet by operation of the local stop button
Ext. Stop	Stopping of the outlet by operation of the external stop button
MC Opened	Main Contactor has opened but not initiated by the IPM Relay
MC Fail	Main Contactor Fail Function Trip
CloseFail	Indicates that the MCI Input did not close within 5 seconds of MCR closing
EC Ω Trip	Pilot/Earth continuity loop exceeds 45 Ohms
EC Leak T	Leakage resistance between the pilot and earth is less than 1500 Ohms
EL Trip	Earth leakage protection tripped
Burp Done	Burp sequence completed
Burp Fail	Burp sequence failed to complete
SC Trip	Trip condition of short circuit protection
OC Trip	Trip condition of overload protection
I bal-Trp	Current balance trip condition
RESET	Records resetting of a protection trip function
Setup Mod	Records that set up data has been modified
Und.I Trp	Under Current Trip caused outlet to stop
uvolt trp	Records that voltage was not present on at least

Event	Description
	one outgoing phase when the main contactor was closed
Ires.trip	Residual E/L Trip condition
Tmem Loss	The thermal memory data has been corrupted
T-mem Rst	Thermal memory has been manually reset to zero
Mem.ERROR	Records that the relay's non-volatile parameter memory has been corrupted
µ- P reset	Internal microprocessor reset
RTM mem. E	Records that the Remote Termination Module's non-volatile memory has been corrupted or Remote Termination Module has gone off line while the outlet is running.
Feeder On	Records RTM machine code and number when main contactor is closed (proceeded by MCR closed). This log only appears when in RTM mode.
RTM Off L	Indicates a loss of communications with the RTM.
Meg Ω Trp	Insulation Test failed
IT: -- . -MΩ	Records the result of the Insulation Test
Insul.Alm	Result of Insulation Test is equal to or less than the alarm level
o/l alarm	Thermal accumulator has exceeded the selected threshold
L-cur alm	Phase current has dropped below the selected threshold
H-cur.alm	Phase current has exceeded the selected threshold
e/l alarm	Earth leakage current exceeded the selected threshold
RTM Stop	In any of the remote start modes; the event log will record when the IPM is stopped via the remote digital input.

12.10 Time and Date



If there is a need to adjust the real time clock, carry out the following procedure:

- Using the display's keys select the time and date information page (Level 4, Screen 5) to display the Day, Month, Year, Hours and Minutes.
- Press the ENTER key. A "v" will appear in the top line above the minute section. This indicates the number to be changed.
- Use the left and right arrow keys to move the "v" to the desired position.
- Press the ENTER key. The "v" now changes to a "?" The right arrow key is used to increment the allowable values, once the desired value is obtained, press the ENTER key again. The "?" returns to a "v".

- Repeat steps 3 and 4 until the correct time and date are displayed.
- With the “v” showing press the reset push button. The “v” then changes to “E” (this is a prompt to press the ENTER key).
- Press the ENTER key. At that instant, the seconds are zeroed and the selected time/date information is transferred to the internal clock.

If the battery voltage is low the time will zero and the date will reset to 1st January on power up.

NOTE

The date and time are used only to time stamp the events in the log (which are recorded sequentially regardless of the date/time). Date and time data is not used for any control functions.

13 USER ADJUSTABLE SETTINGS

13.1 Parameter Groups

There are two groups of adjustable settings contained in the IPM relay’s non-volatile memory. Both groups can be viewed and modified via the display and the up/down and left/right keys.

The first group of settings is always stored in the relay and relates to parameters, which are linked to the system rather than the particular load connected to the outlet.

Table 9: User Adjustable Settings

Group 1 Setting	Description
EC Pilot Mode	Determines if the pilot is to be terminated with a diode or Remote Termination Module
ITM Module	Selects the Insulation Test Module to be used with the IPM Relay
Start Mode	Selects the inputs required to initiate a start condition
ModBus Address	Selects the Modbus Slave Address
ModBus Baud/P	Sets the Modbus baud rate
ModBus Timeout	Sets ModBus Error timing
CT RATIO	Selects between 100:1 and 1000:1 toroids

The second group of settings consists of parameters that are related to the load connected to the protected outlet. These settings are stored, retrieved to/from the memory in the IPM Relay or the memory in the Remote Termination Module, depending on the “Pilot Mode” setting.

If Diode Mode is selected the IPM Relay reads and writes to and from the relay’s internal memory for the group 2 settings.

If RTM Mode is selected, the settings are sent to and retrieved from the memory in the Remote Termination Module.

Table 10: User Adjustable Settings

Group 2 Setting	Description
RTM Mach. Type	Selects the RTM descriptive code transmitted to identify the machine connected to the outlet
RTM Mach. Num	Selects the assigned machine number to be transmitted by the Remote Termination Module
100% Current	Sets the full load current
OC I mul	Combines with OC range to define the full load current
Short Cct. Trp	Sets the short circuit trip level
Short Cct. t	Sets the trip time for the short circuit function
O/L trp t @6x	Modifies the basic overcurrent time curves to achieve the desired trip times
O/L cool mult	Allows the cooling rate of the thermal model to be modified
O/L Rst. Level	Sets the pre-set level to allow a reset of an O/L trip
Cur. Bal. trp	Adjusts current phase balance trip
Under I level	Sets the under current threshold
Residual i Trp	Selects the residual current trip threshold as a % of FLC
Res. Trip time	Sets the trip time for the residual current function
RCD Trp. Level	Sets the sensitivity trip level for the earth leakage protection
RCD Trp. Time	Sets the trip time for the earth leakage protection
Pilot Trip t	Sets the trip time for the earth continuity protection
Remote Start	When “Yes” is selected the IPM Relay ignores the local start input. When “No” is selected the local start/stop inputs control the relay
EC Trip Latch	Determines whether earth continuity trips are self-resetting or not
Ins. Tst. Level	Sets the trip threshold or disables the insulation test function
U/V Trp. Level	Sets the under voltage threshold
Back emf time	Adjustable time delay to inhibit main contactor failure following opening of main contactor
High I alarm	Selects the high current alarm threshold as a % of FLC
O/L Alarm Lev	Selects the overload alarm threshold as a % of the thermal accumulator
Under I Alarm	Selects the under current alarm threshold as a % of FLC
E/L Alarm Lev	Selects the alarm trip level for the earth leakage protection
# Burp Pulses	Sets the number of burp pulses
Burp on Time	Sets the burp pulse on time
Burp Off Time	Sets the burp pulse off time
4-20mA Output	Sets the value to be transmitted
Snore Delay	Sets the Snore Delay Value

13.2 Changing Settings

The procedure for adjusting the settings is independent of where the values are stored. The EC Pilot Mode should be checked prior to making any other adjustments to be certain the changes are made to the desired memory.

- Ensure the outlet is stopped.
- For Group 2 Settings in RTM Mode, ensure RTM is online.
- Display the parameter that has to be changed.
- Close and hold the lock input.
- Press the enter button to change the current parameter.
- Use the left and right arrows to step through the allowable values until the desired new setting is displayed.
- Press the enter button to indicate that the value is the required setting.
- Once Saving indicator has finished on the display, open the lock input.

If the ESC key is operated at any stage during the procedure, the modifying sequence is aborted and the setting reverts to its previously stored value.

When changes have been made to the stored values, the old value and the new value are stored in the event log.

A separate log immediately proceeds this, recording the time and date that the change was made.

14 SERVICE, MAINTENANCE & DISPOSAL

14.1 Equipment Service

A number of external system based checks should be completed on a regular basis. These 'routine inspections' must be carried out by suitably trained people with knowledge of the relay and the systems into which it is fitted. Routine inspections may take the form of either visual-only checks, or visual and 'hands-on' checks.

14.1.1 Visual Only Inspections

A basic visual inspection focuses on looking at the installation for signs of physical damage, water or dust ingress and the condition of cables and labels. This type of inspection may involve opening cabinets to gain access to the relay and other equipment. This level of inspection may also include cleaning display windows that have become obscured by dirt.

Observations would typically be:

- Check that equipment enclosures, cable trays, conduits, etc. are in good order with no physical damage.
- Check that sealed wall boxes are free from water and dust ingress internally. Door seals are in good condition.
- Check that connected cables are free from cuts, abrasions and obvious signs of damage. Cable restraints are in good order and correctly fitted.
- Check that labels on equipment, wall boxes and cables are present and in good condition (especially certification labels).
- Check that no modifications have been carried out to installed equipment.

14.1.2 Hands-On (Detailed) Inspections

A more detailed inspection would include all of the elements of a visual inspection, plus some checks that cover the integrity of connections, fixtures and fittings.

In addition to basic visual observations, more detailed integrity checks would involve:

- Verify that equipment housings, wall boxes and other mechanical fixtures are secured in place. This includes terminal box lids, tightness of cable glands, integrity of wall-box mountings, security of equipment fixing to walls/DIN rails etc.
- Verify all electrical connections are secure with no loose screw terminals or DIN rail terminals not fitted to rails etc.

14.2 Equipment Maintenance

WARNING!

The IPM V2 relay system has no user-serviceable parts.

All repairs must be carried out by Ampcontrol only.

If a fault develops, return the product to Ampcontrol for repair. It is essential that **no attempt be made to repair the product** as any attempt to dismantle or repair the product can **seriously compromise the safety of the unit and voids product warranty**.

It is recommended that the electrical protection system incorporating the relay be subject to regular functional tests at intervals determined by risk assessment or FMEA. These intervals typically coincide with periodic maintenance checks and will cover (but not limited to) tests such as those listed in the commissioning section (Section 5).

14.3 Disposal

ENVIRO

The electronic equipment discussed in this manual **must not be treated as general waste**. By ensuring that this product is disposed of correctly you will be helping to prevent potentially negative consequences for the environment which could otherwise be caused by incorrect waste handling of this product.

15 SPECIFICATIONS

General	
Auxiliary Supply Voltage	24 VDC ± 20%, <10W
Contact Ratings	MCR (1 N/O, 1 C/O), CBR and ALM (1 C/O) 5A/190VAC 100VA max
Communications	RS485 Slave Modbus Baud Rate: 1200 to 19200
Monitoring	4-20mA Analogue Output
Back EMF Timer Delay Settings	2, 5, 10, 15, 20 sec
Machine Numbers	Can be allocated from 1 to 40

Protection Functions	
Earth Leakage	
Trip Settings	OFF, 25, 50, 100, 200, 500mA
Trip Delay	Inst. (<80ms), 50ms, 100ms, 150ms
Alarm Setting	OFF, 10%, 20%, 30%, 40%, 50%, 60%, 80%
Earth Continuity	
Shunt Trip	< 1850Ω
Operating Time	80, 120, 160, 200, 300, 400, 500ms
Trip Resistance	> 45Ω
Reset Resistance	< 45Ω
Earth Fault Lockout	
Resistance	NONE, 1, 2, 5, 10, 20MΩ (test time 2 sec)
Alarm Setting	Trip setting x 1.5
Current Related Functions	
Over Current Protection	
Current Range	0.5125 to 64 Amps (224 steps) 100:1 CT 5.125 to 640 Amps (224 steps) 1000:1 CT
Trip Time (at 6xFLC)	3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 20, 24, 28, 32, 40sec
Cooling Multiplier	1, 1.5, 2, 2.5, 3, 4, 5 times
Overload Reset Level	30%, 40%, 50%, 60%, 70%, 80%, 90%, A-30%, A-40%, A-50%, A-60%, A-70%, A-80%, A-90%
Alarm Setting	OFF, 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%
Short Circuit Protection	
Trip Settings	3.0 to 10.0 times in 0.5 increments (x FLC)
Trip Time	20, 40, 60, 80, 100, 120, 160ms
Under Current	
Trip Setting	OFF, 32%, 40%, 48%, 56%, 64%, 72%, 80%, 88%, 96%
Alarm Setting	OFF, 32%, 40%, 48%, 56%, 64%, 72%, 80%, 88%, 96%
Residual Current	
Trip Setting	OFF, 10%, 20%, 30%, 40%, 50%, 60%, 80%, 100%, 120%, 150%, 200%, 250%
Trip Time	OFF, 100ms, 200ms, 500ms, 1sec, 2, 3, 5sec

High Current Alarm	OFF, 100%, 108%, 120%, 140%, 160%, 200%, 240%, 280%, 320%, 360%, 400%, 500%, 600%
Current Balance	
Trip Setting	OFF, 5%, 10%, 20%, 50%
Trip Time	2sec
Other Protection Functions	
Under Voltage Protection	
Trip Settings	40%, 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, OFF
Trip Time	800ms
Fan (Burp) Function	
Number of Pulses	None and 1 to 6 (selection of none disables the Burp Function)
Time On/Off	0.6, 0.8, 1.0, 1.2, 1.5, 2.0, 2.5 and 3.0sec
Pump (Snore) Function	None, 5,10,15, 20, 8F,15F,20F, 30F, 60F Time in Minutes F= Fixed delay

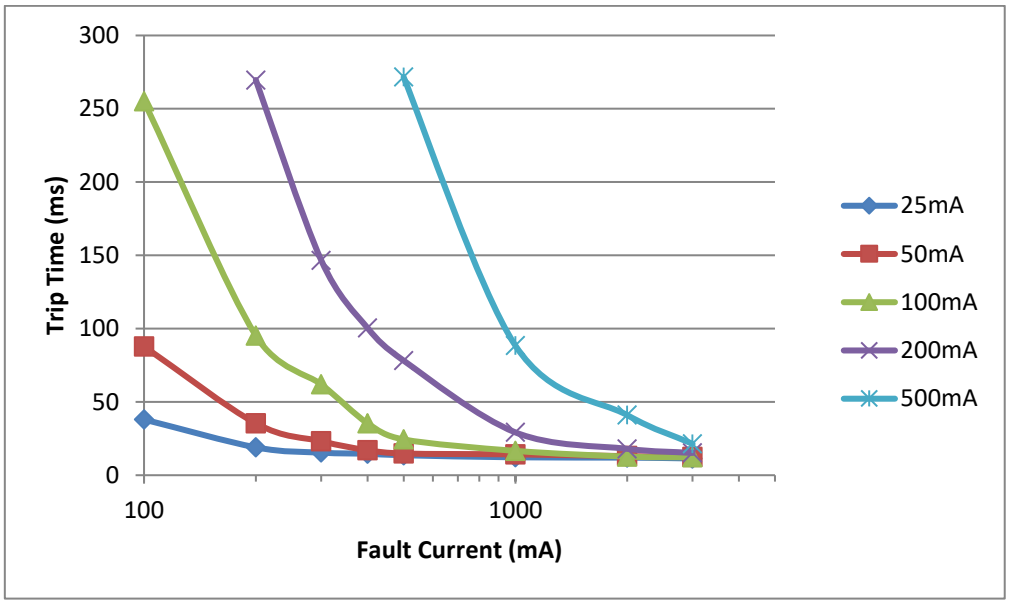
16 EQUIPMENT LIST

Part Number	Description
143794	IPM Integrated Protection Relay 24V
121504	ITM-415 Insulation Test Module
121505	ITM-1000V Insulation Test Module
143315	RTM Remote Termination Module
101703	88mm Earth leakage Toroid
141548	Current Transformer 100:1 [500:5] 45mm I.D.
101272	Current Transformer 1000:1 45mm I.D.
101108	40mm M5 Screw
171010	Support Bracket

APPENDIX 1: IPM Earth Leakage Tripping Curves

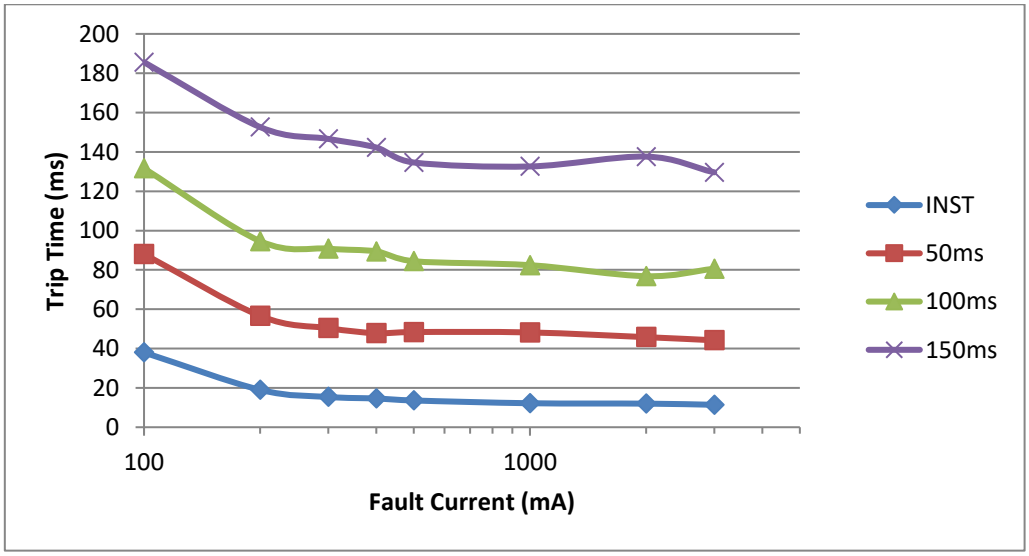
Tripping Curves for Instantaneous Trip Time Setting

The graph below shows the time taken for the IPM relay to trip for a given fault current when the relay is set to a trip time of Instantaneous, and a selection of trip levels.



Tripping Curves for 25mA Trip Level Setting

The graph below shows the relay trip times for a 25mA trip level setting, for different trip time settings.



NOTE

Similar graphs can be obtained for 50mA, 100mA, 200mA and 500mA trip levels.

APPENDIX 2: IPM Full Load Current Selection Table (100:1 CT)

IPM Full Load Current Selection Table – Amps (100:1 CT)						
0.5125	1.025	2.05	4.1	8.2	16.4	32.8
0.5250	1.050	2.10	4.2	8.4	16.8	33.6
0.5375	1.075	2.15	4.3	8.6	17.2	34.4
0.5500	1.100	2.20	4.4	8.8	17.6	35.2
0.5625	1.125	2.25	4.5	9.0	18.0	36.0
0.5750	1.150	2.30	4.6	9.2	18.4	36.8
0.5875	1.175	2.35	4.7	9.4	18.8	37.6
0.6000	1.200	2.40	4.8	9.6	19.2	38.4
0.6125	1.225	2.45	4.9	9.8	19.6	39.2
0.6250	1.250	2.50	5.0	10.0	20.0	40.0
0.6375	1.275	2.55	5.1	10.2	20.4	40.8
0.6500	1.300	2.60	5.2	10.4	20.8	41.6
0.6625	1.325	2.65	5.3	10.6	21.2	42.4
0.6750	1.350	2.70	5.4	10.8	21.6	43.2
0.6875	1.375	2.75	5.5	11.0	22.0	44.0
0.7000	1.400	2.80	5.6	11.2	22.4	44.8
0.7125	1.425	2.85	5.7	11.4	22.8	45.6
0.7250	1.450	2.90	5.8	11.6	23.2	46.4
0.7375	1.475	2.95	5.9	11.8	23.6	47.2
0.7500	1.500	3.00	6.0	12.0	24.0	48.0
0.7625	1.525	3.05	6.1	12.2	24.4	48.8
0.7750	1.550	3.10	6.2	12.4	24.8	49.6
0.7875	1.575	3.15	6.3	12.6	25.2	50.4
0.8000	1.600	3.20	6.4	12.8	25.6	51.2
0.8500	1.700	3.40	6.8	13.6	27.2	54.4
0.8750	1.750	3.50	7.0	14.0	28.0	56.0
0.9000	1.800	3.60	7.2	14.4	28.8	57.6
0.9250	1.850	3.70	7.4	14.8	29.6	59.2
0.9500	1.900	3.80	7.6	15.2	30.4	60.8
0.9750	1.950	3.90	7.8	15.6	31.2	62.4
1.0000	2.000	4.00	8.0	16.0	32.0	64.0

APPENDIX 3: IPM Full Load Current Selection Table (1000:1 CT)

IPM Full Load Current Selection Table – Amps (1000:1 CT)						
5.125	10.25	20.5	41	82	164	328
5.250	10.50	21.0	42	84	168	336
5.375	10.75	21.5	43	86	172	344
5.500	11.00	22.0	44	88	176	352
5.625	11.25	22.5	45	90	180	360
5.750	11.50	23.0	46	92	184	368
5.875	11.75	23.5	47	94	188	376
6.000	12.00	24.0	48	96	192	384
6.125	12.25	24.5	49	98	196	392
6.250	12.50	25.0	50	100	200	400
6.375	12.75	25.5	51	102	204	408
6.500	13.00	26.0	52	104	208	416
6.625	13.25	26.5	53	106	212	424
6.750	13.50	27.0	54	108	216	432
6.875	13.75	27.5	55	110	220	440
7.000	14.00	28.0	56	112	224	448
7.125	14.25	28.5	57	114	228	456
7.250	14.50	29.0	58	116	232	464
7.375	14.75	29.5	59	118	236	472
7.500	15.00	30.0	60	120	240	480
7.625	15.25	30.5	61	122	244	488
7.750	15.50	31.0	62	124	248	496
7.875	15.75	31.5	63	126	252	504
8.000	16.00	32.0	64	128	256	512
8.250	16.50	33.0	66	132	264	528
8.500	17.00	34.0	68	136	272	544
8.750	17.50	35.0	70	140	280	560
9.000	18.00	36.0	72	144	288	576
9.250	18.50	37.0	74	148	296	592
9.500	19.00	38.0	76	152	304	608
9.750	19.50	39.0	78	156	312	624
10.000	20.00	40.0	80	160	320	640

APPENDIX 4: IPM Menu Structure

Level	Menu	Level - Screen	Menu Message / Function	Sub Menu Display	Default
1	**Need IPM Start**	1.1	Start / Status / Error Messages	See Trip / Status Messages;	
				Type 1 – Latched for Display	
				Type 2 – Enabled & Cleared Automatically	
				Type 3 – Triggered by Trip Function	
		1.2-1.50	Event Log : (last 50 events) L2: Event, L3: Time - Event, L4 :Present Time	Pwr Up, Pwr Down, MCR Close, Stopped, Ext. Stop, MC Fail, Close Fail, ECW Trip, EC Leak Trip, EL trip, Burp Done, Burp Fail, SC Trip, OC Trip,Ibal-Trp, RESET, Set up Mod,	
2	**Earth Leakage**	2.1	Current / Voltage / Overload		
		2.2	All Currents; E/L, E/L, IB	% Trip Level to 100% Trip, Current Balance	
3	**Earth Continuity**	3.1	Earth Continuity	When either EC Res or Earth Loop Leakage reaches 100% a trip occurs	
		3.2	Insulation Test Level	1MW, 2MW, 5MW, 10MW, 20MW (Alarm - 1.5 x Set Value) Display shows last measured value	
		3.3	Status Indicator Remote Input		
4	**IPM Relays & Keys**	4.1	IPM Relay & Keys	CBR, MCR, ALM, MCI, Str, Rst, Stp	
		4.2	IPM Dig Inputs	ExtRst, ExtStp, ExtStr, Lock, Aux, A/O 4.0mA	
		4.3	Modbus Status	[Address, Read, Wrt, Exc, CRC, Par, NE, FE]	
		4.4	Clock Setup	[Day, Mth, Yr, Hrs, Mins & Sec] (Time Stamp – Events Log)	
5	**Settings: Grp1-IPM**	5.1	EC Pilot Mode	[Diode, RTM] –Earth Loop Resist. < 45W	
		5.2	ITM Module	[415v / 1000v]	
		5.3	Start Mode	[Selects Inputs Reqd. For Start Mode]	
		5.4	Modbus Addr	[1 -31]	
		5.5	Modbus : Baud /P	[12000,E,N, 24000,E,N, 48000,E,N, 96000,E,N, 192000,E,N]	96000
		5.6	Modbus T-out	0.5, 1.0, 2.0, 5.0, None	0.5 Sec
		5.7	CT Ratio	100:1 and 1000:1	
6	**Settings: Grp2-RTM**	6.1	RTM Machine Type	[J-bo, Fan, Dril, Pump, Hpmp, Wpmp, DCB, Bolt, HRMr, Belt, Winc, Crsh, Dplg, Spare]	
		6.2	RTM Mach. Num.	[1 to 40]	
		6.3	100% Current	[5.125A – 625A]	5.125A
		6.4	Short Cct.Trp	[Selectable; 3.0 to 10 Times FLC]	3.0 x
		6.5	Short Cct.t	[20, 40, 60,80,100, 120, 160 mSec]	20

Level	Menu	Level - Screen	Menu Message / Function	Sub Menu Display	Default
					mSec
		6.6	O/L trp t @ 6x	3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 20, 24, 28, 32, 40 Sec	3 Sec
		6.7	O/L cool mult	[1.0 to 5.0] (ie 2.5 – Fan Cooled Mtr)	1.0
		6.8	O/L Rst Level	[30% - 90%, A30% - A 90%] "A- Auto Reset	30%
		6.9	Cur.Bal Trip	[5%, 10%, 20%, 50%, off]	5%
		6.10	Under I Level	[32%, 40%,48%, 56%,64%, 72%, 80%, 88%, 96%, None]	32%
		6.11	Residual i Trip	[10, 20, 30, 40, 50, 60, 80, 100, 120, 150, 200, 250%]	10%
		6.12	Res. trip time	[100mS, 1, 2, 3, 5 Sec]	100 mS
		6.13	RCD Trp. Level	[25, 50 , 100, 200, 500mA]	25 mA
		6.14	RCD Trp. Time	[50, 100, 150mSec]	50mSec
		6.15	Pilot Trip t	[80, 120, 160, 200, 300, 400, 500mSec] (120mSec)	80mSec
		6.16	Remote Start	No, Yes,	No
		6.17	EC Trip Latch	[On / Off] For Reset – Operate Reset Button	On
		6.18	Ins.Tst Level	1, 2, 5, 10, 20MW, None	1.0MW
		6.19	U/V Trip level	[40, 50, 60, 70, 75, 80, 85, 90, 95%, Off]	40%
		6.20	back emf time	[2 , 5, 10, 15, 20 Sec]	2 Sec
		6.21	High I alarm (Delay – 1s)	[100 – 600% FLC & Off]	100%
		6.22	O/L Alarm Lev (Delay – 2s)	50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, Alarm Off	50%
		6.23	Under I Alarm (Delay – 2s)	32%, 40%, 48%, 56%, 64%, 72%,80%, 88%, 96%, Off	32%
		6.24	E/L Alarm Lev (Delay – 1s)	10%, 20%, 30%, 40%, 50%,60%, 80%, Off	10%
		6.25	Burp Pulses	[None, 1 to 6]	None
		6.26	Burp On Time	[0.6, 0.8, 1.0, 1.2, 1.5, 2.0. 2.5. 3.0Sec]	0.6 Sec
		6.27	Burp Off Time	[0.6, 0.8, 1.0, 1.2, 1.5, 2.0. 2.5. 3.0Sec]	0.6 Sec
		6.28	4-20 Ma Output	[O/L : 0 – 100%, lave: 0-250%, E/L: 0 -100%, MW 0- 40MW	O/L
		6.29	Snore Delay	Off, 5, 10, 15, 20, 8F, 15F, 20F, 30F, 60F (F= Fixed Delay)	Off

Type 1	EC Leak T
Tripped No Volts	EC Ω Trip
MC Close Fail	MC Opened
External MC Open	RTM Off L
Burp MCI Fail	Und.I.Trp
Under Current Trip	Stopped
Last Trip Message	Ext.Stop

Type 2	
Outlet Paused	Snore-Close Aux
Need IPM Start	High Current Alarm
Testing Insulation	Thermal Trip Alarm
Closing Main Cont.	Cur. Balance Alarm
Burp: MCR - Closed	Under Cur. Alarm
Burp: MCR - Open	Earth Leakage Alarm
Running	UnderVoltage Alarm
Snore	Insulat.Test Alarm

Type 3	
Earth Leakage Trip	RTM –Off Line Trip
Earth Cont. Trip	IPM Memory Error
Insulat. Fail Trip	RTM Memory Error
Over Current Trip	Stopped – IPM
Short Circuit Trip	
I Balance Trip	
Residual Cur. Trip	
Main Contactor Fail	

APPENDIX 5: IPM Modbus Address Table

Modbus Address	Byte Name	Bit Identification
0-3		**Reserved**
4 ***Note: Bit set when tripped***	**trips_1** **trips_2**	**Trip Status 1** 0 = Earth Leakage 1 = Earth Continuity Trip 2 = Insulat. test trip 3 = Overload Trip 4 = Short Circuit Trip 5 = Current Balance Trip 6 = Residual Current Trip 7 = Main Contactor Fail **Trip Status 2** 0 = External Stop 1 = RTM Offline Trip 2 = IPM Memory Error 3 = RTM Memory Error 4 = Stopped - IPM 5 = Modbus Timeout 6 = Modbus Stop 7 = RTM CT Ratio Error
5 ***Note: Bit set when tripped***	**soft_trips** **alarms**	**Soft Trip Status** 0 = Tripped No Volts 1 = MC Close Fail 2 = External MC Open 3 = Burp MCI Fail 4 = Under Current 5 = OTS Test Mode Exited 6 = Spare 7 = Last T: **Alarms** 0 = High Current Alarm 1 = Thermal Acc Alarm 2 = Current Balance 3 = Under Cur. Alarm 4 = Earth Leakage Alarm 5 = Under Voltage Alarm 6 = Insulation Test Alarm 7 = Spare
6 ***Note: Bit set when active***	**ipm_stat2_byte** **ipm_stat_byte**	**Relay Status** 0 = Outlet Paused 1 = Need IPM Start 2 = Testing Insulation 3 = Closing Main Cont. 4 = Burp: MC Closed 5 = Burp: MC Open 6 = Running 7 = Manual Insulation Test **Relay Status 2** 0 = Snore 1 = Snore – Close Aux 2 = RTM Version Error 3 = RTM Stop 4 = Wait on RTM Start 5 = Config Error 6 = OTS Test Mode 7 = Spare

Modbus Address	Byte Name	Bit Identification
7 ***Note: Key Bits 0-7 clear when key pressed***	**keys_control** **digital_inputs**	**Digital Inputs** 0 = Spare 1 = Spare 2 = Lock 3 = Reset 4 = Aux 5 = External Stop 6 = External Start 7 = MCI **Keys** 0 = Stop 1 = Start 2 = Reset 3 = Test 4 = Spare 5 = Spare 6 = Spare 7 = Spare
8		**Reserved**
9	**pilot_fwd**	Pilot Forward Resistance as a Percentage (%) of the trip level. Note: The IPM aims to trip at 36Ω (100%).
10	**pilot_rev**	Pilot Forward Resistance as a Percentage (%) of the trip level (nominally 2k).
11	**meg_result**	Insulat. Test Result 0: 0.0MΩ 1-99: 0.1MΩ - 9.9MΩ 100-127: Invalid Values 128-255: 0MΩ - 127MΩ (Modbus register value -128)
12	**cur_gain_Leds** **keys_menu_raw (in high byte)**	**Control Keys** 0 = Up Key 1 = Down Key 2 = Left key 3 = Right key 4 = Enter key 5 = ESC Key 14 = Red LED 15 = Green LED
13	**el_cur**	**Earth Leakage Current** (0…250%)
14	**cur_a**	**A Phase Current** (0…1000%)
15	**cur_b**	**B Phase Current** (0…1000%)
16	**cur_c**	**C Phase Current** (0…1000%)
17	**current_bal**	**Current Balance** (0…100%)
18	**ir_cur_high**	**Residual Current** (0…1000%)
19		**OC Thermal Accum** (0…120%)
20	**volts_a**	**A Phase Voltage** (0…120%)

Modbus Address	Byte Name	Bit Identification
21	volts_b	**B Phase Voltage** (0…120%)
22	volts_c	**C Phase Voltage** (0…120%)
23	volts_average	**Phase Voltage Average** (BCD format)
24	current_ave	**Current Average** (0…250%)
25-29		**Reserved**
30	serial_high	**Serial Number High** Top 16 bit of serial number
31	Serial_low	**Serial Number Low** Lower 16 bit of serial number
32	mia_sw_ver	IPM Software Version – where x = Top 3 bits (Hardware Ver.) y = Bot 5 bits (Software Ver.)
33	sub_second	Time Sub – Second
34	second	Time – Second
35	minute	Time – Minute
36	hour	Time – Hour
37	date	**Date** eg. 1 = 1st, 15 = 15th
38	month	**Month** eg. 1 = Jan, 6 = Jun
39	year	**Year** (two digits only)
40	day	**Day** eg. 0 = Sunday, 1 = Monday
41	pilot_mode	**EC Pilot Mode** 0 = Invalid Data 1 = RTM 2 = Diode
42	param_itm	**ITM Module** 0 = Invalid Data 1 = 415V 2 = 1000V 3 = None
43	param_mb_adr	**Modbus Address** 0 = Invalid Data 1……31
44	param_mb_baud	**Modbus Baud Rate** 0 = Invalid Data 1 = 1200 Even Parity 2 = 1200 Odd Parity 3 = 1200 No Parity 4 = 2400 Even Parity 5 = 2400 Odd Parity 6 = 2400 No Parity 7 = 4800 Even Parity 8 = 4800 Odd Parity 9 = 4800 No Parity 10 = 9600 Even Parity 11 = 9600 Odd Parity 12 = 9600 No Parity 13 = 19200 Even Parity 14 = 19200 Odd Parity 15 = 19200 No Parity

Modbus Address	Byte Name	Bit Identification
45	machine_type	**Machine Type** 0 = - - - - 1 = J-bo - Jumbo 2 = Fan 3 = Drill 4 = Pump 5 = Hpmp - Hydraulic Pump 6 = Wpmp - Water Pump 7 = DCB 8 = Bolt - Bolter 9 = HRMr - Hard Rock Miner 10 = Belt 11 = Winc - Winch 12 = Crush - Crusher 13 = DPlug – Dummy Plug 14 = Spare
46	machine_num	**Machine Number** 0 = Invalid Data 1 …. 40
47	cur_range_param	**FLC Setting (See OC section)** 1..32 = 5.125..10.000A 33..64 = 10.25..20.00A 65..96 = 20.5..40.0A 97..128 = 41..80A 129..160 = 82..160A 161..192 = 164..320A 193..224 = 328..640A
48	short_cct_param	**SC Trip Level (xFLC)** 0 = Invalid Data 1 = 3x 2 = 3.5x 3 = 4x 4 = 4.5x 5 = 5x 6 = 5.5x 7 = 6x 8 = 6.5x 9 = 7x 10 = 7.5x 11 = 8x 12 = 8.5x 13 = 9x 14 = 9.5x 15 = 10x
49	sc_trp_tm_param	**SC Trip Time** 0 = Invalid Data 1 = 20 ms 2 = 40 ms 3 = 60 ms 4 = 80 ms 5 = 100 ms 6 = 120 ms 7 = 160 ms

Modbus Address	Byte Name	Bit Identification
50	time_mul_param	**O/L Trip Time @ 6x FLC** 0 = Invalid Data 1 = 3s 2 = 4s 3 = 5s 4 = 6s 5 = 7s 6 = 8s 7 = 10s 8 = 12s 9 = 14s 10 = 16s 11 = 20s 12 = 24s 13 = 28s 14 = 32s 15 = 40s
51	cool_mul_param	**S-Cool Ratio** 0 = Invalid Data 1 = 1.0 2 = 1.5 3 = 2.0 4 = 2.5 5 = 3.0 6 = 4.0 7 = 5.0
52	ol_rst_param	**O/L Reset Level** 0 = Invalid Data 1 = 30% 2 = 40% 3 = 50% 4 = 60% 5 = 70% 6 = 80% 7 = 90% 8 = A-30% 9 = A-40% 10 = A-50% 11 = A-60% 12 = A-70% 13 = A-80% 14 = A-90%
53	cur_bal_param	**Current Balance Trip** 0 = Invalid Data 1 = 5% 2 = 10% 3 = 20% 4 = 50% 5 = OFF
54	p_und_cur	**Under I Trip** 0 = Invalid Data 1 = 32% 2 = 40% 3 = 48% 4 = 56% 5 = 64% 6 = 72% 7 = 80% 8 = 88% 9 = 96% 10 = OFF

Modbus Address	Byte Name	Bit Identification
55	rc_lev_param	**Ires Trip Level (%FLC)** 0 = Invalid Data 1 = 10% 2 = 20% 3 = 30% 4 = 40% 5 = 50% 6 = 60% 7 = 80% 8 = 100% 9 = 120% 10 = 150% 11 = 200% 12 = 250% 13 = OFF
56	rc_tim_param	**Ires Trip Time** 0 = Invalid Data 1 = 100ms 2 = 200ms 3 = 500ms 4 = 1 Sec 5 = 2 Sec 6 = 3 Sec 7 = 5 Sec
57	el_sens	**RCD Trip Level** 0 = Invalid Data 1 = 25mA 2 = 50mA 3 = 100mA 4 = 200mA 5 = 500mA 6= OFF
58	el_time	**RCD Trip Time** 0 = Invalid Data 1 = Ins. (Instantaneous) 2 = 50ms 3 = 100ms 4 = 150ms
59	ectime_adj	**Pilot Trip Time** 0 = Invalid Data 1 = 80ms 2 = 120ms 3 = 160ms 4 = 200ms 5 = 300ms 6 = 400ms 7 = 500ms
60	remote_control	**Remote Start** 0 = Invalid Data 1 = No 2 = Yes 3 = Aux
61	pilot_latch	**Pilot Latch** 0 = Invalid Data 1 = On 2 = OFF
62	meg_level	**Meg Level** 0 = Invalid Data 1 = 1.0M 2 = 2.0M 3 = 5.0M 4 = 10M 5 = 20M 6 = None

Modbus Address	Byte Name	Bit Identification
63	uv_lev_param	**Under Voltage Trip Level** 0 = Invalid Data 1 = 40% 2 = 50% 3 = 60% 4 = 70% 5 = 75% 6 = 80% 7 = 85% 8 = 90% 9 = 95% 10 = OFF
64	b_emf_time	**Back EMF Time** 0 = Invalid Data 1 = 2 Sec 2 = 5 Sec 3 = 10 Sec 4 = 15 Sec 5 = 20 Sec
65	hc_alm_param	**High Current Alarm** 0 = Invalid Data 1 = 100% 2 = 108% 3 = 120% 4 = 140% 5 = 160% 6 = 200% 7 = 240% 8 = 280% 9 = 320% 10 = 360% 11 = 400% 12 = 500% 13 = 600% 14 = OFF
66	ta_alm_param	**O/L Alarm Level** 0 = Invalid Data 1 = 50% 2 = 60% 3 = 70% 4 = 75% 5 = 80% 6 = 85% 7 = 90% 8 = 95% 9 = OFF
67	uc_alm_param	**Under Current Alarm** 0 = Invalid Data 1 = 32% 2 = 40% 3 = 48% 4 = 56% 5 = 64% 6 = 72% 7 = 80% 8 = 88% 9 = 96% 10 = Off

Modbus Address	Byte Name	Bit Identification
68	ec_alm_param	**Earth Leakage Alarm** 0 = Invalid Data 1 = 10% 2 = 20% 3 = 30% 4 = 40% 5 = 50% 6 = 60% 7 = 80% 8 = OFF
69	p_burp_num	**Number of Burp Pulses** 0 = Invalid Data 1 = None 2 = 1 3 = 2 4 = 3 5 = 4 6 = 5 7 = 6
70	p_burp_on	**Burp On Time** 0 = Invalid Data 1 = 0.6 S 2 = 0.8 S 3 = 1.0 S 4 = 1.2 S 5 = 1.5 S 6 = 2.0 S 7 = 2.5 S 8 = 3.0 S
71	p_burp_off	**Burp Off Time** 0 = Invalid Data 1 = 0.6 S 2 = 0.8 S 3 = 1.0 S 4 = 1.2 S 5 = 1.5 S 6 = 2.0 S 7 = 2.5 S 8 = 3.0 S
72	p_4_20_op	**4-20mA Output** 0 = Invalid Data 1 = O/L 2 = Iave 3 = Iel 4 = MΩ
73-74		**Reserved**
75	_snoreIndex	**Snore Delay** 0 = Invalid Data 1 = OFF 2 = 5 3 = 10 4 = 15 5 = 20 6 = 8F 7 = 15F 8 = 20F 9 = 30F 10 = 60F
76	RCD_rst_lock	**RCD Reset Lock** 0 = Invalid Data 1 = OFF 2 = ON
77-78		**Reserved**

APPENDIX 6: Drawings

The drawings listed in the below table appear in Section 6 in the same order.

Drawing No.	Description
IPM2E002	Connection Diagram
IPM2A013	IPM2 Integrated Protection Relay Display Map
IPM2E008	Motor Overload & Short Circuit Trip Times
IPM2A017	IPM2 S/S Fascia Case Dimension Detail
IPM2A001	IPM Relay Backplane Connection Details
IPM2A002	IPM 415V ITM Dimension & Marking Details
IPM2A003	IPM 1kV ITM Dimension & Marking Details
IPM2A005	IPM RTM Remote Termination Module Dimension & Marking Details
IPM2A018	IPM Relay Current TXF Profiles