IPE – INTEGRATED PROTECTION RELAY

User Manual

Version: 3, November 2023

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 IPE.

WARNING!

STOP

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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DEFINITIONS

Term	Definition
2FB	2x Fixed Outlet IO Block
4FB	4x Fixed Outlet IO Block
2WB	2x Withdrawable Outlet IO Block
4WB	4x Withdrawable Outlet IO Block
Base	The hardware the IPE Relay plugs into. Contains HVR's.
CB	Circuit Breaker
CCM	Cable Connection Module
Dongle	A small memory device which is used to store setting information for the IPE or RTX.
EC	Earth Continuity
EFLO	Earth Fault Lockout
EL	Earth Leakage
ELV	Extra Low Voltage
EMF	Electro-Motive Force
FC	Frozen Contactor
FLC	Full Load Current
FMEA	Failure Modes and Effects Analysis
Healthy	A state in which nothing should trip during the transition of the state under test
HMI	Human Machine Interface
HVR	High Voltage Resistors
IPE	Integrated Protection Relay Type E
RTX	Remote Termination Unit Type X
LOV	Loss of Vacuum
MC	Main Contactor
MEM	Main Electronics Module
OL	Overload
OTS	Outlet Test System
Outlet	The interface that sits on the load side of the Main Contactor
PIP	Protection Interface Platform
PIPS	Protection Interface Platform Screen
PIT	Protection Interface Terminal
IPE	Integrated starter with AS/NZS 2081 protection for underground hard rock mines
RTD	Resistive Termination Device
Running	Main contactor closed and main contactor auxiliary indication in correspondence with the main contactors state (i.e., indicating that the main contactor is closed).
SC	Short Circuit
Start	A sequence beginning with a start command being issues from the PLC, the completion of several outlet pre-energising checks leading up to the closing of the main contactor
Stopped	Main contactor open and main contactor auxiliary indication in correspondence with the main contactor state (i.e., indicating that the main contactor is closed).
Trip	A fault condition which requires the opening of the main contactor or the circuit breaker (fault dependent) to clear the fault, or prevents the closing of the main contactor or circuit breaker
TXF	Transformer
UC	Under current
UV	Under Voltage

1 VERSION HISTORY

IPE Protection Software Version History

Version	Release Date	Changes
V14	01/07/2016	Added additional start state for Parallel feed control.
V15	13/07/2017	Improvements to internal CPU stack to prevent Internal Logic Error trips.
V16	18/04/2019	Extend FC trip setting to 400ms from 100ms for relays with FW <16.
V17	13/07/2020	Added additional system voltages (415 V, 690 V) FW at IPE Release

IPE COMM’s Software Version History

Version	Release Date	Changes
V8	28/02/2018	Improved data mapping as well as writing and storage of data

RTX Version History

Version	Release Date	Changes
V8	12/09/2019	FW at IPE Release

2 SAFETY AND OTHER WARNINGS

For safety reasons, the IPE and associated hardware 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 equipment in accordance with the instructions contained in this manual may create hazardous operating conditions.

2.1 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:

2.1.1 Intended Use of Equipment

The IPE is intended to be used as a part of the electrical protection system operating on outlets supplying underground mining machinery. Multiple protection functions, as listed in this document, 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 IPE is not intended to be the sole method of providing electrical protection for machinery and personnel. Other measures, such as E-Stops, interlocks and earth-fault-current limiting resistors are to be employed to ensure the highest level of operational safety. It is recommended that safety analysis techniques such as risk assessment or FMEA be conducted on installations employing the IPE to maximise the safe operation of the installation.

2.1.2 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.

2.1.3 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.

2.1.4 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 equipment and gloves should be worn.

2.1.5 Installation

Correct operation and safety depend on the IPE and associated equipment being installed and configured 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.

2.1.6 Operation

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

2.2 Supplementary Documentation

The IPE User Manual is expected to be read in conjunction with the following documentation:

- MAG-311 – PIP User Manual
- MAG-182 – OCS User Manual

2.3 Certification

WARNING! STOP	To comply with the **Conditions of Certification**, ensure full serviceable life of the product, and avoid nullifying the warranty, it is essential to exercise great care with the installation, use and storage of the system components. Failure to comply with the Conditions of Certification may seriously compromise the integrity of the system and/or its components, and the consequence could be fatal. The user must ensure that the "Special Conditions" outlined in the certificate and its attachment are met or the certificate (and the IS rating) will not be valid.

The latest certificate and its associated attachments outlining the special conditions of the certification are maintained and available on the IEC Ex Website : http://iecex.iec.ch , certificate IECEx ITA 12.0032X. Installers and users of the IPE need to refer to this information to ensure the latest information & conditions are considered.

Certification drawings IPEZ001 & IPEZ002 are included in this manual.

2.3.1 IS Parameters

Combined Phase & Pilot Port	RTX
C: 3.72 µF	Ui: 28.0 V
L/R: 4.5 mH	Ci: 18.8 nF
L/R: 207 µH/Ohm	Li: nil

Terminals 3 to 28: Um = 132 VAC RMS phase to earth

Flying leads: Um = 2286 V RMS phase to earth

Temperature Range: 0 °C < Ta < 60 °C

The above load parameters apply where;

a. The external circuit contains no combined lumped inductance (Li) or lumped capacitance (Ci) greater than 1% of the above values. OR
b. The external circuit contains either only lumped inductance (Li) or lumped capacitance (Ci) in combination with a cable. OR
c. The inductance and capacitance are distributed as in a cable.

In all other situations e.g. the external circuit contains combined lumped inductance and capacitance, up to 50 % of each of the inductance and capacitance values are allowed.

2.4 HV Insulation Test

WARNING! STOP	This equipment generates **dangerously high voltage levels**. Because of the potential risks associated with this equipment it is essential that only appropriately qualified and experienced personnel be permitted to work on or around this equipment.

The IPE has a 'High Voltage Insulation Test' function. Because of this, 2700 / 900 VDC may be present on Ua, Ub and Uc whenever 24 V control power is present.

2.5 Requirements for Safe Operation

Circuit breakers typically have a higher current breaking capacity than contactors. Because of this, during certain trips, for example a short circuit trip, the IPE will open the circuit breaker, by opening its CBR, and not the main contactor. The MCR will be held closed for one second after the CBR has opened in order to give the circuit breaker sufficient time to clear the fault.

When installed in systems without a circuit breaker, a short circuit fault that occurs at the same time as another type of fault, for example earth leakage, will prevent the main contactor from opening for one second. To prevent this hold off time simply wire the CBR in series with the MCR so that any fault that occurs will cause the main contactor to open.

- All settings must be implemented in accordance with the user's fault and touch potential control studies
- Upstream protection must be implemented in accordance with the user's fault and touch potential control studies
- Upstream isolation must be carried out in accordance with user's risk assessments and operating procedures
- All requirements for safe operation should be integrated into the user's own work procedures
- Earthing must be in compliance with all regulations that the installation is subject to
- Users must periodically confirm the correct operation of E-stop as per their risk assessment
- The IPE and associated hardware must be installed, operated and serviced only by authorised and competent personnel
- The user is responsible for implementing a change management strategy to ensure all settings are configured in compliance with site protection and touch potential studies
- The IPE is not designed for use in explosive atmospheres
- Do not operate in direct sunlight
- Do not operate the IPE and associated hardware outside of their electrical or mechanical ratings.
- The IPE and associated hardware is designed for underground or indoor use

2.6 Operational Restrictions and Limits

The operational restrictions listed below must be understood before considering using the IPE within systems designed to ensure the safety of personnel.

2.6.1 Installation

CAUTION!	The selection, installation, commissioning and use of this protective device should only be undertaken following the application of a **detailed risk assessment** that is consistent with the methodology outlined in **AS/NZS ISO 31000** risk management. Additionally, identified risk control measures identified within the risk assessment, in addition to the safety controls and/or directions contained within this operating manual, must be validated as effective before use of the product in any capacity.

CAUTION!	The IPE integrated protection relay is **NOT designed to be used as the sole means of ensuring safety to personnel or equipment**.

CAUTION!	The IPE integrated protection relay is **NOT water resistant** and must be **mounted within a suitably IP rated enclosure** for use where the overall system is to be rated water resistant

2.6.2 Certification

WARNING!	To comply with the **Conditions of Certification**, ensure full serviceable life of the product, and avoid nullifying the warranty, it is essential to exercise great care with the installation, use and storage of the System components. **Failure to comply** with the Conditions of Certification may **seriously compromise the integrity of the system** and/or its components, and the consequence could be fatal. The user must ensure that the "Conditions of Safe Use" outlined in the certificate are met or the **certificate (and the I.S. rating) will not be valid**.

WARNING!	The IPE integrated protection relay is **NOT certified for use in Group II hazardous area applications**

WARNING!	The IPE integrated protection relay **must NOT be modified in any way**. A controller that differs in any way from its 'as-certified' condition must not be used.

2.6.3 Maintenance

CAUTION!

The IPE integrated protection relay is **NOT on-site repairable** and contains no user serviceable parts.

CAUTION!

An IPE integrated protection relay showing **any visible signs of damage must not be used**.

CAUTION!

All **ancillary equipment** used with the IPE integrated protection relay **should be as specified in the IPE Equipment List** to ensure safe operation of the relay.

CAUTION!

Cleaning the controller may create an **electrostatic hazard**. Anti-static cleaning media must be used.

3 RECEIVING AND STORAGE

3.1 Receiving

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

In the 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.

3.2 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.

3.3 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.

3.4 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.

4 PRODUCT DESCRIPTION

4.1 Overview

The Ampcontrol IPE Integrated Protection Relay is an intelligent protection relay based on microprocessor technology.

The integrated relay provides the necessary functions required for protecting electrical outlets supplying underground mining machinery. 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.

Control of the relay is achieved through the Protection Interface Platform (PIP). Details on how this system integrates the IPE can be achieved through the PIP user manual and should be read in conjunction to this user manual.

4.2 Key Features

- Improved integration
- Simplified wiring and installation
- Parameter dongle for storage of protection and control settings
- Integrated cable connection module (CCM)
- Improved robustness of pilot communications with new Remote Terminal Unit (RTX)
- Improved protection function performance
- AS/NZS 2081: 2011 Compliance
- IEC 60079 Certification
- Capability for future expansion platform

4.3 Protection Functions

- Configurable Earth Leakage (EL)
- Configurable Earth Continuity (EC)
- Main Contactor Failure (MCF) protection include Frozen Contactor (FC) protection
- Configurable Short Circuit (SC) and Overload (OL)
- Motor thermal modelling
- Configurable current imbalance
- Configurable Under Voltage (UV) / Under Current (UC)
- Automatic HV insulation test prior to outlet closing
- Remote start/stop functionality
- Machine identification – Remote Terminal Unit Type X (RTX)
- Wide range of System Voltage compatibilities – 415 V / 690 V / 1.1 kV / 3.3 kV

NOTE

If the IPE is to be used in a hazardous environment, it must be installed within suitably certified flameproof enclosure.

NOTE

The equipment is to be operated within an ambient temperature range of – 20 °C to + 40 °C.

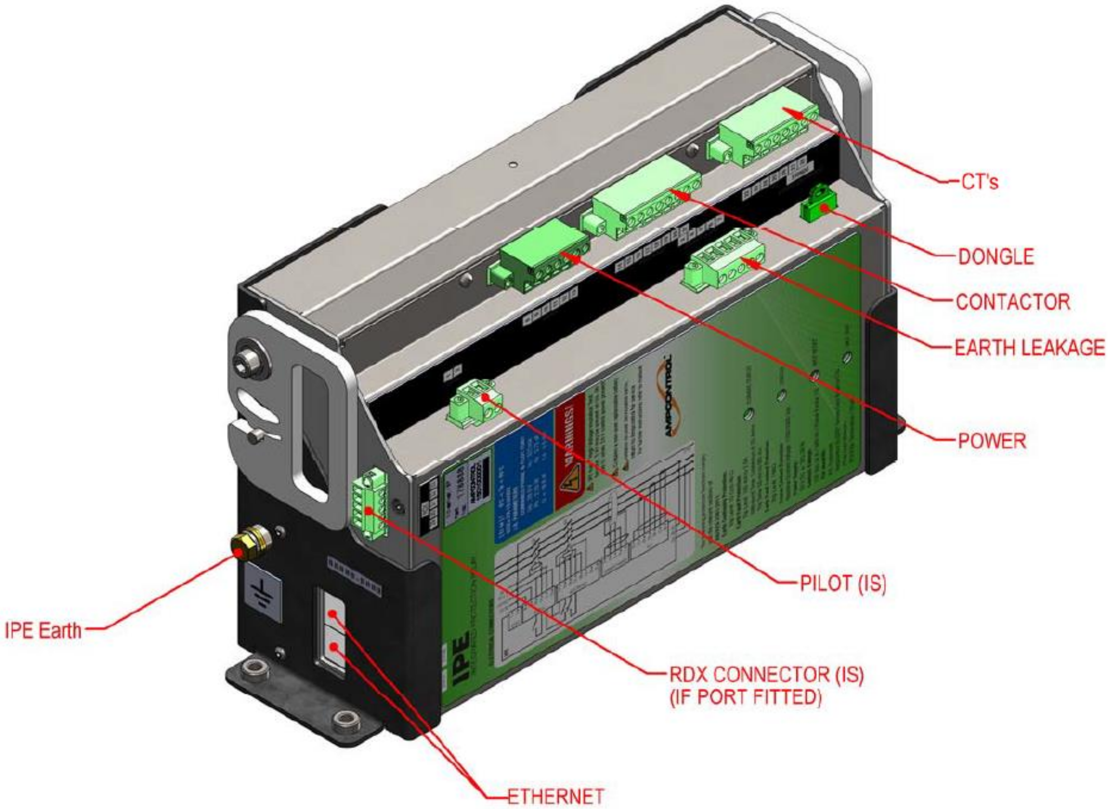


Figure 1: IPE Relay (197358)

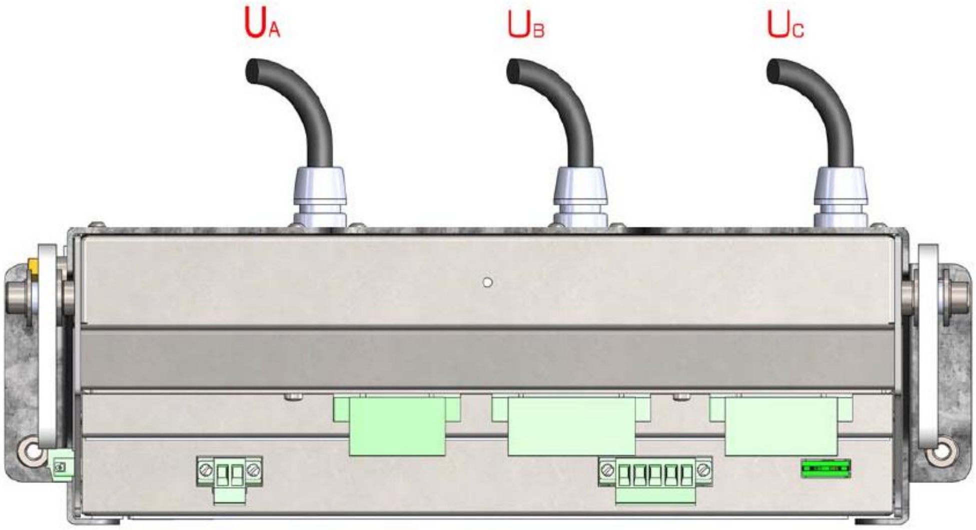


Figure 2: IPE Relay (197358) Top View

4.4 IPE Introduction

The IPE relay was designed for standalone outlet protection applications. The IPE provides a number of control and protection functions that ensure the electrical distribution system in the mine operates safely. Typically there will be one IPE to control each individual power outlet in the power system. Installations of power outlets, cables and machines are provided with restrained couplers, however glanded connections and Bolted adapters are also commonly utilised. These couplers allow for quick and easy reconfiguration of the mine power systems, as equipment is moved to different locations / applications.

The IPE can force the power system into a safe state by removing power from the connected cable and machine on the power outlet it controls. To achieve this, the system includes two external actuators, a Main Contactor (MC) and Circuit Breaker (CB). Typically the MC is used to control the supply of power to an outlet. The CB is opened when a fault is detected with the MC. The CB is also opened in the event of a short circuit fault, to ensure the current interruption limit of the MC is not exceeded. There are often multiple outlets, each controlled via individual contactors, fed from a single circuit breaker.

The IPE is designed to operate on impedance earthed power systems as described in AS/NZS 2081:2011. Under such an arrangement, the power system is supplied from a star transformer winding, with the star point connected to earth through a Neutral Earthing Resistor (NER). The NER limits the fault level of any single-phase fault to earth. All the equipment connected to the power system including motors and cables, are built with earth partitions where possible. This means the initial fault on the system will be a low energy fault that is detected and cleared by earth leakage protection.

The Protection Interface Platform (PIP) is connected via Ethernet/IP to the protection relay and is used to control / interface the IPE into a system including sequence controllers, PLC’s or Network Monitoring systems.

The Remote Termination Module Type X (RTX) can be installed at the load to communicate to the IPE through a pilot conductor in the power cable. The pilot is primarily used as an electrical interlock, but the RTX provides additional advanced functionality on top of the electrical interlock functionality. The RTX provides Machine recognition as well as storing the outlet protection settings for a particular load in which the RTX is installed. Alternatively the pilot can be terminated with a diode.

In a typical operating scenario, the IPE receives a command to start the outlet (closing the MC) or to stop (opening the MC). During a start sequence, if all protection functions are healthy the MCR will close to complete the contactor coil circuit to energise an outlet. If at any time a fault is detected or a stop is requested, the IPE will remove power from the outlet by opening either the MC or CB.

5 INSTALLATION

5.1 General Warnings

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

Before the IPE can be installed, there are a number of things that need to be considered and understood to prevent incorrect or unsafe operation of the IPE 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:

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

It is extremely important that the limitations and functionality of the IPE 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.

5.1.2 Ensure that the application into which the IPE 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.

5.1.3 Ensure that the IPE will properly perform the required functions within the system design.

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

5.1.4 Modifications of any form to the IPE are prohibited.

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

5.2 Mandatory Installation Practices

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

Using the IPE 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 IPE must be powered within the specified voltage range
- The installation of the IPE must be carried out by suitably trained and qualified personnel
- Identification labels fixed to the IPE must not be damaged, removed or covered
- The installation shall be in accordance with the relevant installation Standards/Codes of Practice
- IPE must not be modified. The unit is built to and complies with the relevant standards and modifications to its design and construction will render the unit non-compliant
- UV Protection should NOT be disabled to maintain compliance to AS/NZ 2081 unless appropriately risk assessed to comply with AS/NZ 4871
- Complete and accurate records of the installation(s) must be maintained
- The equipment is to be installed and maintained as per the conditions in the certification documentation
- Consideration of noise coupling and signal paths should be applied when terminating and routing the terminations of the relay, in particular the pilot circuit
- A regulated control supply should be used to reduce the transients and noise introduced into the relay during operation
- It is recommended that appropriate filters and or snubber circuits be installed on all power and control contactors to reduce the noise and transients coupled into the installed equipment

5.3 Mechanical Installation Information

5.3.1 IPE Dimensions Including Base

The IPE Relay has a Stainless-Steel enclosure designed to be mounted into existing enclosures, i.e., flameproof equipment or other enclosures of adequate IP rating. Connections to the IPE Relay are made via a series of plugs on the top of the relay.

The relay is designed to operate when mounted either laid down flat or in a vertical position. Sufficient spacing between relays should be used to maintain air gaps to assist in the cooling of the electronics inside the relay.

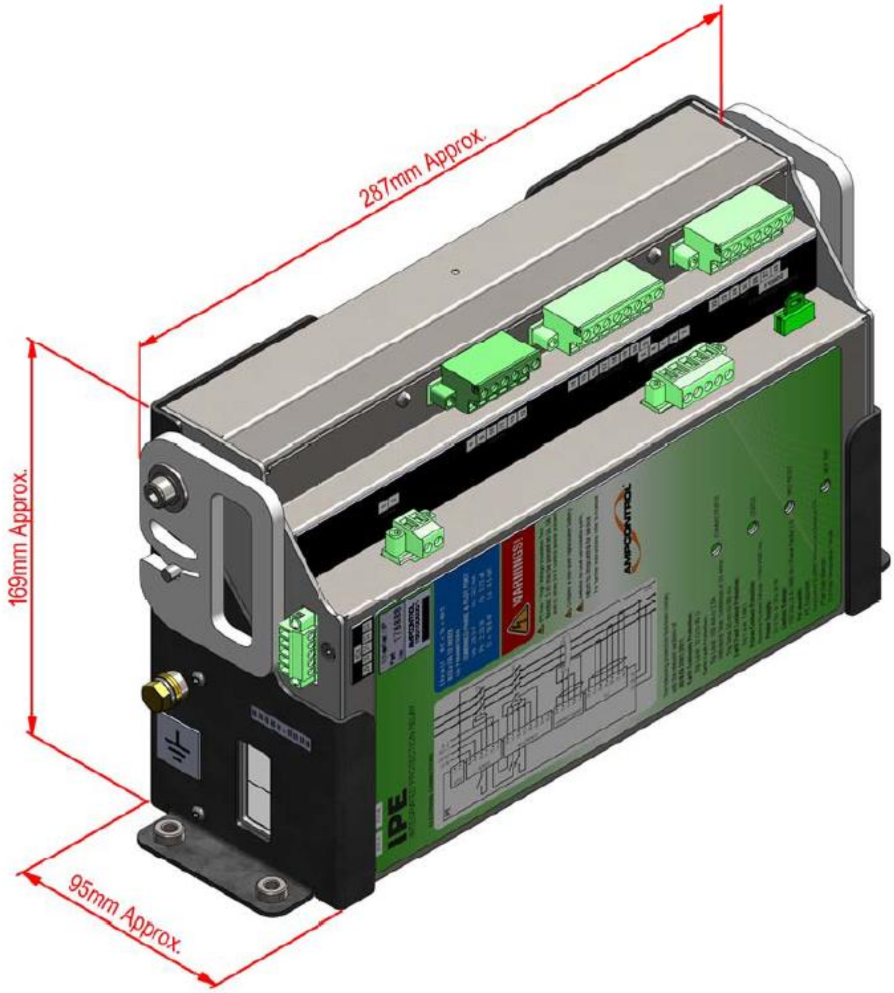


Figure 3: IPE Relay Dimensions

5.3.2 IPX Base Mounting Arrangement

The base provides flying leads for connection to the phases for the bases internal HVR's. The IPE relay is secured into the Base with securing clips once the relay has been inserted.

The base is to be securely fastened to the enclosure in which it is being installed. The designer should ensure that sufficient space is allowed around the relay for the ease of change out during routine maintenance. There is no restriction on orientation of installation.

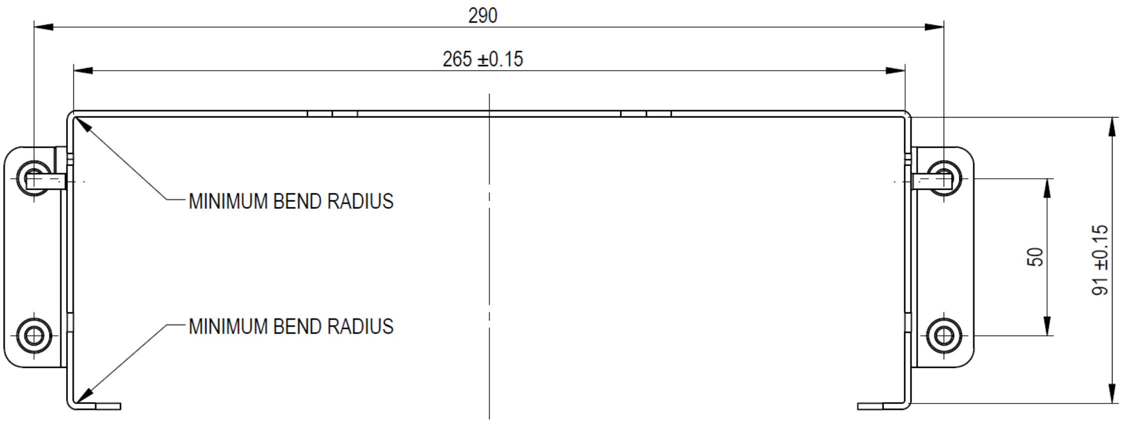


Figure 4: IPX Base Mounting Dimensions

NOTE	
	The IPE and Base can be installed into an enclosure at any orientation.

5.4 Electrical Installation

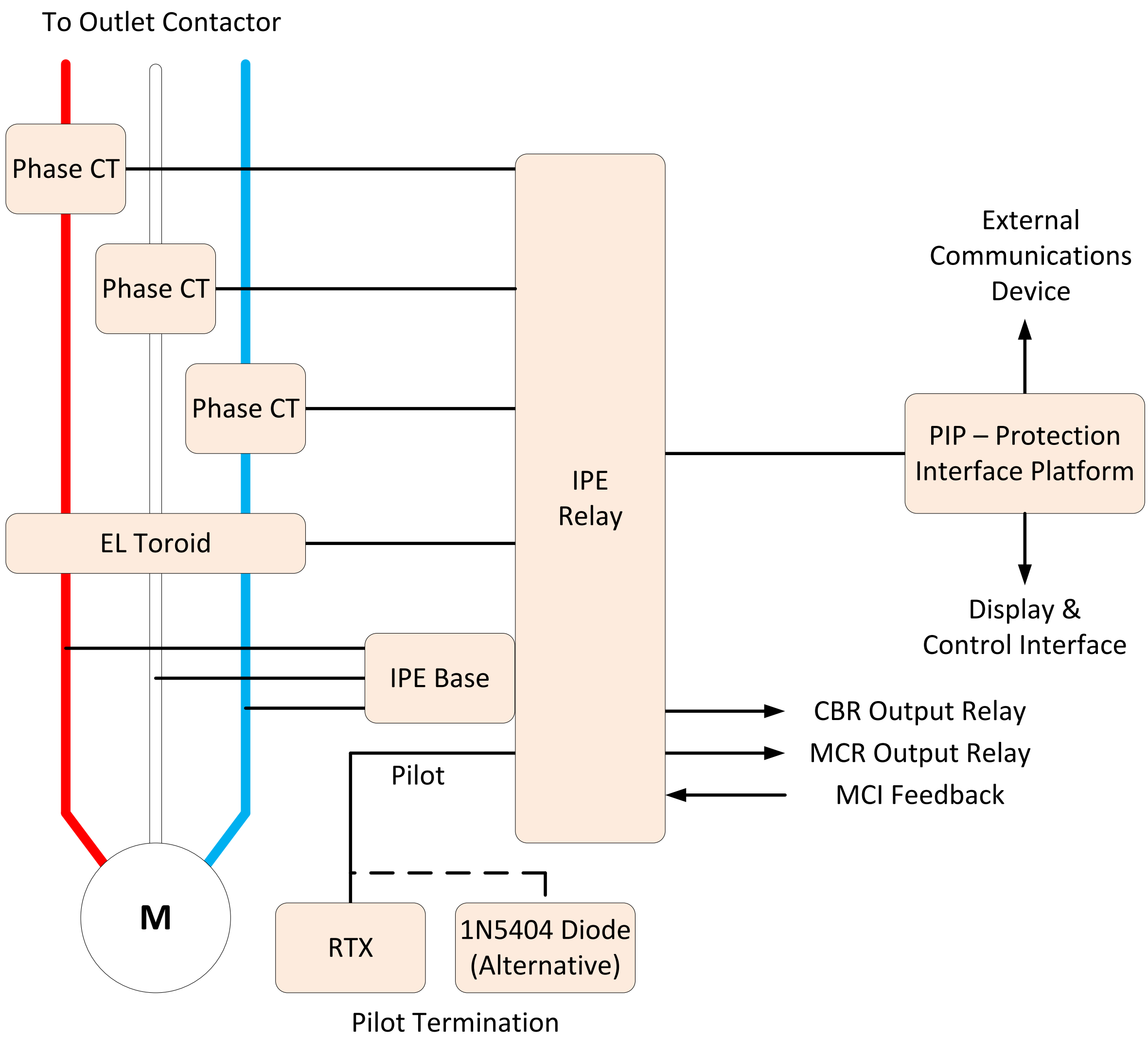


Figure 5: IPE Electrical Block Diagram

The below table will outline the connections to be made to the IPE relay. The IPE has 5x Plugs connections, 2x Ethernet connections, 1x dongle, phase connections and earth connections.

NOTE	
	All IPE I.S. Signals are earth referenced.

Terminal No.	Name	Functionality	Requirements
Relay Misc Connections			
	Ethernet Port 1	Local System network connection for all communications and control	Standard cat 5 Ethernet. Preferably shielded to eliminate interference.
	Ethernet Port 2		
	Parameter Dongle		The parameter dongle has no wiring, but it is recommended that it is tethered to wiring loom coming off the IPE to ensure the settings remain with the outlet if the IPE is replaced.
Base Connections			
Ua	IPX Base wiring Guidelines:	Used for voltage monitoring, EFLO and insulation testing	Phase connections Ua, Ub, Uc are connected directly to the 415/690/1100V/3300 V power conductors.
Ub			
Uc			
	IS Earth.		Earth connection is via a M6 bolt on the side of the IPX Base. Conductor size should be a minimum of 4 mm^2 and be secured with a spring or star washer to prevent the connection from coming loose, as per the IS installation standards.
Pilot Plug (I.S.)			
1	NA	This is an earth connection through the metalwork chassis	Not required to be connected
2	Pilot	Earth Continuity Signal	Only the pilot signal on the two pin connector should be wired (the earth should be left unconnected). The return signal is through the IS Earth connection on the IPX-Base.
	Pilot Shield		Shielding should be considered if required for I.S. segregation. Earthing of the shield in this case should be as per IS installation standards.
EL Plug			
3	Shield	Earth Leakage core balance CT input.	The shield terminal of the IPE is internally connected to earth and so the cable shield should not be connected to earth at any other point.
4	EL+		EL Connection – twisted pair. Recommended total cable resistance to be less than 0.5 Ω[1], to ensure the CT burden limit is not exceeded.
5	EL-		
6	Test+	The test circuit should be looped through the EL CT.	Test Drive connection – twisted pair. Recommended total cable resistance of less than 0.5 Ω.
7	Test-		
Power Plug			
8	0V	Supplies control power for the IPE	24 VDC, 1 A. Regulated Supply
9	24 V		

Terminal No.	Name	Functionality	Requirements
10	CBR NO	Connects to the internal CBR output NO relay	110 VAC. No special requirements. Current rated as per circuit breaker control and contactor coil specifications.
11	CBR COMM		
12	COIL SUPPLY +	Looped through to COIL-FEED-1/2 to supply the contactor coil	
13	COIL SUPPLY -		
Contactor Plug			
14	MCR1 COIL -	Looped through from COIL-SUPPLY-1/2	110 VAC/DC. No special requirements. Current rated as per circuit breaker control and contactor coil specifications.
15	MCR1 COIL +		
16	MCR2 COMM	Second MCR contact output NO relay	
17	MCR2 NO		
18	MCI +	Contactor feedback digital input. Connect to Auxiliary NO contact	24 VDC wiring. No special requirements. Low current only.
19	MCI -		
20	Outlet Comms Test Input	From PIP IO to confirm outlet identification	24 VDC wiring. No special requirements. Low current only.
21	NA		Do Not Connect
CT Inputs			
22	Shield	Phase current CT inputs.	Ia, Ib, Ic – Each CT should be a twisted pair. Recommended total cable resistance to be less than 0.1 Ω[1] to ensure the CT burden limit is not exceeded. The shield terminal of the IPE is internally connected to earth and so the cable shield should not be connected to earth at any other point.
23	Ia+		
24	Ia-		
25	Ib+		
26	Ib-		
27	Ic+		
28	Ic-		

5.4.1 Base Wiring

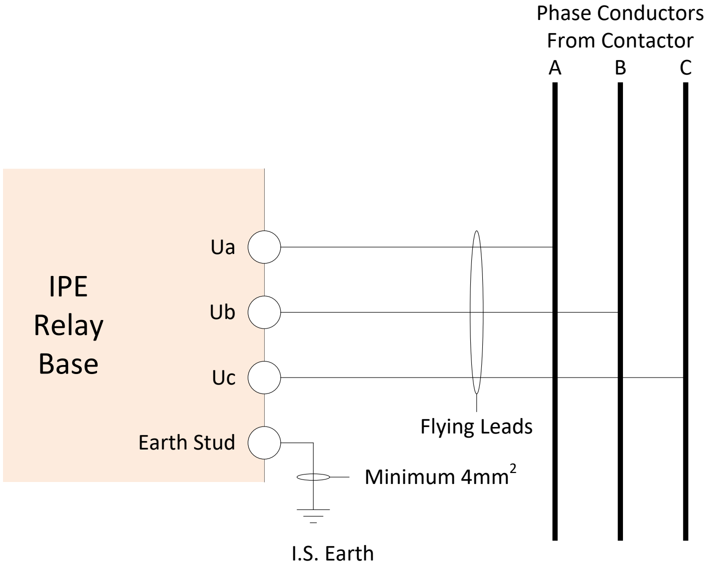


Figure 6: IPX Base Wiring

5.4.2 Pilot Plug Wiring

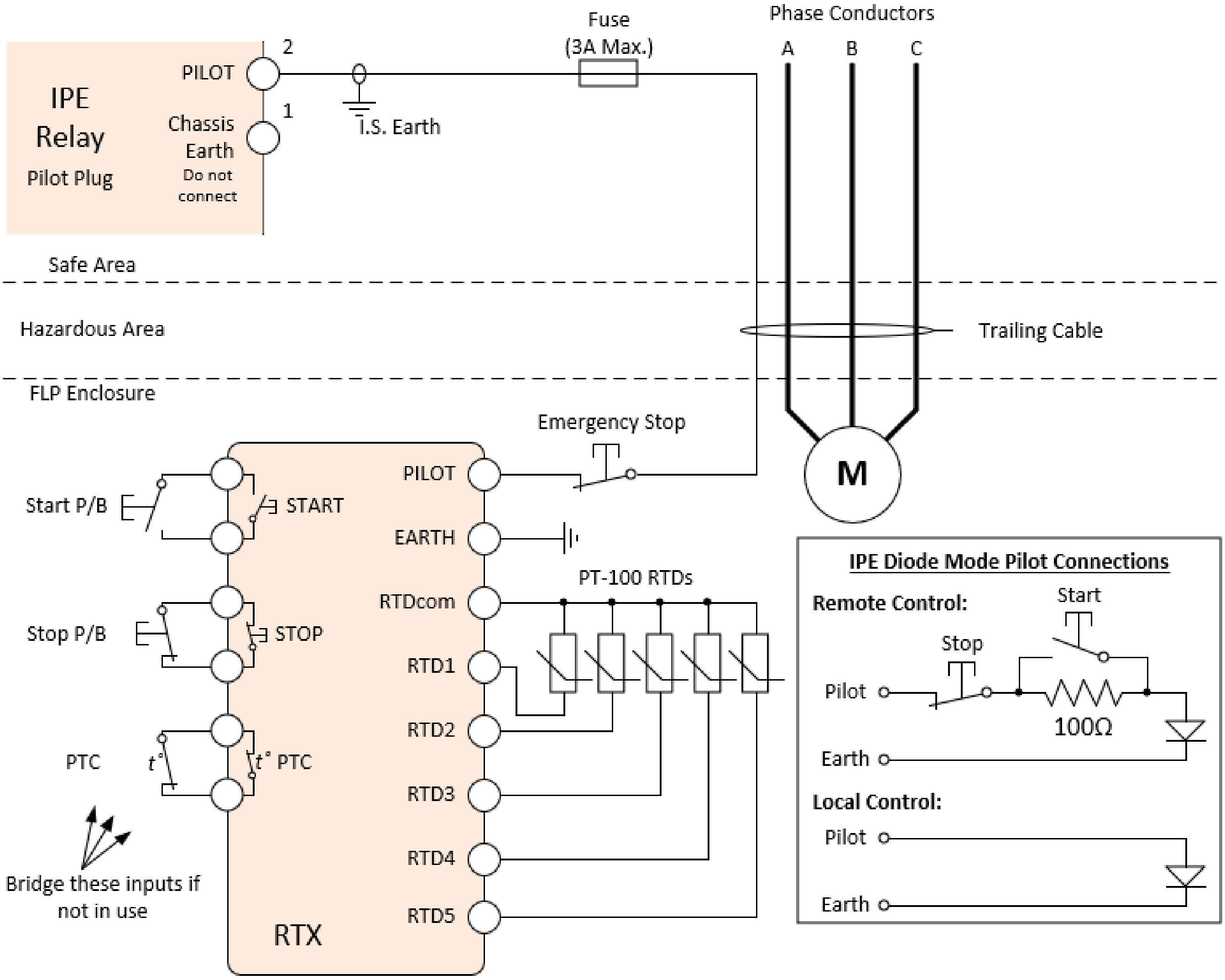


Figure 7: IPE Pilot Plug Wiring

5.4.3 **Earth Leakage Plug Wiring**

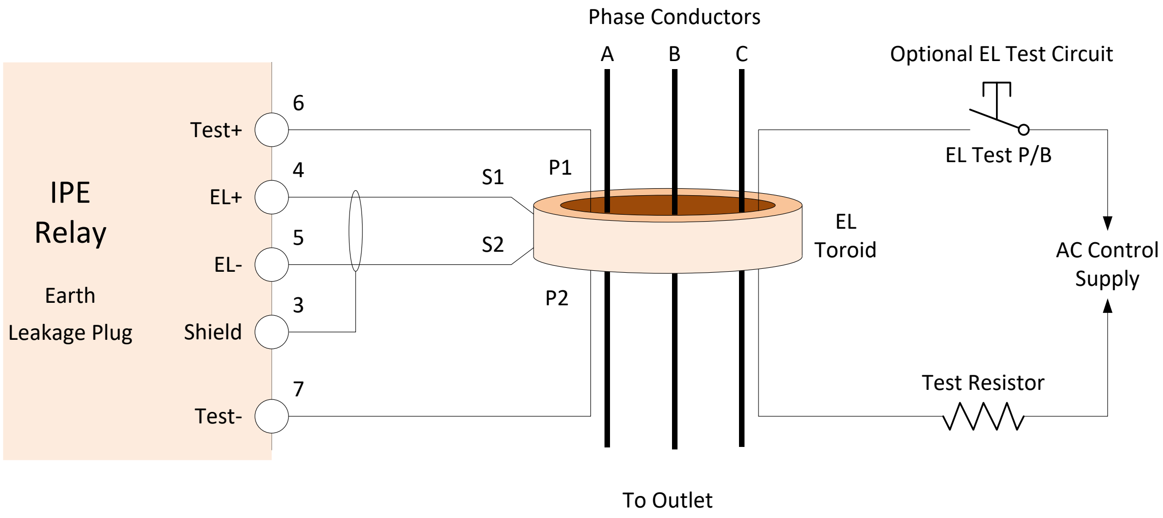


Figure 8: IPE Earth Leakage Plug Wiring

5.4.4 **Power Plug Wiring**

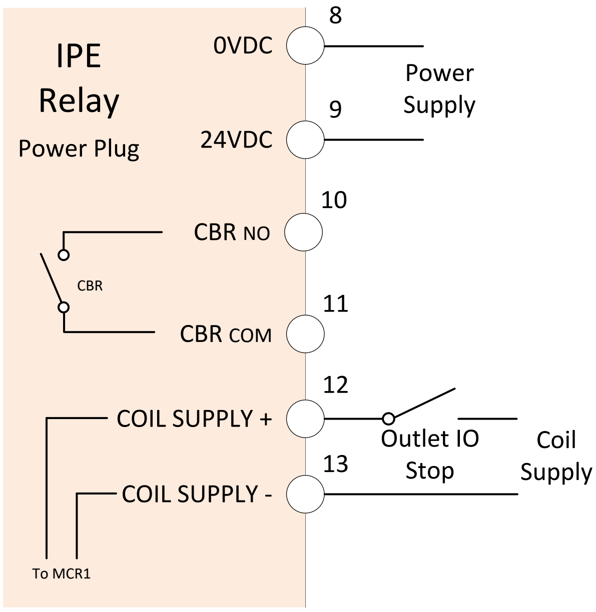


Figure 9: IPE Power Plug Wiring

5.4.5 **Contactor Plug Wiring**

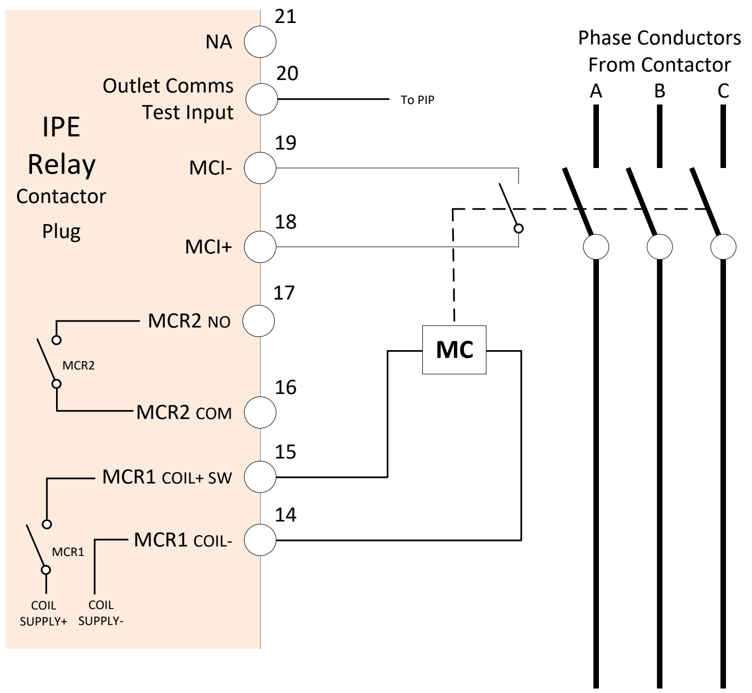


Figure 10: IPE Contactor Plug Wiring

5.4.6 **CT Plug Wiring**

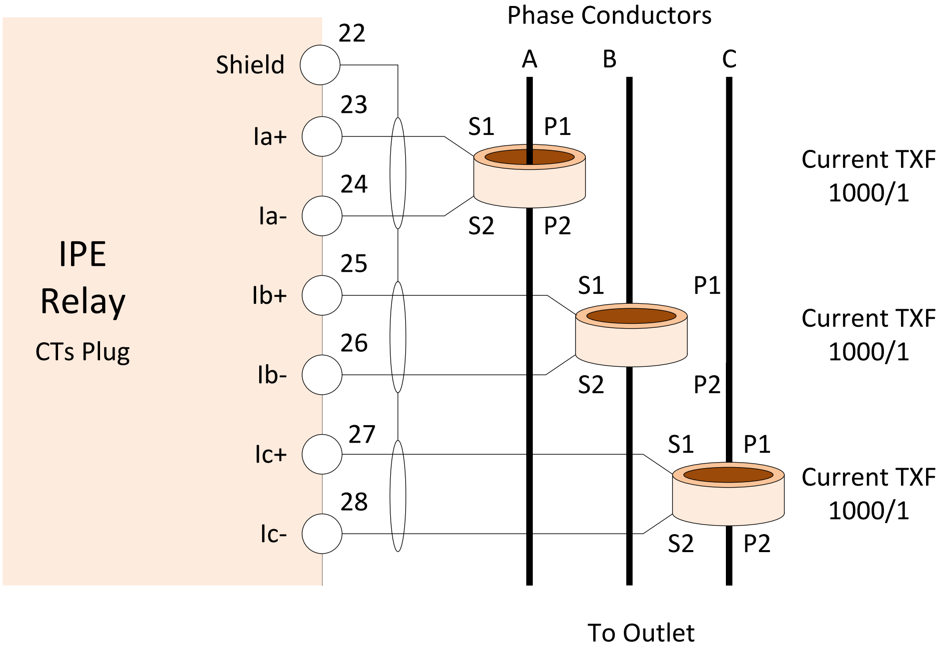


Figure 11: IPE CT Plug Wiring

6 ACCESSORIES

6.1 Earth Leakage Toroid

The IPE requires a summation toroid to be installed around the outlet's three phase conductors. This toroid allows the IPE to measure the magnitude of outlet's earth leakage current.

Only one (1) earth leakage toroid is required per IPE.

There are two standard sizes of Earth Leakage Toroid that are permitted for use with the IPE Relay, a 60 mm Inner Diameter and a 112 mm Inner Diameter. The approved toroid classifications are EL500 and EL500S.

Current transformers are not ideal devices and if correct procedures are not followed during installation, nuisance tripping can result. See Appendix for installation notes.

Figure 12: IPE Earth Leakage Toroid, EL500 60 mm

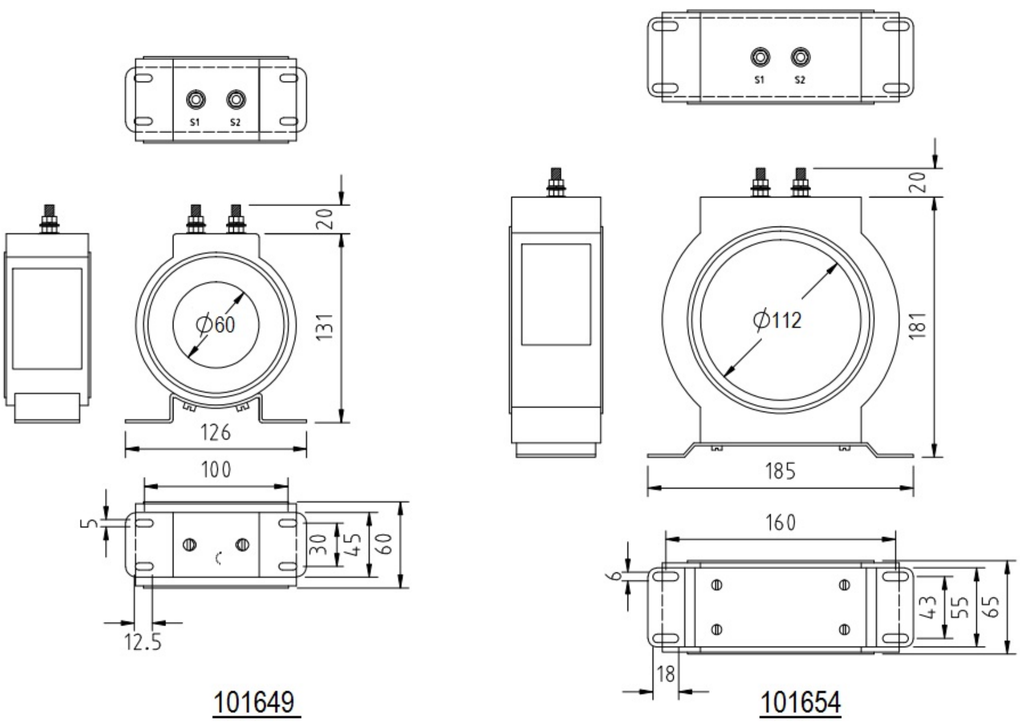


Figure 13: IPE EL500 Toroid Dimensions

6.2 Phase CT's

The IPE relay uses three 1000:1 phase CT's to measure each phase current individually. These measured current values allow the IPE to implement its overload and short circuit protection functions.

The IPE requires three (3) phase CT's.

The phase current transformers are available in two standard sizes: 45mm inner diameter and 88mm inner diameter.

Current transformers are not ideal devices and if correct procedures are not followed during installation, nuisance tripping can result. See Appendix for installation notes.

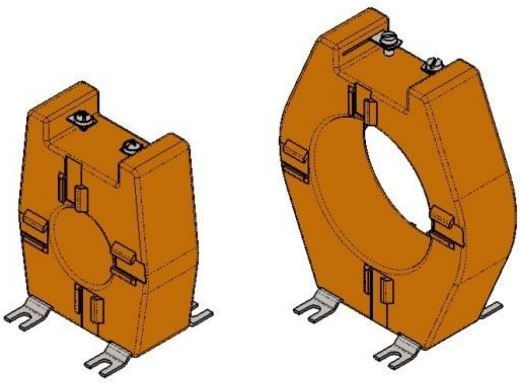


Figure 14: Phase CT's

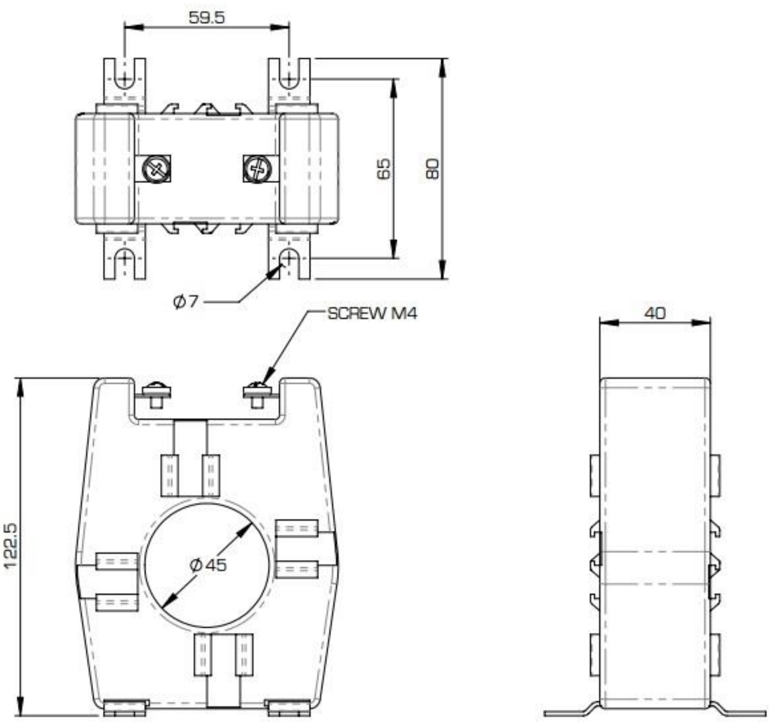


Figure 15: Current Transformer 45 mm I.D. (Part: 101272) Dimensional Details

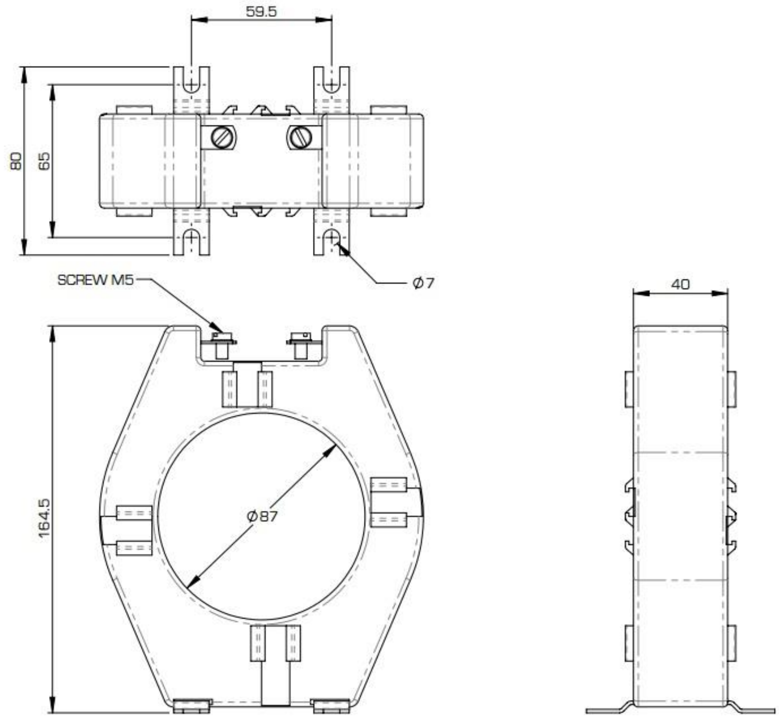


Figure 16: Current Transformer 88 mm I.D. (Part: 101703) Dimensional Details

6.3 Remote Termination Module Type X (RTX)

The RTX is a microprocessor based module that can be utilised to replace the diode at the end of the trailing cable pilot conductor. It is powered by and communicates via the pilot line. Its non-volatile memory stores the IPE's configuration and protection settings, allowing load identification and protections settings to be utilised whenever the load is used.

All RTX terminals are fully shrouded, with the pilot and earth terminals being segregated from the other control and monitoring terminals.

The RTX provides remote start and stop input facilities. The circuitry involved in these functions is self-diagnostic and will cause the outlet to turn off if the circuits are earthed or interconnected. This reduces the chance of the outlet operating when not required to do so due to wiring faults. It should be noted that these functions are operational only, and that any emergency stops should be wired directly into the pilot circuit.

WARNING!

Any emergency stops should be wired directly into the pilot circuit.

PTC terminals are provided for a semiconductor 'switching' thermistor. These terminals are protected in a similar manner to the stop and start circuits. The resistance threshold is as follows, trip when resistance exceeds 1960 Ω and reset when value drops back below 1847 Ω.

Five RTD inputs are provided for PT100 RTDs. The IPE can be programmed to trip on RTD over-temperature.

A parameter dongle allows an RTX to be replaced without needing to re-program the parameters. When installed, this dongle should be firmly secured to the machine/equipment. The relevant settings changes made on the connected IPE are automatically pushed to the RTX parameter dongle.

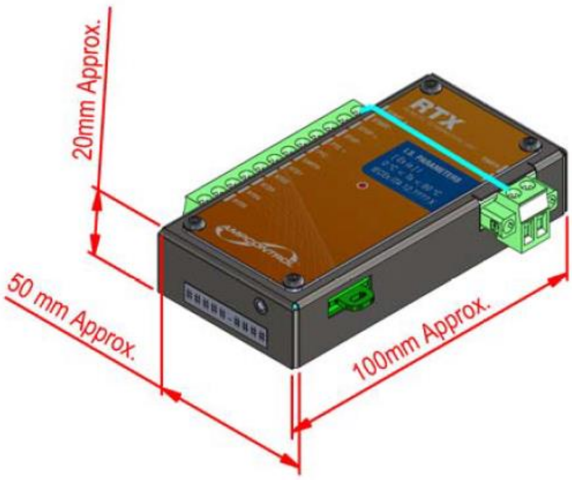


Figure 17: Remote Termination Unit Type X (RTX C/W Dongle: 196912)

Table 1: RTX Pinout

RTX			
Left Side		***Right Side***	
Terminal	***Description***	***Terminal***	***Description***
1	Start +	13	Earth
2	Start -	14	Pilot
3	Stop +	Parameter Dongle	
4	Stop -		
5	PTC +		
6	PTC -		
7	RTD Com		
8	RTD1		
9	RTD2		
10	RTD3		
11	RTD4		
12	RTD5		

A remote Start / Stop button can be implemented in the motor enclosure provided that the IPE's earth continuity protection is enabled.

If the remote start, stop, and PTC functions are not required, each set of terminals must be bridged to prevent incorrect data and control inputs being detected.

NOTE

If the **Remote Start**, **Stop**, and **PTC** functions are **not required**, each set of **terminals must be bridged**

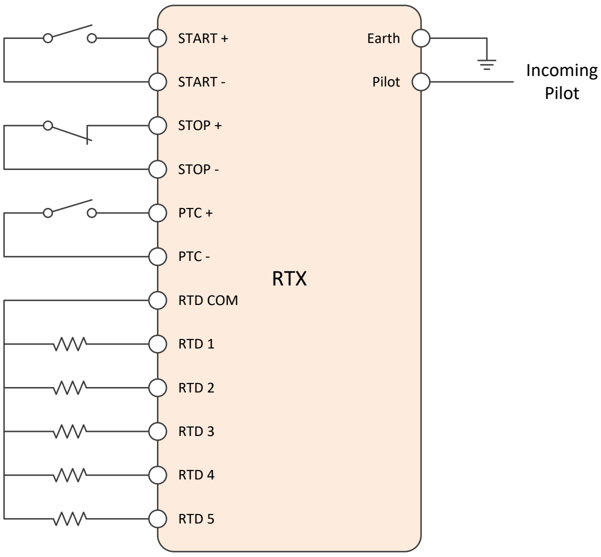


Figure 18: Load Connection Module (RTX) – Connection Diagram

6.3.1 RTX Mounting Options

The RTX features internal magnets for magnetic mounting to simplify installation and an optional screw-on mounting base for situations where magnetic mounting is not suitable.

When attached to a flat, mild steel surface the RTX magnetic mounting option requires a force of approximately 7kg (perpendicular to the surface) to remove the RTX.

6.4 Parameter Dongle's

Parameters important to the running of the IPE and the safe operating of the outlet onto which it is connected are stored in the IPE Parameter Dongle. The Parameter dongle is exchangeable between IPE relay's and is intended to stay with the outlet to which it controls. This way, should an IPE fail, simply replacing the relay and re-install the parameter dongle, the relay will load all of the previous protection settings from the failed relay. This removes the need to reprogram the new relay.

Although the IPE and RTX use the same physical parameter dongle the parameters they store are different. As such the parameter dongle is not interchangeable between the IPE and RTX.

Figure 19: IPE and RTX Parameter Dongle (See part numbers for details)

7 COMMISSIONING

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 IPE during commissioning. This is not intended to provide an exhaustive commissioning checklist but should be considered to be a minimum set of tests. During testing the PIP interface will display the appropriate trip messages and logs of the trips being performed.

7.1 Earth Leakage

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

Disconnect the toroid from the IPE and ensure that an EL CT fault trip is issued with similar effect.

Ensure that the MC successfully operates during a trip and clearing the trip requires an authorised reset.

General EL Testing can be initiated from the PIP menus.

7.2 Earth Continuity

In order to test that the earth continuity protection is functioning correctly, series and shunt resistance tests must be performed. Ensure that the MC successfully operates during a trip and clearing the trip requires a general reset (if EC latching selected) or automatically resets (if non-latching mode is selected)

The EC series resistance trip creates an open circuit in the pilot line. The EC shunt resistance trip creates a short circuit between the pilot line and earth.

General EL Testing can be initiated from the PIP menus.

7.3 Earth Fault Lockout

The earth fault lockout protection can be tested by connecting a suitably rated test resistor to a single outgoing power conductor. Attempt to energise the outlet and confirm that the protection module trips on earth fault lockout and fails to close the MC. This test should be repeated for all phases.

The PIP interface will display the relevant trip messages.

WARNING!

STOP

If the earth fault lockout protection fails, **full system voltage and power may be subsequently applied to the test resistors**.

7.4 Insulation Test (High Voltage)

If the Earth Fault Lockout and Earth Continuity tests are successful, check that an automatic HV insulation test is initiated by the IPE when the relay is started.

WARNING!

STOP

During this test the **Cassette Protection Element will generate up to 2700 VDC** from the 24 VDC input supply **and apply this voltage to the phase conductors**.

Ensure that the MC fails to close during a test and clearing the trip requires a general reset.

7.5 Overcurrent \ Motor Overload Current Injection

Test the Overcurrent \ Motor Overload protection by carrying out secondary/primary injection on the CT inputs of the IPE.

Inject 2x Full Load Current (FLC) 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 other CT terminals.

Ensure that the MC successfully operates during a trip and clearing the trip requires a general reset.

7.6 Short Circuit Current Injection

Test the Short Circuit protection by carrying out secondary/primary injection on the CT inputs of the IPE.

Inject a current value relevant to 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 other CT terminals.

Ensure that the CB successfully operates during a test and clearing the trip requires an authorised reset.

7.7 Main Contactor Fail

While the IPE is stopped (MC open), apply a voltage on the load side of the contactor. The voltage must be greater than the selected trip level to initiate a Loss of Vacuum (LOV) trip. Ensure that a CB trip is initiated by the IPE. A MCF reset can be achieved by pressing the physical button on the relay or through the PIP if configured to do so.

While the IPE is stopped (i.e., the MCR output is open), close the MCI digital input. Ensure that a CBR trip is initiated by the IPE. Similarly reset the MCF.

7.8 Voltage Measurement

Validate the voltage measurement function of the IPE by checking the information from the PIP data tables or through the PIPS interface with the contactor closed.

7.9 Remote Termination Module Type X (RTX)

Required if: RTX pilot termination selected

Validate the correct operation of the RTX by making changes to parameters and ensuring these changes take effect. Perform the Remote Stop and Remote Start tests with the RTX installed.

7.10 Remote Stop Test

Required if: Earth Continuity Protection is activated & a remote stop button is installed

The remote stop function requires a N/C pushbutton/switch be installed in series with the pilot circuit.

1. Energise the outlet and confirm that it is running.
2. Operate the remote stop operator and confirm an EC Series trip stops the outlet.
3. Release the remote stop button
    a. If the EC trip is set to latching, a reset should be required to restart the outlet.
    b. If the EC trip is set to non-latching, the outlet can be restarted.

7.11 Remote Start Test

Required if: Earth Continuity Protection is activated, Remote Start is enabled & a remote start button is installed

With the outlet healthy, operate the remote start pushbutton/switch and confirm that the outlet energises.

Stop the outlet and restart using the remote start pushbutton/switch, continue to hold the start active once the outlet energises for greater than 5 seconds to initiate a Held/Stuck Start Input trip. Ensure that the contactor successfully trips and required a general reset.

8 PRODUCT OPERATION

8.1 Outlet Control

In a typical installation, the outlet contactor is directly controlled by the IPE. The PIP will send commands to the IPE to start or stop the outlet. The IPE will respond by controlling its MCR output accordingly. In the event of any trip condition occurring, the IPE will open the MCR output (or CBR output as appropriate) and prevent reclosing the output until the fault condition has cleared and the trip has been reset.

To energise an outlet, the following start sequence will be followed:

- If there are any active trips, the IPE will ignore any start command received
- If all trips are cleared, the IPE will initiate a start sequence as requested
- A LV earth fault lockout test is conducted. This test checks for a cable fault to earth. The test voltage and current are limited to intrinsically safe levels. If the test fails, the start sequence will be cancelled and the IPE will report an earth fault lockout trip
- If the earth fault lockout test passes, the IPE may then conducts an optional high voltage DC insulation test on the cable. If the insulation test fails, the start sequence will be cancelled and the IPE will report an insulation test trip. The insulation test can also be disabled via parameter settings
- If the insulation test passes, the start sequence moves to the closing state and the MCR output will be closed
- The IPE now waits for the MCI digital input to close. This auxiliary feedback from the signal confirms that the main contactor has closed. If the MCI does not follow the MCR within five seconds a 'close fail' trip will occur and the start sequence will be cancelled
- If the MCI digital input closes, the IPE moves from the start sequence to the running state. It will continue in the running state with the outlet closed until a stop command is received or any protection function trips
- If at any point during the start sequence a stop command is received or a protection function trips the start sequence is immediately cancelled and the MCR (or CBR if appropriate) output will be opened

8.2 Outlet Resets

All resets in the IPE are handled through the PIP. Most trips are reset with a general reset, not requiring authorised access. Some trips require an authorised reset to provide a level of competency associated with resetting faults. Authorisation is provided by the locked Push Button inputs on the front of the equipment connected to the PIP, alternatively this can be achieved through external communications to the PIP.

The following latched trips may be cleared (once the fault has cleared) with a general reset:

- Earth Continuity (EC)
- Overload (OL)
- Current Imbalance (CI)
- Under Voltage (UV)
- Under Current (UC)
- Earth Fault Lockout (EFLO)
- Remote start stuck

The following latched trips may be cleared only after authorised confirmation:

- Earth Leakage (EL)
- Earth Leakage CT detect (EL CT)
- Main Contactor Faults
    - Frozen Contact (FC)
    - Loss of Vacuum (LOV)
    - Fail to Close (FTC)
    - Fail to Open (FTO)
- Short Circuit (SC)

In the event of a MCF trip, Ampcontrol recommends the user performs a test sweep to verify the operation of the protection functions and contactor.

The following trip types will always latch (and require reset to continue): EL, ELCT, FC, SC, OL, UV, UC EFLO, Circuit Breaker. Thermal Block trips will never latch.

8.3 Internal Trips

The IPE has a number of trip functions that are not directly associated with the protection of the outlet, but signal that other dangerous faults have been detected.

8.3.1 CCM ID

The IPE has an internal detection circuit to identify the CCM module that is assembled within the base. If the CCM identity fails to match with that which is expected, the IPE will set this trip. There is currently one CCM version which is used for both 1.1 kV and 3.3 kV outlets. If this trip occurs the base should be returned for repair.

8.3.2 MCF Battery Trip

The IPE has an internal battery. This is used to power the real time clock (used to timestamp log messages) as well has power the main contactor fail latch. The health of this battery is monitored and if the battery condition is failing this trip will be set. If this trip occurs the IPE should be returned to have the battery repaired or replaced.

8.3.3 Internal Logic Error

This trip will be set in the event that an internal fault has been detected. If this trip occurs the IPE Relay should be returned for repair.

8.4 Event Log

The recorded event logs provide a history of the IPE’s operation. A real time clock/calendar is included, allowing each log to sequentially record the time, date and details of each event. A chronological list of the previous 50 events is stored and is viewable from the HMI or over the communications interface.

Each log is made up of 5 words (10 Bytes). The below table outlines the data block structure.

Table 2: Event Log Data Structure

Word	Upper Byte	Lower Byte
1	Not used: ‘00000000’	Event ID: The Event Type number. This number is defined in Section 7.2.
2	Data 1: Depending on the Event Type this contains extra information for the event.	Data 2: Depending on the Event Type this contains extra information for the event.
3	Sec: The second in which the event occurred.	Min: The minute in which the event occurred.
4	Hour: The hour in which the event occurred.	Day: The day in which the event occurred.
5	Not used: ‘00000000’	Month: The Month in which the event occurred.

The following table outlines the events that are logged:

Table 3: Event Log Entry Types

Event ID	***String***	***Description***
0	*Unused*	Not a valid Message. Should not be seen.
1	Feed On	Logs the Machine Type (Data1) and Machine Number (Data2) when the main contactor has been closed while in RTX mode.
2	Insulation Test Record	The results of an automatic HV insulation test.
3	Earth Leakage Trip	Earth leakage current was measured above the selected trip level.
4	Series Earth Continuity Trip	The series resistance of the pilot was measured to be above the selected trip level.
5	Overcurrent \ Overload Trip	The currents exceeded the bounds of the selected trip characteristic.
6	Short Circuit INST Trip	An Instantaneous Short Circuit trip occurred.
7	Close Failed;	After being requested to close, the Main Contactor has not closed within 5 seconds. (As detected via the MCI)
8	Main Contactor Relay Closed	The main contactor relay was closed.
9	Under Current Trip	Phase currents were measured to be below the selected trip level.
10	General Trip Reset	A Trip was cleared via a General Reset request.
11	Power Down	The system has been powered down correctly.
12	Protection Element Dongle Parameter Error	There was an error with the IPE Protection Element parameter dongle.
13	Unexpected Restart	The MEM Processor restarted without a clean power down (most likely due to the watchdog resetting the system).
14	Frozen Contactor	The MCI Detects the contactor is closed while the Main Contactor is requested to be open.
15	Loss of Vacuum	Voltage was detected at the outlet while the Main Contactor was open.
16	Current Balance Trip	The difference between the measured phase currents is greater that the selected trip level.
17	Thermal Memory Loss	The system was unable to read the Thermal Memory value from Battery Backed up Ram while booting. The Motor Overload value will be initialised to 100 %.

Event ID	*String*	*Description*
18	Main Contactor Opened	The main contactor auxiliary contact opened while in run mode.
19	RTX Parameter Error	There was an error with the RTX parameter dongle.
20	Shunt Earth Continuity Trip	The resistance of the pilot to earth was less than the trip level.
21	Thermal Memory Reset	The thermal memory was overridden by user intervention & reset to zero.
22	RTX Stop	The RTX stop input was activated causing an outlet stop.
23	RTX Offline	The RTX went offline causing an outlet trip.
24	Insulation Trip	The pre-start high voltage insulation test failed.
25	RTX Comms Timeout	RTX is online, but there was repeated data corruption.
26	Power Up	The system has powered up after a clean power down.
27	Under Voltage Trip	The phase voltage dropped below the trip level causing the outlet to drop out of run mode.
28	Stopped	General log denoting when the system completed the request to drop out of run mode.
29	No Coil Voltage Trip	Logs when a ‘No Coil Supply’ trip occurred.
30	CT Detection Error	The earth leakage system could not detect an adequate toroid connection.
31	Remote Start Stuck	The remote start button was detected to be closed for longer that the trip limit.
32	PIP Comms Timeout	The PIP failed to provide ‘heart beat’.
33	Start Disabled	The Protection Element was disabled by the PIP
34	Earth Fault Lockout Trip	The resistance measured between the phases and earth during an intrinsically safe EFLO test was below the set level.
35	Unknown Restart Status	The system has powered up but cannot work out if the system powered down cleanly or if it had a restart.
36	Short Circuit Trip Reset	A short circuit trip was reset.
37	Earth Leakage Trip Reset	An earth leakage trip was reset.
38	Fatal Clock Error	The clock time was not able to be read from the Real Time Chip.

Event ID	***String***	***Description***
39	MCF Battery Under Voltage	The Battery which stores the Main Contactor Failure state and powers the Battery Backed Ram is under Voltage (e.g. the battery has reached the end of its life)
40	Control Mask Changed	Notes that the value of the control mask has been changed (e.g. a Test Relay has been closed). Data1 stores the old mask value; Data2 stores the new mask value.
41	Invalid CCM	Logs the fact an invalid CCM was attached to the Protection Element. This is the logged version of a 'CCM ID' trip.
42	Internal Logic Error	An error has occurred in the operation of the code within the Protection Element. The log is used to denote that the stack has grown too big or that the system has run out of RAM. In normal operation neither of these things should occur.
43	PTC Trip	The outlet was stopped due to the RTX's PTC input exceeding its trip resistance level.
44	RTX RTD Group 1 Trip	The outlet was stopped due to one of the RTD inputs within group 1 going above the set trip level.
45	RTX RTD Group 2 Trip	The outlet was stopped due to one of the RTD inputs within group 2 going above the set trip level.
46	Short Circuit LT Trip	Short Circuit 'Long Time' tripped.
47	Residual Voltage Trip OCS-RV Only	Residual voltage was measured above the selected trip level.
48	Residual Voltage Reset OCS-RV Only	A residual voltage trip was reset.
49	Pilot Interlock Trip OCS-RV Only	The Fast element of the earth continuity detected resistance in excess of 100 Ohms for the selected trip time.
50-127	Unused	
128 - 218	Parameter Modified.	To work out which parameter was modified, minus 128 from the Event ID (e.g. 130 means parameter 2 was modified).The value which was changed from is stored in Data1 and the new value is in Data2. Outlet Network Parameters – 0-11 Outlet parameters - 12-29 Dongle Load parameters - 30-59 RTX Load parameters - 60-89. See Appendix B for parameter specifications

8.5 Time and date

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

8.6 Parameter Saving

All parameter changes are logged. The parameter change acceptance time will vary depending on whether the IPE is operating in Diode or RTX Mode. When in Diode Mode the process is quicker than that when operating in RTX Mode.

For a Pilot Mode change, once the change has been verified, then the parameter sets for the new Pilot Mode are loaded (e.g. if the Pilot Mode is changing from Diode to RTX mode, then all the RTX parameters will need time to be loaded into the IPE).

When a parameter set is loaded, the parameter Invalid Masks are checked. If any UI parameter is invalid, it will be added to a list (shown on status page 6), and a trip will be flagged. To make a parameter ‘valid’ again, it can either be explicitly modified, or it will be set to its default value implicitly the next time any other parameter value is changed (i.e., when the Save button is pressed).

Parameter sets will be reloaded at the following times:

- At start up
- When they have their values changed
- After an internal Communications Fault is cleared
- If the RTX is detached, and reattached (or a new one is attached)

Anytime that parameters are being changed or loaded/reloaded, then a “Parameter Syncing” message will display on the GUI. During this time no outlet starts will be allowed. After a power cycle, if the UI detects that the protection parameters have changed, then any auto-restart is disabled. A log message will appear to that effect.

8.7 RTX Machine Type Identifiers and ID Numbers

When using an RTX, each load can be associated with an individual Machine type and Number. Ampcontrol as pre-allocated the first 51 values, the remainder can be utilised for specific applications by the user and translated externally.

Machine ID Number = 0-255, default = 0

Machine Type: default = 0

Number	Machine Type	Number	Machine Type
0	Blank	16	Moveable Boot End
1	Conveyor Belt	17	Bolter
2	Shearer	18	Hard Rock Miner
3	Stage Loader	19	Winch
4	Hydraulic Pump	20	Jumbo
5	Water Pump	21	Belly Belt
6	Continuous Miner	22	Stacker
7	Shuttle Car	23	Add-Car
8	Breaker Feeder	24	Inert Gas
9	Crusher	25	Transfer Belt
10	Fan	26	Dummy Plug
11	DCB	27	Scrubber
12	Blank	28-50	Reserved for future use.
13	Interlock Fan	51-255	Customer utilisation
14	AFC Maingate		
15	AFC Tailgate		

9 TOUCH POTENTIAL PROTECTION FUNCTIONS

The IPE provides a number of protection functions that meet the requirements of the AS/NZS 2081 standard. These protection functions are:

- Earth Leakage
- Earth Continuity
- Earth Fault Lockout
- Main Contactor Fail

9.1 Earth Leakage

9.1.1 Trip Characteristics

Table 4: Earth Leakage Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Frequency Range</td><td>Narrow Band, 50Hz</td></tr>
<tr><td>Power Cycle</td><td>Trip status maintained</td></tr>
<tr><td>Reset</td><td>Requires an authorised reset after the trip condition has cleared</td></tr>
<tr><td>Trip Actions</td><td>Open Main Contactor
Prevent Main Contactor from closing</td></tr>
<tr><td>Active Period</td><td>Always active</td></tr>
<tr><td>Logging</td><td>Always logged</td></tr>
<tr><td>Monitoring</td><td>Earth Leakage current displayed as 0-125% of selected trip level</td></tr>
<tr><td>Trip Level (mA)</td><td><table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>100mA</td></tr>
<tr><td>1</td><td>150mA</td></tr>
<tr><td>2</td><td>200mA</td></tr>
<tr><td>3</td><td>250mA</td></tr>
<tr><td>4</td><td>300mA</td></tr>
<tr><td>5</td><td>350mA</td></tr>
<tr><td>6</td><td>400mA</td></tr>
<tr><td>7</td><td>450mA</td></tr>
<tr><td>8</td><td>500mA</td></tr>
</table></td></tr>
<tr><td>Trip Time (ms)</td><td><table>
<tr><th>Value</th><th>Max. Trip Time</th></tr>
<tr><td>0</td><td>Instant</td></tr>
<tr><td>1</td><td>50ms</td></tr>
<tr><td>2</td><td>75ms</td></tr>
<tr><td>3</td><td>100ms</td></tr>
<tr><td>4</td><td>150ms</td></tr>
<tr><td>5</td><td>200ms</td></tr>
<tr><td>6</td><td>250ms</td></tr>
<tr><td>7</td><td>300ms</td></tr>
<tr><td>8</td><td>350ms</td></tr>
<tr><td>9</td><td>400ms</td></tr>
<tr><td>10</td><td>450ms</td></tr>
<tr><td>11</td><td>500ms</td></tr>
</table></td></tr>
</table>

9.1.2 Operation Summary

The earth leakage protection function utilises a core balance toroid to measure the earth fault current. This function is tested to AS/NZS 2081:2011. A definite time operating characteristic is provided with adjustable trip sensitivity and an adjustable time delay. The earth leakage protection function uses an Ampcontrol EL500 series toroid to measure the earth fault current.

When a fault occurs such that the trip level and time delays are exceeded a trip occurs. This trip opens / prevents a close on the Main Contactor and is latched. An earth leakage trip is considered a special fault and requires an authorised reset.

The outlets status page when viewed through the PIP system displays the Earth Leakage current (EL) with the bar graph visually showing the percentage compared to the trip level.

9.1.3 Earth Leakage CT Failure Protection

Table 5: Earth Leakage CT Failure Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset after the trip condition has cleared
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	Always active
Logging	Always logged
Monitoring	CT Detect trip status bit
Trip Time	4.5s

The IPE continuously monitors the integrity of the earth leakage detection circuit, as required by AS/NZS 2081:2011, by passing a 10-15 mA, 200 Hz test signal through the primary of the earth leakage CT. If the test signal is not detected by the IPE a 'CT Detection Error' trip will occur. As the test signal is always present, the display will constantly indicate an earth leakage level of approximately 10-15 mA, even when no actual earth leakage current is present. The test signal will also interact with earth leakage currents and, depending on the frequency of the earth leakage current, create minor fluctuation in the earth leakage value shown in the display.

The Earth Leakage CT Failure trip time is fixed at 4.5 s.

NOTE

The CT detection signal registers as a leakage current for the outlet which is displayed on the main status even when the outlet is open.

NOTE

The **loop resistance** of the CT Detection Signal circuit must remain **below 0.5 Ω**.

9.2 Earth Continuity

This function monitors the continuity of the earth between the outlet and the machine, via the pilot core. This is designed in accordance with AS/NZS 2081:2011. The IPE measures the resistance of the pilot-earth loop (Series) and the leakage between the pilot and earth conductors (Shunt). The series detection is used to monitor the cables length and in turn touch potentials while the shunt measurement ensures that a pilot to earth fault is detected.

If the pilot-earth loop is not healthy (series resistance greater or shunt resistance lower than their respective trip settings) a trip occurs opening the main contactor. The trip can be configured as latching or non-latching. This allows the user to determine if the trip is manually or automatically reset once the pilot-earth loop is healthy.

The IPE can be configured to operate in either Diode or RTX mode. This determines what terminating device the IPE is expecting on the pilot. When the RTX is terminated, the pilot can also be used to transfer data for machine communications.

The Earth Continuity mode can be configured to either Diode or RTX termination.

Value	Meaning
0	Pilot is terminated by a diode.
1	Pilot is terminated by an RTX.

NOTE

The RTX will only be recognised by the IPE and will **not be seen as a suitable pilot termination by other earth continuity devices unless identified as a compatible device.**

NOTE

Ampcontrol recommends the use of symmetrical cables to eliminate induced voltage on the pilot conductor from the power conductor.

CAUTION!

Cable parameters are important to the correct operation of the Pilot E/C function. Resistance & capacitance values can **determine the length of cable that the relay can drive**.

9.2.1 Earth Continuity - Series Trip Characteristics

Table 6: Earth Continuity Series Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Power Cycle</td><td>Trip status maintained</td></tr>
<tr><td>Reset</td><td>Requires a general reset (latched mode) or automatically resets (non-latching mode) after the trip condition has cleared.</td></tr>
<tr><td>Trip Actions</td><td>Open Main Contactor
Prevent Main Contactor from closing</td></tr>
<tr><td>Active Period</td><td>EC is always enabled.</td></tr>
<tr><td>Logging</td><td>Logged only if outlet is running</td></tr>
<tr><td>Monitoring</td><td>Available as the raw ohms measurement, resolution of 1 Ω.</td></tr>
<tr><td>Trip Time (ms)</td><td><table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>100ms</td></tr>
<tr><td>1</td><td>150ms</td></tr>
<tr><td>2</td><td>200ms</td></tr>
<tr><td>3</td><td>300ms</td></tr>
<tr><td>4</td><td>400ms</td></tr>
<tr><td>5</td><td>500ms</td></tr>
</table></td></tr>
<tr><td>Trip Level (Ω)</td><td><table>
<tr><th>Value</th><th>Ohms</th></tr>
<tr><td>0</td><td>10</td></tr>
<tr><td>1</td><td>15</td></tr>
<tr><td>2</td><td>20</td></tr>
<tr><td>3</td><td>25</td></tr>
<tr><td>4</td><td>30</td></tr>
<tr><td>5</td><td>35</td></tr>
<tr><td>6</td><td>40</td></tr>
<tr><td>7</td><td>45</td></tr>
</table></td></tr>
<tr><td>Latch</td><td><table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>ON</td></tr>
<tr><td>1</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>Remote Start</td><td><table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>Disabled</td></tr>
<tr><td>1</td><td>Enabled</td></tr>
</table></td></tr>
</table>

9.2.2 Earth Continuity - Shunt Trip Characteristics

Table 7: Earth Continuity Shunt Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset (latched mode) or automatically resets (non-latching mode) after the trip condition has cleared.
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	EC is always enabled.
Logging	Always logged
Trip Time (ms)	Same as EC-Series
Trip Level (Ω)	1500
Monitoring	Available as the raw ohms measurement, resolution of 100 Ω.

9.2.3 Remote Start

Remote start mode can be used to allow the start sequence to be initiated from the load via a pilot core. In remote start mode, comms sources cannot force the start of the outlet. They can however prevent the outlet from starting.

- In Diode mode: Remote start is implemented with a 100 Ω resistor (1 % 5 W) connected in series with the pilot circuit and a normally open pushbutton connected in a parallel to this resistor. The loop resistance of the circuit will then be 100 Ω plus the resistance of the pilot-earth loop.
- In RTX mode: Remote start is implemented through a normally open pushbutton connected to the "Start Input" of the RTX.

The remote start setting requires the following sequence for a start to be triggered:

Diode Mode:

1. The IPE must be healthy and ready to start, all trips must be clear.
2. The IPE's earth continuity protection and remote start function must be enabled.
3. The pilot resistance must be detected above 90 Ω to ensure that a start resistor is in place.
4. As soon as the 100 Ω resistance is shorted a start is triggered.
   (Note that the EC series protection function will still be operating, and the start will not be triggered if the EC measurement is above the EC trip level).
5. If the EC resistance falls below 90 Ω but remains above the EC series threshold it will result in a remote start error trip after 1 second.
6. The start sequence (EFLO, IT, MC closing) starts immediately after the trigger.
7. The start resistor must remain shorted out by the start button for the duration of the pre-start tests and until the outlet is energised (greater than ~3 sec).
8. If the EC resistance does not return to above 90 Ω within 5 seconds after the outlet energises, the IPE will trip on 'Remote Start Stuck'.
9. The Remote Start Fault is automatically reset once the EC resistance return to above 90 Ω. (An external reset is not required)

If the earth continuity trip is set to non-latching, the "Start Timed Out" fault will automatically reset once the start resistor is detected (a manual reset is not required).

RTX Mode:

1. The IPE must be healthy and ready to start, all trips must be clear.
2. The IPE's earth continuity protection and remote start function must be enabled.
3. The communications between the IPE and RTX must be healthy.
4. As soon as the start input is shorted a start is triggered.
5. The start sequence (EFLO, IT, MC closing) starts immediately after the trigger.
6. The start input does not need to remain shorted out by the start button for the duration of the pre-start tests, it can be held closed or released.

Note:

a. This input is edge triggered.
b. There is no 'Remote Start Stuck" trip in RTX Mode as the start is initiated through the RTX and does not affect the pilot circuit.

9.2.4 Remote Stop

Remote stops can be utilised in any mode of operation, it does not require Remote Start Mode to be active. This allows for outlet stops to be initiated from the load via a pilot core. Regardless of the mode of operation, a stop can be initiated from any source (PIP, Remote, External Communication's, Remote Desktop) and will prevent the outlet from starting.

In Diode mode: Remote stop button can be implemented by installing a normally closed pushbutton in series with the pilot conductor. When the pushbutton is pressed it will create an open circuit on the pilot line causing an earth continuity series trip.

If earth continuity is not set to latch, the IPE can be started and stopped at the motor enclosure. If earth continuity is set to latch, a reset must be performed before the outlet can be started again.

In RTX mode: Remote stop is implemented through a normally closed push button connected to the "Stop Input" of the RTX. If not being used this input need to be shorted out to prevent a stop being initiated. This input should not be used for a E/Stop functionality, E/Stops should be installed into the pilot circuit.

CAUTION!

E/Stop operators need to be **installed into the pilot circuit** when using RTX and not the machine stop input terminal.

9.3 Earth Fault Lockout

The IPE can provide a two-step insulation test as part of the Earth Fault Lockout protection function. The initial test is the mandatory intrinsically safe test, this can be followed by a selectable automatic High Voltage 'Insulation Test'.

9.3.1 Intrinsically Safe EFLO

The initial earth fault lockout function tests the resistance of the three phase lines to earth. The IPE applies an extra low voltage signal prior to the closure of the main contactor in accordance with AS/NZS 2081:2011. The test is automatically initiated by a starting sequence once all starting conditions are met. This test takes 2 seconds. When the impedance of any of the phase conductors falls below the tripping threshold a trip occurs.

The EFLO trip point has been chosen to ensure compliance to the worst case scenario as defined in AS/NZS 2081:2011 section 7.2.

"Earth fault lockout protection devices shall be designed to prevent energization of the circuit interrupting device when the insulation resistance of any active conductor to earth is below 1 MΩ. This requirement shall apply to any combination of active conductors to earth"

To ensure compliance with AS/NZS 2081:2011, the EFLO set point is influenced by the configuration that reduces the impedance to earth the greatest. This being all three phases shorted together through a load or connected motor, essentially causing all three phase leakage impedance's to be paralleled. An electric motor or load can be treated as a short circuit for the applied DC test voltage. Under this circumstance the IPE needs to trip before it detects 1 MΩ to ensure compliance.

The individual leakage impedances for each phase is an un-shorted configuration (due to load or motor) is then required to be greater that 3MΩ to ensure the minimum level of safety is maintained.

Table 8: EFLO Trip Threshold

EFLO Trip Threshold	***Outlet Configuration***	***Example***
1 Meg	Load on Outlet	Outlet cable terminated by Motor
3 Meg	Open Circuit	Outlet Shuttle car with incomer contactor

Table 9: Earth Fault Lockout Trip Characteristics

Parameter	Action
Power Cycle	Trip status maintained
Reset	Requires a general reset
Trip Actions	Prevent Main Contactor from closing
Active Period	Single test performed during the start sequence
Logging	Logged when test fails
Monitoring	Last test value stored, for each phase. Value stored is from 0-150 %, where 100 % is 3 MΩ Values for single phase are roughly 0 % ~ 10 MΩ 100 % ~ 3 MΩ 150 % ~ 1.9 MΩ For Three phase loads (Phases connected together through load like motor) the above values are a third. 0 % ~ 3.3 MΩ 100 % ~ 1 MΩ 150 % ~ 630 KΩ
Trip Level	3PH Load Disconnected – Trip by 3 MΩ 3PH Load Connected – Trip by 1 MΩ
Test Time	2 seconds

9.3.1 High Voltage Insulation Test

Table 10: Earth Fault Lockout Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Power Cycle</td><td>Trip status maintained</td></tr>
<tr><td>Reset</td><td>Requires a general reset</td></tr>
<tr><td>Trip Actions</td><td>Prevent Main Contactor from closing</td></tr>
<tr><td>Active Period</td><td>Single test performed during the start sequence. Optionally can be disabled.</td></tr>
<tr><td>Logging</td><td>Always logs the measured test result. Trip events are logged separately</td></tr>
<tr><td>Monitoring</td><td>Last test value stored.</td></tr>
<tr><td>Test Voltages</td><td>This setting depends on the system voltage. 900 VDC
(1.1 kV System or 3.3 kV System) or 2700 VDC (3.3 kV System)
<table>
<tr><th>Value</th><th>Test Voltage Level</th></tr>
<tr><td>0</td><td>1100VAC+ IT @ 900V</td></tr>
<tr><td>1</td><td>3300VAC + IT @ 2700</td></tr>
<tr><td>2</td><td>3300VAC + IT @ 900V</td></tr>
<tr><td>3</td><td>415VAC (No IT) *</td></tr>
<tr><td>4</td><td>690VAC + IT 900V *</td></tr>
</table></td></tr>
<tr><td>Trip Levels</td><td>
<table>
<tr><th>Value</th><th>Resistance Level</th></tr>
<tr><td>0</td><td>OFF</td></tr>
<tr><td>1</td><td>1MΩ</td></tr>
<tr><td>2</td><td>2.5MΩ</td></tr>
<tr><td>3</td><td>5.0MΩ</td></tr>
<tr><td>4</td><td>10MΩ</td></tr>
<tr><td>5</td><td>20MΩ</td></tr>
<tr><td>6</td><td>50MΩ</td></tr>
</table></td></tr>
<tr><td>Test Time</td><td>4 seconds</td></tr>
</table>

If an insulation trip level has been selected, an automatic High Voltage DC 'Insulation Test' is carried out after an Intrinsically Safe Earth Fault Lockout Test has been passed.

During the 'Insulation Test' the IPE generates a high DC voltage, approaching the peak system voltage, which is applied between each phase and earth. The IPE measures the voltage on the line and calculates the meg-ohm resistance to earth for all three phases. If the resistance value is above the pre-set threshold the IPE will close its MCR output, allowing the main contactors control circuit to energise. The insulation test takes 4 seconds.

The results of the insulation test should only be used as a guide to confirm that insulation remains above the pre-set threshold. Insulation tests apart from the generated insulation test via the IPE should be still carried out on a regular basis for maintenance purposes.

NOTE

It should be noted that when undertaking a HV Insulation Test with an RTX Dummy Plug or RTX + Phase Indicator Dummy lug Installed, the test will fail for insulation settings set above 10 MΩ.

9.4 Main Contactor Protection

There are four main contactor protection functions. Each of the functions monitors the states of the outlet's main contactor. If a fault is detected, the circuit breaker is opened in order to remove power from the potentially faulty contactor.

9.4.1 Load Side Voltage Detection (Loss of Vacuum)

Table 11: Voltage Detection Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Power Cycle</td><td>Trip status maintained</td></tr>
<tr><td>Reset</td><td>An Authorised Reset through the PIP or physical reset after a trip. The physical reset button is found on the front cover of the Protection Element. The condition of the contactor is required to be investigated and documented. Ampcontrol recommends performing a controlled start and stop prior to returning to service.</td></tr>
<tr><td>Trip Actions</td><td>Open Circuit Breaker
Prevent Main Contactor from closing</td></tr>
<tr><td>Active Period</td><td>When outlet is not energised and the Back EMF timer has expired.</td></tr>
<tr><td>Logging</td><td>Logged when a trip occurs</td></tr>
<tr><td>Monitoring</td><td>Phase voltages are continuously updated.</td></tr>
<tr><td>Back EMF Time (sec)</td><td><table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>2 sec</td></tr>
<tr><td>1</td><td>5 sec</td></tr>
<tr><td>2</td><td>10 sec</td></tr>
<tr><td>3</td><td>15 sec</td></tr>
<tr><td>4</td><td>20 sec</td></tr>
</table></td></tr>
<tr><td>Loss of Vacuum Level (VAC or VDC)</td><td><table>
<tr><th>Value</th><th>Trip Level</th></tr>
<tr><td>0</td><td>25VAC</td></tr>
<tr><td>1</td><td>50VAC*</td></tr>
<tr><td>2</td><td>100VAC* **</td></tr>
<tr><td>3</td><td>150VAC* **</td></tr>
</table>
* If the system voltage level is set to 415 VAC, max voltage trip point will be 25 VAC.
** If the system voltage level is set to 690/1100 VAC, max voltage trip point will be 50 VAC.</td></tr>
<tr><td>Trip Time</td><td>< 1 Second</td></tr>
</table>

The Loss of Vacuum trip in the IPE acts like a Main Contactor Fail Electrical trip. Loss of Vacuum detection provides protection against a faulty contactor that has failed due to ionisation between the contacts (or welded contacts) causing voltage to be detected on the output when the contactor is open.

The voltage level at which the main contactor failure protection should be initiated is outlined in AS/NZS 2081:2011 Clause 9.2.1, being 25 VAC or 60 VDC or up to 10 % of the system voltage.

If the LOV setting is set about the voltage level defined by AS/NZS 2081: 2011 Clause 9.3 and Appendix H, the protection scheme will no longer be compliant to the standard. Users are required to be diligent in the configuration of the settings to ensure the IPE remains compliant to the relevant standards. The voltage setting is for both AC and DC voltages, a setting of 25 V will trip from 25 VAC or 25 VDC.

The loss of vacuum protection cannot be enabled immediately after the outlet is stopped as there is the potential for back EMF from the load to cause a nuisance trip. Subsequently, a back EMF timer is provided and allowed to elapse after the outlet has stopped, before the Loss of Vacuum protection can be operated.

9.4.2 Frozen Contactor (FC)

The Frozen Contactor trip in the IPE acts like a main contactor fail logical trip. AS/NZS 2081:2011 Clause 9.2.2 states that the MC's auxiliary interlocks must be in agreement with the control signals being sent to the MC, else tripping of the upstream CB shall commence. If the IPE detects that the main contactor has closed when requested to be open, or remains closed after requested to open, it will result in a frozen contactor trip, tripping the circuit breaker.

The frozen contactor protection activates in approximately 100 ms.

Table 12: Frozen Contactor Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	An Authorised Reset through the PIP or physical reset after a trip. The physical reset button is found on the front cover of the Protection Element. The condition of the contactor is required to be investigated and documented. Ampcontrol recommends performing a controlled start and stop prior to returning to service.
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	When outlet is not running
Logging	Always
Monitoring	None
Trip Time	400 ms (from v16 FW)

9.4.3 **Close Fail**

Close fail detects the event when the IPE attempts to close the main contactor but receives no confirmation of the close via the contactor feedback. As a result, the IPE will trip the circuit breaker. AS/NZS 2081:2011 Clause 9.2.2 states that the MC's auxiliary interlocks must be in agreement with the control signals being sent to the MC, else tripping of the upstream CB shall commence.

Close fail protection activates in approximately 1 second.

Table 13: Contactor Close Fail Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	An Authorised Reset through the PIP or physical reset after a trip. The physical reset button is found on the front cover of the Protection Element. The condition of the contactor is required to be investigated and documented. Ampcontrol recommends performing a controlled start and stop prior to returning to service.
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	After closing MCR, prior to receiving confirmation from the MCI
Logging	Always
Monitoring	None
Trip Time	1 second

9.4.4 **External Open**

Table 14: External Open Trip Characteristic

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	An Authorised Reset through the PIP or physical reset after a trip. The physical reset button is found on the front cover of the Protection Element. The condition of the contactor is required to be investigated and documented. Ampcontrol recommends performing a controlled start and stop prior to returning to service.
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	While running
Logging	Always
Monitoring	None
Trip Time	1 second

An external open trip occurs if the main contactor is detected as having been opened while the system is in run mode.

External open protection activates in approximately 1 second.

9.4.5 Coil Voltage Detection

Table 15: Coil Voltage Detection Trip Characteristics

Parameter	***Action***
Power Cycle	–
Reset	Automatic
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	Always
Logging	Only logged if it results in the protection module stopping a running outlet
Monitoring	Coil voltage status bit

The coil voltage is internally detected by the IPE by sensing the voltage across terminals 12 & 13. This additional functionality is provided so in the event of the contactor coil voltage being lost while the outlet is running a nuisance main contactor Failure trip does not occur, as the changing of state for the main contactor can be explained by the loss of coil voltage.

9.4.6 MCF Latch

AS/NZS 4871.1 Clause 2.6.3.6 requires contactor related trips to be reset only by an authorised person. To this end it is deemed that physical access inside the switchgear enclosure would be required to perform the relevant checks, and as such the Main Contactor Failure can be reset by the push-button on the IPE or alternatively over comms through the PIP.

All trip bits that feed into the main contactor failure flag are individually logged in the IPE for event analysis in the instance of a circuit breaker trip.

For any MCF fault, the condition of the contactor is required to be investigated and documented. Ampcontrol recommends performing a controlled start and stop, prior to returning to service.

10 LOAD RELATED PROTECTION FUNCTIONS

The IPE individually measures all three of the outlets phase currents. The measured currents are used to implement the following protection functions:

- Inverse time protection – Overcurrent or Motor Overload
- Short Circuit
- Under Voltage
- Phase Current Imbalance
- Under Current

The 'Full Load Current' setting determines the base current for all of the phase current related functions: the measured currents are normalized based on the selected value. The range is selectable from 5.125 A to 640 A.

The IPE relay uses 1000:1 Phase CT's to measure the current in each phase, the error of this measurement is <1 % for currents >1 A. This accuracy will be dependent on the noise coupled into the signal wires and the level may deteriorate over longer cable lengths with coupled noise.

10.1 Inverse Time Protection

The 'Overload Model' setting is used to select one of three Inverse Time-Current characteristics:

- Very Inverse Overcurrent
- Extremely Inverse Overcurrent
- Motor Overload

NOTE

When the Motor Overload parameter is set, the Short Circuit functionality is also modified to better suit motor starting transients.

The overcurrent Time Multiplier setting (TMS) scales the basic trip time for the basic overcurrent characteristics to the desired response time. Values are provided from 0.05 to 30; refer to Appendix for the full list of values. For cross reference, the nominal trip times are listed for each TMS value, for each of the curve options at 10x FLC.

10.1.1 Overcurrent

Table 16: Overcurrent Trip Characteristics

Parameter	*Action*
Power Cycle	–
Reset	Requires a general reset.
Trip Actions	Open Main Contactor Prevent Main Contactor from closing Block restart if the thermal accumulator is not below the selected start block level.
Active Period	When overcurrent curve is set to Very Inverse or Extremely Inverse.
Logging	Always
Monitoring	Phase currents displayed as a percentage of selected full load current, Presented as a modelled Trip/Thermal Accumulator (TAC)
Curve	Very Inverse as per IEC 60255-151 B Curve, or Extremely Inverse as per IEC 60255-151 C Curve
Time Multiplier Setting (TMS)	See Appendix A2 0.05 – 30x FLC
Full Load Current	See Full Load Current Selection Table in Appendix A1
Thermal Accumulator Start Block	<table><tr><th>Value</th><th>Reset Level</th></tr><tr><td>0</td><td>20%</td></tr><tr><td>1</td><td>30%</td></tr><tr><td>2</td><td>40%</td></tr><tr><td>3</td><td>50%</td></tr><tr><td>4</td><td>60%</td></tr><tr><td>5</td><td>70%</td></tr><tr><td>6</td><td>80%</td></tr><tr><td>7</td><td>90%</td></tr></table>

The three phase currents are compared and the highest current is used to determine the trip time. If the current exceeds the selected full load current, an overcurrent trip accumulator (TAC) increases. If the overcurrent condition persists so that the trip accumulator reaches 100% then a trip occurs. If viewed during start up, the trip accumulator can help determine if the overcurrent settings are correct.

The overcurrent curves provided are as follows:

1. **Very Inverse** as per IEC 60255-151 B Curve. The trip time and reset time in seconds for current I follows the characteristic defined by:

$$t(I) = TMS \cdot \left(\frac{13.5}{I-1}\right)$$

$$t_R(I) = TMS \cdot \left(\frac{1.69}{1-I}\right)$$

2. **Extremely Inverse** as per IEC 60255-151 C Curve. The trip time and reset time in seconds for current I follows the characteristic defined by:

$$t(I) = TMS \cdot \left(\frac{80}{I^2-1}\right)$$

$$t_R(I) = TMS \cdot \left(\frac{1.28}{1-I^2}\right)$$

Where:

$t(I)$	=	the idealised trip time,
I	=	the input current ratio relative to the full load current set point – i.e., per unit current,
	=	$I_{fault\ current}$ / $I_{full\ Load}$
note	-	$I_{fault\ current}$ must be greater than $I_{full\ Load}$
TMS	=	the overcurrent Time Multiplier Setting,
$t_R(I)$	=	the idealised reset time.

See Overcurrent Curves drawing in Appendix.

The thermal characteristics utilised in these overload functions are restricted compared to the Motor overload option. Thermal load is contributed to the accumulator only when the currents are above the overload set-point. The trip accumulator resets relatively quickly if the current falls below the selected full load current level.

When the IPE is not in the ‘running’ state, and if the thermal accumulator is not below the selected start block level, a start block (trip) will occur. This will automatically clear once the thermal accumulator drops to, or is below the selected level. Note this will generally happen quickly when the inverse overcurrent modes are selected.

Tuning of the start block setting may be required as equipment wears, or the system characteristics and settings alter.

See Overcurrent Curves, drawing in Appendix.

NOTE

1. The per-unit current is clipped to a maximum of 1250 %. Therefore the trip time for input currents above this level will not decrease any further i.e., the trip characteristic ‘flat lines’ beyond 1250 % of the selected full load current.
2. Independent of the selected curve and TMS setting, the minimum trip times for the overcurrent functions are nominally 100 ms.
3. The trip times calculated from the above formulae are idealised. The trip calculations are executed every 20 ms, so there is an additional delay and uncertainty of 25 ms +/-15 ms.

10.1.2 Motor Overload

Table 17: Motor Overload Trip Characteristics

Parameter	**Action**
Power Cycle	Trip Status maintained
Reset	Requires a general reset (and all three measured phase currents must be below the 100 %).
Trip Actions	Open Main Contactor Prevent Main Contactor from closing Block restart if the thermal accumulator is not below the selected start block level.
Active Period	When overcurrent curve is set to Motor Overload.
Logging	Always
Parameters	Time Multiplier Full Load Current Cooling Multiplier Thermal Accumulator Start Block
Monitoring	Phase currents displayed as a percentage of selected full load current TAC.
Curve	Thermal Model as per IEC 60255-8
Time Multiplier	See Appendix A2 0.05 – 30x FLC
Full Load Current	See Full Load Current Selection Table, See Appendix A1
Cooling Multiplier	(see table below)
Thermal Accumulator Start Block (%)	(see table below)

Cooling Multiplier:

Value	Cooling Multiplier
0	1.0x
1	1.5x
2	2.0x
3	2.5x
4	3.0x
5	4.0x
6	5.0x

Thermal Accumulator Start Block (%):

Value	Reset Level
0	20%
1	30%
2	40%
3	50%
4	60%
5	70%
6	80%
7	90%

This protection scheme uses a first order thermal model of an electric motor to determine the tripping characteristic utilised. It is fundamentally different to the overcurrent protection outlined above in that all current levels contribute to the model heating, and the effects of that heating persist in the model once outlet has stopped, relying on the cooling multiplier to determine reset time.

The three measured phase currents are squared and added together to provide the heating input into the thermal model. The cooling is assumed to be proportional to the model's 'temperature' at any given time. The thermal accumulator (TAC) is the model's 'temperature' (presented in a %) where 0 % represents the motor being cold, and 100% meaning the motor has reached its maximum temperature limit (and will therefore trip). The thermal accumulator shows the state of the thermal model: 0 % = Cold, 100 % = Trip. When a trip occurs it cannot be reset until the current is below the pick-up level.

The trip time is dependant not only on the present current level, but also the prior current history. Since motor currents typically vary widely during starting and running, the actual trip time is also variable. To facilitate co-ordination of the protection with motor capabilities (and upstream protection), the trip time in seconds for a simple (theoretical) scenario of a fixed overload current of I is given by:

$$t(I) = TMS \cdot 72.9 \cdot ln\left(\frac{I^2 - {I_p}^2}{I^2 - 1.05^2}\right)$$

Where:

$t(I)$	=	the idealised trip time,
I	=	the input current ratio relative to the full load current set point – i.e., per unit current,
	=	$I_{outlet\ current} / I_{full\ Load}$
I_p	=	The load current that was flowing (long enough to reach thermal stability) prior to the overload occurrence
TMS	=	the overcurrent Time Multiplier Setting,
ln	=	the natural logarithm

NOTE

1. The per-unit current is clipped to a maximum of 1250 %. Therefore the trip time for input currents above this level will not decrease any further: i.e., the trip characteristic 'flat lines' beyond 1250 % of the selected full load current.
2. Independent of the selected TMS setting, the minimum trip times for the overload function is nominally 100 ms.
3. The trip times calculated from the above formulae are idealized. The trip calculations are executed every 20 ms, so there is an additional delay and uncertainty of 25 ms +/-15 ms.
4. The above characteristic is equivalent to IEC 60255-8 (equation below) with the substitution of τ =TMS • 72.9. This scaling aligns the trip time at 10PU current with that of the Extremely Inverse curve above (e.g. 808 ms with a TMS of 1.0).

$$t = \tau \cdot \ln\left(\frac{I^2 - {I_p}^2}{I^2 - (k \cdot I_B)^2}\right)$$

Where in the protection module:

k = 1.05, called the 'Service Factor'

I_B = 1

The base thermal model provides a thermal time constant of 72.9 seconds. The TMS setting scales the basic thermal time constant, allowing a maximum time constant of over 36 minutes (TMS = 30).

See Motor Overload Curves drawing in Appendix.

The TAC provides information about how much thermal capacity is left, and therefore how long it will take to trip from a given starting point and overload current. If the motor current I is constant (and below 1.05PU), the TAC will eventually settle to a value as follows:

$$TAC = \left(\frac{I}{1.05}\right)^2 \cdot 100\%$$

For example, if the long term average load current was 0.7PU, the TAC would settle at 44%.

The relative trip time for a constant current as a function of the initial value of the TAC is given by:

$$t(TAC) = (\ 100\% - TAC\ )\ \cdot Cold\ Trip\ Time$$

Continuing the example above, with the TAC starting at 44 %, the trip time would be 56 % of the cold trip time (for the same current), that is, if the long term average current (Ip) prior to an overload was 0.7PU, the trip time for an overload from that starting point would be 56 % of the trip time for the same overload current starting from cold. Drawing IPXB013 in Appendix C also shows the overload curve for various values of Ip.

The motor manufacturer's data should be consulted to select the time multiplier appropriate for the motor being protected. Typically, the capacity of a cold motor is given at six times its rated current. The characteristic equation above can be used to select the TMS to match the motors overload capacity.

While the main contactor is closed, the cooling output from the thermal model is calculated to achieve the necessary behaviour to match the characteristic above.

The overload cooling multiplier 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. A cooling multiplier of 1 means the cooling is independent of whether the motor is running or not – e.g., a water-cooled motor. A setting of 2.5 may be appropriate for a fan-cooled motor, however for the best protection consult the motor manufacturer. Values are provided from 1.0 to 5.0. The cooling time can be calculated by:

$$Cooling\ time\ (\text{sec}) = \ CoolingMultiplier \times TMS \times 72.9$$

The thermal model continues to simulate the motor's thermal behaviour even if the power is removed from the relay, i.e. storing the TAC in memory on shut down. When power is restored the thermal memory is loaded and would be at the same level had there been no loss of power.

When the IPE is not in the 'running' state, and if the thermal accumulator is not below the selected start block level, a 'start block' (trip) will occur. This will automatically clear once the thermal accumulator drops to or is below the selected level. This functionality is used to ensure adequate thermal capacity is available before another start is allowed. If necessary it will force sufficient cooling time to allow the restoration of sufficient thermal reserve. If for example the application required capability to permit a locked rotor start lasting up to 60% of the allowable 'cold' locked rotor start time (before tripping on Motor Overload), the 'Start Block Level' parameter would be set to 40%.

CAUTION!

Incorrect motor protection setup, **may cause or lead to motor failure or permanent motor damage**.

Resetting the Thermal accumulator can be performed from the PIP HMI, this cannot be performed through the EIP or Modbus TCP connection. Resetting the TAC can cause motor failure and or damage due to overheating and stress placed upon the motor itself. This should only be performed after appropriate assessment and authorisation on site.

10.2 Short Circuit

Table 18: Short Circuit Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Power Cycle</td><td>Trip Status maintained</td></tr>
<tr><td>Reset</td><td>Specific short circuit reset</td></tr>
<tr><td>Trip Actions</td><td>Open Circuit Breaker
Open Contactor 1 second after Circuit Breaker opens</td></tr>
<tr><td>Active Period</td><td>Always</td></tr>
<tr><td>Logging</td><td>When a fault occurs</td></tr>
<tr><td>Monitoring</td><td>Phase currents displayed as a percentage of selected full load current.</td></tr>
<tr><td>Trip Level (Multiples of FLC</td><td>See appendix A3

Default = 6.5
1.5 to 12.5 in 0.25 increments in OC mode

3.0x to 25x when in MOL mode with additional slower trip element at 1.5x to 12.5x (Multiples of Full Load Current)

Trip occurs at the level determined by selected Full Load Current x SC or at a level of 6 kA, whichever is lesser.</td></tr>
<tr><td>Trip Time (ms)</td><td><table>
<tr><th>Value</th><th>Delay Period</th></tr>
<tr><td>0</td><td>40ms</td></tr>
<tr><td>1</td><td>60ms</td></tr>
<tr><td>2</td><td>80ms</td></tr>
<tr><td>3</td><td>100ms</td></tr>
<tr><td>4</td><td>120ms</td></tr>
<tr><td>5</td><td>140ms</td></tr>
<tr><td>6</td><td>160ms</td></tr>
<tr><td>7</td><td>180ms</td></tr>
<tr><td>8</td><td>200ms</td></tr>
</table></td></tr>
<tr><td>Short Circuit Output Relay</td><td><table>
<tr><th>Value</th><th>Trip Level</th></tr>
<tr><td>0</td><td>CBR Relay</td></tr>
<tr><td>1</td><td>MCR Relay</td></tr>
</table></td></tr>
<tr><td>Upper Detection Limit (A)</td><td>6016A</td></tr>
</table>

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 trip level is adjustable from 1.5 to 12.5 times the Full Load Current (FLC) in 0.25 increments. Note that there is also an upper limit in the current measuring system of 6 kA (RMS). This limit will effectively override selections where the combination of the selected full load current and the selected short circuit level exceeds 6 kA. For example, if 640 A is selected, the short circuit will trip at 9.4PU (940 %) even if the short circuit level is set to 9.5x or above. The per unit current at which the 6kA limit takes effect is listed as ‘SC max’ along with the full range current values in

The trip time is selectable from 40 to 200 ms.

If the overcurrent function is set to Motor Overload, the short circuit functionality is modified as follows:

1. The primary ‘instantaneous’ short circuit trip level is double the selected value: therefore, so it covers a range from 3.0 to 25 times full load current.
2. A second ‘time delayed’ short circuit element becomes active. This element operates at the selected short circuit trip level, but the trip time is the selected (primary) trip time plus 60 ms.

There is a separate ‘SC-LT’ trip bit (LT stands for ‘long time’) & event log to differentiate each of the short circuit elements. This modified functionality allows the short circuit protection to be set just above the locked rotor current level without risking spurious trips due to initial transient offsets (which can effectively double the initial inrush peak current).

The Short Circuit Output Relay setting is used to control which trip action a SC trip will control: the trip can be directed to either the CBR (preferred) or the MCR.

If the Short Circuit Output Relay setting is set to ‘CBR’, when a short circuit trip occurs, the circuit breaker is opened and the main contactor left closed for one second to allow the circuit breaker time to clear the fault. Any other trips or control actions to open the contactor during this time – except for earth leakage, will be blocked.

WARNING!

The circuit interrupting device tripped by the selected output relay for the Short Circuit function **MUST be rated to interrupt the full prospective system short circuit current**.

10.3 Under Voltage

Table 19: Under Voltage Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Power Cycle</td><td>–</td></tr>
<tr><td>Reset</td><td>Automatic</td></tr>
<tr><td>Active Period</td><td>When outlet is running</td></tr>
<tr><td>Logging</td><td>Only if outlet is running</td></tr>
<tr><td>Monitoring</td><td>Phase voltage displayed in Volts.</td></tr>
<tr><td>Trip Level</td><td>
<table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>OFF</td></tr>
<tr><td>1</td><td>40 %</td></tr>
<tr><td>2</td><td>50 %</td></tr>
<tr><td>3</td><td>60 %</td></tr>
<tr><td>4</td><td>70 %</td></tr>
<tr><td>5</td><td>75 %</td></tr>
<tr><td>6</td><td>80 %</td></tr>
<tr><td>7</td><td>85 %</td></tr>
<tr><td>8</td><td>90 %</td></tr>
<tr><td>9</td><td>95 %</td></tr>
</table>
</td></tr>
<tr><td>Trip Time</td><td>850 ms</td></tr>
</table>

Under Voltage (UV) protection is enabled as soon as the main contactor is closed. If any of the phase voltages drop below the selected trip setting of the nominal line voltage for 800 ms then the outlet is stopped.

The UV protection provides additional back up protection for the physical termination of the cable connection module (CCM) to the outlet circuit. If the CCM is disconnected, the LV EFLO and HV IT tests can be performed on an open circuit system causing the protection relay to be blind to any potential faults on the outlet circuit. It is because of this that Ampcontrol **recommends not disabling UV protection**, this should only be reserved for specific application with appropriate risk assessments.

WARNING!

Turning off UV protection is **NOT** recommended. UV protection is used to identify CCM connection faults, disabling the protection will result in undetected failure modes.

10.4 Current Imbalance

Table 20: Current Imbalance Trip Characteristics

<table>
<tr><th>Parameter</th><th>Action</th></tr>
<tr><td>Power Cycle</td><td>Trip Status maintained</td></tr>
<tr><td>Reset</td><td>General reset</td></tr>
<tr><td>Trip Actions</td><td>Open Main Contactor
Prevent Main Contactor from closing</td></tr>
<tr><td>Active Period</td><td>Always</td></tr>
<tr><td>Logging</td><td>Always</td></tr>
<tr><td>Monitoring</td><td>Phase currents displayed in Amps.</td></tr>
<tr><td>Trip Level</td><td><table>
<tr><th>Value</th><th>Acceptable Imbalance</th></tr>
<tr><td>0</td><td>5 %</td></tr>
<tr><td>1</td><td>10 %</td></tr>
<tr><td>2</td><td>20 %</td></tr>
<tr><td>3</td><td>50 %</td></tr>
<tr><td>4</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>Trip Time</td><td>2 seconds</td></tr>
</table>

The current imbalance measurement is available and is calculated as:

$$i_{bal} = \frac{MAX\ \Delta\ i \times 100\%}{i_{av}}$$

Where:

i_{av} = the average of the 3 phase currents

MAX Δ i = the maximum deviation of a phase current from the average.

The phase current imbalance protection is inhibited while the average current is below 20 % of the selected full load current.

If the trip level is exceeded, a timer is triggered. If the imbalance remains above the set level for more than 2 seconds the IPE trips.

10.5 Under Current

Under current protection monitors all three phase currents. If any phase drops below the selected threshold, the trip timer starts counting. The under current protection will trip after any phase current is below the threshold for 4 seconds.

Table 21: Under Current Trip Characteristics

Parameter	***Action***
Power Cycle	–
Reset	Automatic
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	When outlet is running
Logging	When a fault occurs
Monitoring	Phase currents displayed in Amps.
Trip Level	Value / Level: 0 – **Disabled** 1 – 30% 2 – 35% 3 – 40% 4 – 45% 5 – 50% 6 – 55% 7 – 60% 8 – 65% 9 – 70% 10 – 75% 11 – 80% 12 – 85% 13 – 90% 14 – 95%
Trip Time	4 seconds

11 SERVICE, MAINTENANCE & DISPOSAL

11.1 Equipment Service

In addition to the recommended overhaul, 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 IPE 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.

11.1.1 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 IPE relays 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

11.1.2 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
- Check that the terminal compartment is free from water and dust ingress internally
- Verify that all internal covers are fitted
- Ensure terminal cover and gland plate seals are in good condition

11.1.3 Offsite Overhaul

In line with AS/NZS 2290:2014, for continued reliable and safe performance, Ampcontrol recommends that the IPE relay is overhauled to AS/NZS 3800 and Ampcontrol’s work instructions at intervals not exceeding that as recommended by the standard.

11.2 Equipment Maintenance

WARNING!	The IPE has no user-serviceable parts. **All repairs must be carried out by Ampcontrol only**. If a fault develops, return the IPE to Ampcontrol for repair. It is essential that **no attempt be made to repair the IPE** as any attempt to dismantle or repair the IPE can **seriously compromise the safety of the unit and voids product warranty**.

It is required that the electrical protection system incorporating the IPE and its associated elements be subjected to regular functional tests at intervals determined by risk assessment and FMEA. These intervals typically coincide with periodic maintenance checks and should cover as a minimum (but not be limited to) tests such as:

- Earth Leakage Tests
- Earth Continuity Tests
- Earth Fault Lockout Tests
- Overcurrent Injection Tests

Equipment maintenance, repair and overhauls shall also be in accordance with legislation and standards applicable to the Country and State of use. In Australia to ensure compliance to the legislative referenced standards AS/NZS 2290, AS/NZS 3800 and HB 239, the manufacturers requirements are as follows:-

11.2.1 External Inspections

External inspections are to be carried out daily, when mounted externally & visible, or 6 Monthly, when mounted inside Ex-d enclosures.

11.2.2 Internal Inspections

Internal inspections are **not permitted** - do not open any of the IPE components.

11.2.3 Repair and Overhaul

This is required every 4 years. The following components shall be returned to Ampcontrol for AS3800 inspection, repair and overhaul:-

- Integrated Protection Relay IPE - Part # 197358
- IPX Base 5m Tails - Cable Connection Module - Part # 180902 (or 159324)
- Remote Termination Unit RTX - Part # (where used & available)

NOTE	IS battery life (and the interoperability of the IS system components) is fundamental to reliable operation of the product and maintaining safety in operation.

CAUTION!	All **ancillary equipment** used with the IPE integrated protection relay **should be as specified in the IPE Equipment List** to ensure safe operation of the relay.

11.3 Disposal

Please return unwanted units to the Ampcontrol for disposal/recycling.

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.

12 SPECIFICATIONS

NOTE

The IPE's default settings are indicated below with bold font.

Specifications	
General	
Control Supply Volts:	24 VDC ± 20 %, 30 W*
Power Consumption - IPE	Typically 10 W, Max 30 W
Power Consumption - BASE	13.6 W @ 3.3 kV Phase to Earth System Voltage (~800 k Resistors)
System Phase-Phase Voltage	3.3 kV ± 20 % (voltage selections of 3.3 kV or 1.1 kV ± 20 %)
Contact Ratings	110 VAC, 20 A, 1000 VA, Power Factor 0.4
Certification	
AS/NZS 2081, IECEx ITA 12.0032X (refer to http://iecex.iec.ch/ for latest certificate)	
I.S. Parameters	
Combined Phase & Pilot Port	**RTX**
C: 3.72 µF	Ui: 28.0 V
L/R: 4.5 mH	Ci: 18.8 nF
L/R: 207 µH/Ohm	Li: nil
Mechanical & Environmental	
Dimensions (H x W x D)	287 x 169 x 95 (mm)
Weight – IPE	3.65 kg
Weight – Base	3.3 kg
Operating Temperature Range	0 °C to + 60 °C
IP Rating	IP2X
Humidity	Between 10 % relative humidity and the dew point, non-condensing
UV Stability	None
RTX	
Machine Name	**0**-255
Machine ID	**0**-255
RTD 1-2 Trip Level	**0**-200
RTD 3-5 Trip Level	**0**-200
RTD 1-2 Reset Level	**0**-200
RTD 3-5 Reset level	**0**-200

Touch Potential Protection Functions	
Earth Leakage	
Frequency Response	Narrowband, Designed for 50 Hz
Trip Times (mSec) + 0 %, -20 %	Instant, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, **500**
Trip Levels (mA) ± 10 %	100, 150, 200, 250, 300, 350, 400, 450, **500**
Earth Continuity	
Trip Times (mSec)	100, 150, 200, 300, 400, **500**
Trip Levels – Series (Ω)	10, 15, 20, 25, 30, 35, 40, **45**
Trip Levels – Shunt (Ω)	**1500**

Touch Potential Protection Functions	
Latching Trip	**ON** / OFF
Remote Start at Machine	ON / **OFF**
Pilot Termination	**Diode (1N5404)**, RTX
Earth Fault Lockout	
EFLO – Low Voltage Test	3PH Load Disconnected – Trip by 3 MΩ 3PH Load Connected – Trip by 1 MΩ
HV Insulation Test Voltage	900 VDC (1.1 kV System or 3.3 kV System) or 2700 VDC (3.3 kV System)
HV Insulation Test Level	OFF, 1 MΩ, 2.5 MΩ, 5 MΩ, **10 MΩ**, 20 MΩ, 50 MΩ
Frozen Contactor/Loss of Vacuum	
Back EMF Timer (Sec)	2, 5, 10, 15, **20**
*Loss of Vacuum Level (*VAC)	OFF, **25**, 50, 100, 150

Load Related Protection Functions	
Overload Protection	
OL Model	**Very Inverse**, Extreme Inverse, Motor Overload
*Time Multiplier (TMS) (*x FLC)	0.05, 0.055, 0.06, 0.065, 0.07, 0.075, 0.08, 0.085, 0.09, 0.1, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19, 0.2, 0.22, 0.24, 0.26, 0.28, 0.3, 0.32, 0.35, 0.38, 0.42, 0.46, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, **1**, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7 ,1.8, 1.9, 2, 2.2, 2.4, 2.6, 2.8, 3, 3.2, 3.5, 3.8, 4.2, 4.6, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 26, 28, 30
FLC (A)	5.125-640 [**10**]
Cooling Multiplier	1.0x, 1.5x, 2.0x, 2.5x, 3.0x, 4.0x, **5.0x**
Thermal Accumulator Start Block (%)	20, 30, 40, 50, 60, 70, 80, **90**
Short Circuit Protection	
Current Multiplier (trip level) (xFLC)	1.5, 1.75, 2, 2.25, 2.5, 2.75, 3x, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75, 5, 5.25, 5.5, 5.75, 6, 6.25, **6.5**, 6.75, 7, 7.25, 7.5, 7.75, 8, 8.25, 8.5, 8.75, 9, 9.25, 9.5, 9.75, 10, 10.25, 10.5, 10.75, 11, 11.25, 11.5, 11.75, 12, 12.25, 12.5
SC Trip Setting Limits	1.5 to 12.5 in 0.25 increments in OC mode 3.0x to 25x when in MOL mode with additional slower trip element at 1.5x to 12.5x (Multiples of Full Load Current)
Time (mSec) ± 15 ms	**40** ,60, 80, 100, 120, 140, 160, 180, 200
SC Detect Level	6016A
Under Voltage Protection	
Trip Level (%)	OFF, **40**, 50, 60, 70, 75, 80, 85, 90, 95
Current Imbalance Protection	
Trip Level (% FLC)	**OFF**, 5, 10, 20, 50
Under Current Protection	
Trip Level (% FLC)	**OFF**, 30, 35, 40, 45, 50, 55, 60 , 65, 70, 75, 80, 85, 90, 95

Find Out More
For more information on this product, contact Ampcontrol Customer Service on +61 1300 267 373 or *customerservice@ampcontrolgroup.com* or visit the Ampcontrol website: www.ampcontrolgroup.com

13 EQUIPMENT LIST

(198557) IPE Protection Relay Kit		
Part Number	**Description**	
197358	IPE Relay	
180902	IPX Base 5m Tails	
195677	OCS / IPE Plug Set	
Earth Leakage Toroid		
Part Number	**Description**	
101649	EL Toroid EL500 60mm	
101654	EL Toroid EL500 112mm	
101658	EL Toroid EL500S 60mm	
101656	EL Toroid EL500S 112mm	
Phase CT		
Part Number	**Description**	
101272	45mm CT 1000:1	
101703	88mm CT 1000:1	
Outlet Dongle Part Numbers		
Part Number	**Description**	
199230	IPE Dongle Outlet 1 – PIP	(1000V, for 3300V add note to Purchase order)
199231	IPE Dongle Outlet 2 – PIP	
199232	IPE Dongle Outlet 3 – PIP	
199233	IPE Dongle Outlet 4 – PIP	
199234	IPE Dongle Outlet 5 – PIP	
199235	IPE Dongle Outlet 6 – PIP	
199236	IPE Dongle Outlet 7 – PIP	
199237	IPE Dongle Outlet 8 – PIP	
199238	IPE Dongle Outlet 9 – PIP	
199239	IPE Dongle Outlet 10 – PIP	
199240	IPE Dongle Outlet 11 – PIP	
199241	IPE Dongle Outlet 12 – PIP	
199242	IPE Dongle Outlet 13 – PIP	
199243	IPE Dongle Outlet 14 – PIP	
199244	IPE Dongle Outlet 15 – PIP	
199245	IPE Dongle Outlet 16 – PIP	
Accessories		
Part Number	**Description**	
160292	RTX	
172094	RTX Dongle	
196912	RTX Complete with Dongle	
195677	Kit OCS / IPE Plug Set	
164268	BRIDGE IPX	
115119	Module PTB Diode Pilot Termination	
169732	RES 100R 5W 1%	
117023	Diode 1N5404 3A	

PIP System Components	
Part Number	**Description**
300104	KIT Protection Interface Platform (PIP) C/W Dongle & 12 VPS
198608	Protection Interface IO Block 2 (PI2)
198601	2FB - 2 Outlet Fixed IO Block*
198602	4FB - 4 Outlet Fixed IO Block*
198600	2WB - 2 outlet Withdrawable IO Block*
198598	4WB - 4 outlet Withdrawable IO Block*
302301	GFB – Group Feed IO Block
198557	IPE Outlet Kit (Relay + Base + Plug Kit)
198599	PIPS - PIP Screen 10.1" (Optional)
300716	PIPS SS - PIP Screen 10.1" Stainless Steel Bezel (Optional)
199332	HDMI to DVI Cable 1.5m (to connect PIP to PIPS) (Optional)
176082	Temp Sensor (Optional)
198558	MOXA 5x Ethernet Port Switch (Un-managed) (Optional)
157711	Power supply 24 V 10 A
165165	Track Pad – Hazardous Area (Optional)
172912	Trackpad Interface – Hazardous Area (Optional)

*For other PIP System items required see PIP user manual

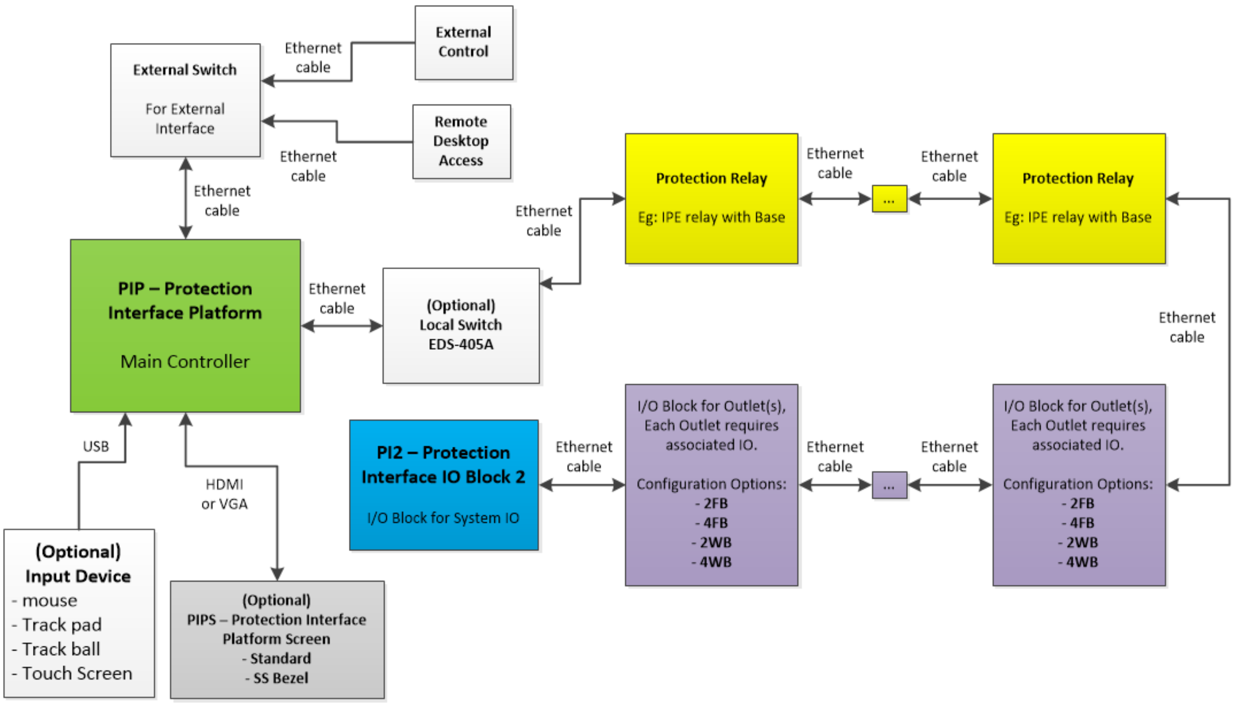


Figure 20: PIP System Component Layout

APPENDIX A: PROTECTION ELEMENT LOAD CURRENT TABLES

A1: Protection Module Full Load Current Table

IPE Full Load Current Selection Table – Amps (1000:1 CT), and Max effective SC Level

Value	Amps	Value	Amps	Value	Amps	Value	Amps	Value	Amps	Value	Amps	SC max	Value	Amps	SC max
0	5.125	32	10.25	64	20.5	96	41	128	82	160	164	25.0x	192	328	18.3x
1	5.250	33	10.50	65	21.0	97	42	129	84	161	168	25.0x	193	336	17.9x
2	5.375	34	10.75	66	21.5	98	43	130	86	162	172	25.0x	194	344	17.4x
3	5.500	35	11.00	67	22.0	99	44	131	88	163	176	25.0x	195	352	17.0x
4	5.625	36	11.25	68	22.5	100	45	132	90	164	180	25.0x	196	360	16.7x
5	5.750	37	11.50	69	23.0	101	46	133	92	165	184	25.0x	197	368	16.3x
6	5.875	38	11.75	70	23.5	102	47	134	94	166	188	25.0x	198	376	16.0x
7	6.000	39	12.00	71	24.0	103	48	135	96	167	192	25.0x	199	384	15.6x
8	6.125	40	12.25	72	24.5	104	49	136	98	168	196	25.0x	200	392	15.3x
9	6.250	41	12.50	73	25.0	105	50	137	100	169	200	25.0x	201	400	15.0x
10	6.375	42	12.75	74	25.5	106	51	138	102	170	204	25.0x	202	408	14.7x
11	6.500	43	13.00	75	26.0	107	52	139	104	171	208	25.0x	203	416	14.4x
12	6.625	44	13.25	76	26.5	108	53	140	106	172	212	25.0x	204	424	14.2x
13	6.750	45	13.50	77	27.0	109	54	141	108	173	216	25.0x	205	432	13.9x
14	6.875	46	13.75	78	27.5	110	55	142	110	174	220	25.0x	206	440	13.6x
15	7.000	47	14.00	79	28.0	111	56	143	112	175	224	25.0x	207	448	13.4x
16	7.125	48	14.25	80	28.5	112	57	144	114	176	228	25.0x	208	456	13.2x
17	7.250	49	14.50	81	29.0	113	58	145	116	177	232	25.0x	209	464	12.9x
18	7.375	50	14.75	82	29.5	114	59	146	118	178	236	25.0x	210	472	12.7x
19	7.500	51	15.00	83	30.0	115	60	147	120	179	240	25.0x	211	480	12.5x
20	7.625	52	15.25	84	30.5	116	61	148	122	180	244	24.6x	212	488	12.3x
21	7.750	53	15.50	85	31.0	117	62	149	124	181	248	24.2x	213	496	12.1x
22	7.875	54	15.75	86	31.5	118	63	150	126	182	252	23.8x	214	504	11.9x
23	8.000	55	16.00	87	32.0	119	64	151	128	183	256	23.4x	215	512	11.7x
24	8.250	56	16.50	88	33.0	120	66	152	132	184	264	22.7x	216	528	11.4x
25	8.500	57	17.00	89	34.0	121	68	153	136	185	272	22.1x	217	544	11.0x
26	8.750	58	17.50	90	35.0	122	70	154	140	186	280	21.4x	218	560	10.7x
27	9.000	59	18.00	91	36.0	123	72	155	144	187	288	20.8x	219	576	10.4x
28	9.250	60	18.50	92	37.0	124	74	156	148	188	296	20.3x	220	592	10.1x
29	9.500	61	19.00	93	38.0	125	76	157	152	189	304	19.7x	221	608	9.9x
30	9.750	62	19.50	94	39.0	126	78	158	156	190	312	19.2x	222	624	9.6x
31	10.00	63	20.00	95	40.0	127	80	159	160	191	320	18.8x	223	640	9.4x

A2: Protection Module TMS Table

IPE Overcurrent Time Multiplier Settings (TMS)

including nominal trip time in seconds at 10 PU Current

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.
0	0.050	0.040	0.075
1	0.055	0.044	0.083
2	0.060	0.048	0.090
3	0.065	0.053	0.098
4	0.070	0.057	0.105
5	0.075	0.061	0.113
6	0.080	0.065	0.120
7	0.085	0.069	0.128
8	0.090	0.073	0.135
9	0.10	0.081	0.150
10	0.11	0.089	0.165
11	0.12	0.097	0.180
12	0.13	0.105	0.195
13	0.14	0.113	0.210
14	0.15	0.121	0.225
15	0.16	0.129	0.240
16	0.17	0.137	0.255
17	0.18	0.145	0.270
18	0.19	0.154	0.285
19	0.20	0.162	0.300
20	0.22	0.178	0.330
21	0.24	0.194	0.360
22	0.26	0.210	0.390
23	0.28	0.226	0.420
24	0.30	0.242	0.450
25	0.32	0.259	0.480
26	0.35	0.283	0.525
27	0.38	0.307	0.570
28	0.42	0.339	0.630
29	0.46	0.372	0.690
30	0.50	0.404	0.750
31	0.55	0.444	0.825
32	0.60	0.485	0.900
33	0.65	0.525	0.975
34	0.70	0.566	1.050
35	0.75	0.606	1.125
36	0.80	0.646	1.200
37	0.85	0.687	1.275
38	0.90	0.727	1.350
39	1.0	0.808	1.50
40	1.1	0.889	1.65
41	1.2	0.970	1.80
42	1.3	1.05	1.95
43	1.4	1.13	2.10
44	1.5	1.21	2.25
45	1.6	1.29	2.40
46	1.7	1.37	2.55
47	1.8	1.45	2.70
48	1.9	1.54	2.85
49	2.0	1.62	3.00
50	2.2	1.78	3.30
51	2.4	1.94	3.60
52	2.6	2.10	3.90
53	2.8	2.26	4.20
54	3.0	2.42	4.50
55	3.2	2.59	4.80
56	3.5	2.83	5.25
57	3.8	3.07	5.70
58	4.2	3.39	6.30
59	4.6	3.72	6.90
60	5.0	4.04	7.50
61	5.5	4.44	8.25
62	6.0	4.85	9.00
63	6.5	5.25	9.75
64	7.0	5.66	10.50
65	7.5	6.06	11.25
66	8.0	6.46	12.00
67	8.5	6.87	12.75
68	9.0	7.27	13.50
69	10.0	8.08	15.0
70	11.0	8.89	16.5
71	12.0	9.70	18.0
72	13.0	10.51	19.5
73	14.0	11.31	21.0
74	15.0	12.12	22.5
75	16.0	12.93	24.0
76	17.0	13.74	25.5
77	18.0	14.55	27.0
78	19.0	15.35	28.5
79	20.0	16.16	30.0
80	22.0	17.78	33.0
81	24.0	19.39	36.0
82	26.0	21.01	39.0
83	28.0	22.63	42.0
84	30.0	24.24	45.0

A3: Protection Module Short Circuit Table

Value	Trip Level	Value	Trip Level	Value	Trip Level
0	1.50x	15	5.25x	30	9.00x
1	1.75x	16	5.50x	31	9.25x
2	2.00x	17	5.75x	32	9.50x
3	2.25x	18	6.00x	33	9.75x
4	2.50x	19	6.25x	34	10.00x
5	2.75x	20	6.50x	35	10.25x
6	3.00x	21	6.75x	36	10.50x
7	3.25x	22	7.00x	37	10.75x
8	3.50x	23	7.25x	38	11.00x
9	3.75x	24	7.50x	39	11.25x
10	4.00x	25	7.75x	40	11.50x
11	4.25x	26	8.00x	41	11.75x
12	4.50x	27	8.25x	42	12.00x
13	4.75x	28	8.50x	43	12.25x
14	5.00x	29	8.75x	44	12.50x

APPENDIX B: PRODUCT SPECIFICATIONS

The parameter changes identified in the event logs are described below:

Offset	Event ID	Parameter ID	Description	Valid Parameter Range
Network Parameters				
0	128	0	IP Address Byte 1	1-255
1	129	1	IP Address Byte 2	0-255
2	130	2	IP Address Byte 3	0-255
3	131	3	IP Address Byte 4	1-255
4	132	4	Subnet Mask Byte 1	0-255
5	133	5	Subnet Mask Byte 2	0-255
6	134	6	Subnet Mask Byte 3	0-255
7	135	7	Subnet Mask Byte 4	0-255
8	136	8	Gateway Address Byte 1	0-255
9	137	9	Gateway Address Byte 2	0-255
10	138	10	Gateway Address Byte 3	0-255
11	139	11	Gateway Address Byte 4	0-255
Outlet Parameters				
0	140	12	Pilot Mode	0-1
1	141	13	Loss of Vacuum Level	0-3
2	142	14	Voltage Level	0-4
3	143	15	SC Output Relay	0-1
4	144	16	<Reserved>	0
5	145	17	<Reserved>	0
6	146	18	<Reserved>	0
7	147	19	<Reserved>	0
8	148	20	<Reserved>	0
9	149	21	<Reserved>	0
10	150	22	<Reserved>	0
11	151	23	<Reserved>	0
12	152	24	<Reserved>	0
13	153	25	<Reserved>	0
14	154	26	<Reserved>	0
15	155	27	<Reserved>	0
16	156	28	<Reserved>	0
17	157	29	<Reserved>	0
Outlet Dongle Load Parameters				
0	171	43	<Reserved>	0-255*
1	172	44	<Reserved>	0-255*
2	173	45	Full Load Current Range	0-223
3	174	46	Short Circuit Trip Level	0-44
4	175	47	Short Circuit Trip Time	0-8
5	176	48	Overcurrent Curve	0-2
6	177	49	Overcurrent Time Multiplier	0-84

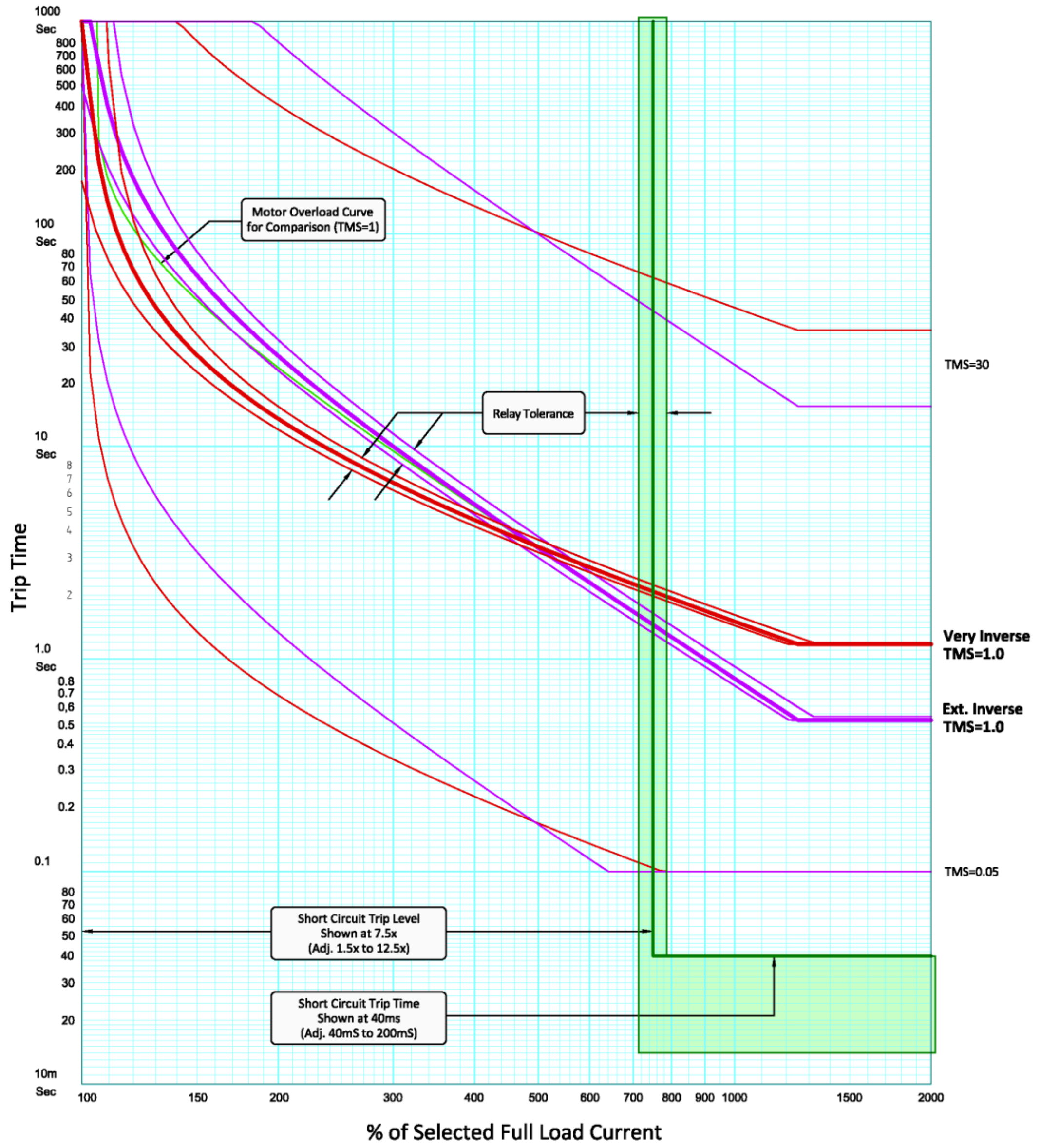
Offset	Event ID	Parameter ID	Description	Valid Parameter Range
7	178	50	Overload Cooling Multiplier	0-6
8	179	51	<Reserved>	0
9	180	52	Overload Start Block Level	0-7
10	181	53	Current Balance Trip Level	0-4
11	182	54	Under Current Trip Level	0-14
12	183	55	Earth Leakage Trip Level	0-8
13	184	56	Earth Leakage Trip Time	0-11
14	185	57	Earth Continuity Trip Level	0-7
15	186	58	Earth Continuity Trip Time	0-5
16	187	59	Earth Continuity Latch	0-1
17	188	60	Remote Start	0-1
18	189	61	Insulation Test Trip Level	0-6
19	190	62	Under Voltage Trip Level	0-9
20	191	63	[RTX Only]	NA
21	192	64	[RTX Only]	NA
22	193	65	[RTX Only]	NA
23	194	66	[RTX Only]	NA
24	195	67	Back EMF Time	0-4
25	196	68	<Reserved>	0
26	197	69	<Reserved>	0
27	198	70	<Reserved>	0
28	199	71	<Reserved>	0
29	199	71	<Reserved>	0
RTX Dongle Load Parameters				
0	200	72	Load Machine Type	0-255*
1	201	73	Load Machine ID	0-255*
2	202	74	Full Load Current Range	0-223
3	203	75	Short Circuit Trip Level	0-44
4	204	76	Short Circuit Trip Time	0-8
5	205	77	Overcurrent Curve	0-2
6	206	78	Overcurrent Time Multiplier	0-84
7	207	79	Overload Cooling Multiplier	0-6
8	208	80	<Reserved>	0
9	209	81	Overload Start Block Level	0-7
10	210	82	Current Balance Trip Level	0-4
11	211	83	Under Current Trip Level	0-14
12	212	84	Earth Leakage Trip Level	0-8
13	213	85	Earth Leakage Trip Time	0-11
14	214	86	Earth Continuity Trip Level	0-7
15	215	87	Earth Continuity Trip Time	0-5
16	216	88	Earth Continuity Latch	0-1
17	217	89	Remote Start	0-1
18	218	90	Insulation Test Trip Level	0-6
19	219	91	Under Voltage Trip Level	0-9

Offset	Event ID	Parameter ID	Description	Valid Parameter Range
20	220	92	RTX RTD 1-2 Trip Temp	0-200
21	221	93	RTX RTD 3-5 Trip Temp	0-200
22	222	94	RTX RTD 1-2 Reset Temp	0-200
23	223	95	RTX RTD 3-5 Reset Temp	0-200
24	224	96	Back EMF Time	0-4
25	225	97	<Reserved>	0
26	226	98	<Reserved>	0
27	227	99	<Reserved>	0
28	228	100	<Reserved>	0
29	229	101	<Reserved>	0

APPENDIX C: DRAWINGS

The drawings in this appendix are as per the below table.

Drawing Number	Drawing Title
IPXB014	Overcurrent and Short Circuit Curves
IPXB013	Motor Overload and Short Circuit Curves
IPEZ001	IPE General Arrangement (Certification Drawing)
IPEZ002	IPE IS System Diagram



Very Inverse as per IEC 60255-151 B Curve.

The trip time in seconds for current I follows the characteristic defined by:

$$t(I) = TMS \cdot \left(\frac{13.5}{I-1} \right)$$

Extremely Inverse as per IEC 60255-151 C Curve.

The trip time in seconds for current I follows the characteristic defined by:

$$t(I) = TMS \cdot \left(\frac{80}{I^2-1} \right)$$

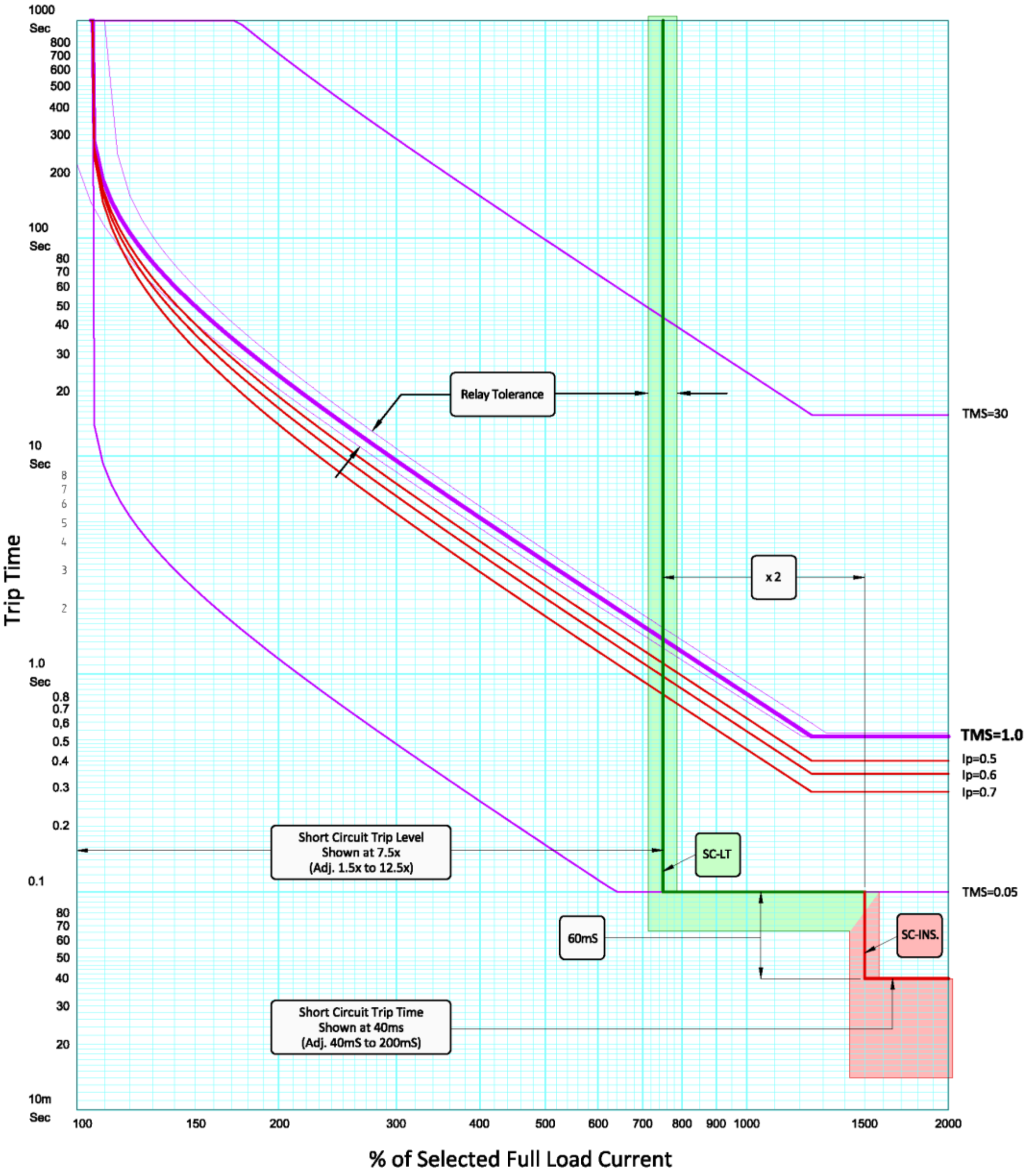
Where:

$t(I)$ is the idealized trip time,
I is the input current ratio relative to the full load current set point - ie per unit current,
TMS is the Over Current Time Multiplier Setting,
Ip is the load current that was flowing (long enough to reach thermal stability) prior to the overload occurrence.

Full Load Current Adjustable from 5.125A to 640A
TMS Selectable from 0.05 to 30

Note :

1. The per unit current is clipped to a maximum of 1250%. Therefore the trip time for input currents above this level will not decrease any further : ie, the trip characteristic 'flat lines' beyond 1250% of the selected full load current.
2. Independent of the selected TMS setting, the minimum trip times for the Overload function is nominally 100 mS.
3. The trip times calculated from the above formulae are idealized. The trip calculations are executed every 20 mS, so there is an additional delay and uncertainty of 25 mS +/-15 mS.



Full Load Current Adjustable from 5.125A to 640A
TMS Selectable from 0.05 to 30

Motor Overload Characteristic

The trip time in seconds for a simple (theoretical) scenario of a fixed overload current of I is given by :

$$t(I) = TMS \cdot 72.9 \cdot ln\left(\frac{I^2 - I_p^2}{I^2 - 1.05^2}\right)$$

Where:

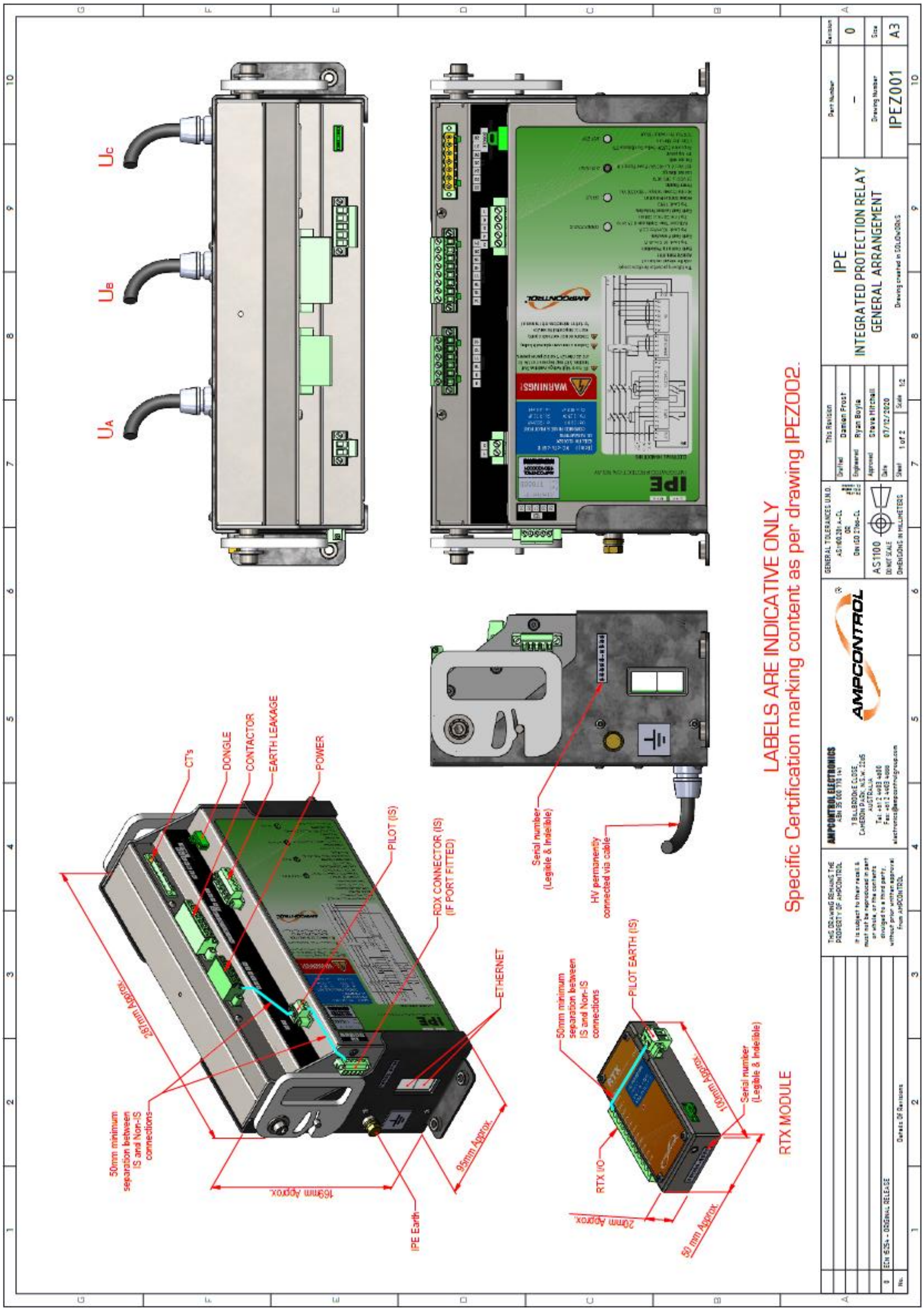
$t(I)$ is the idealized trip time,
I is the input current ratio relative to the full load current set point - ie per unit current,
TMS is the Over Current Time Multiplier Setting,
Ip is the load current that was flowing (long enough to reach thermal stability) prior to the overload occurrence.

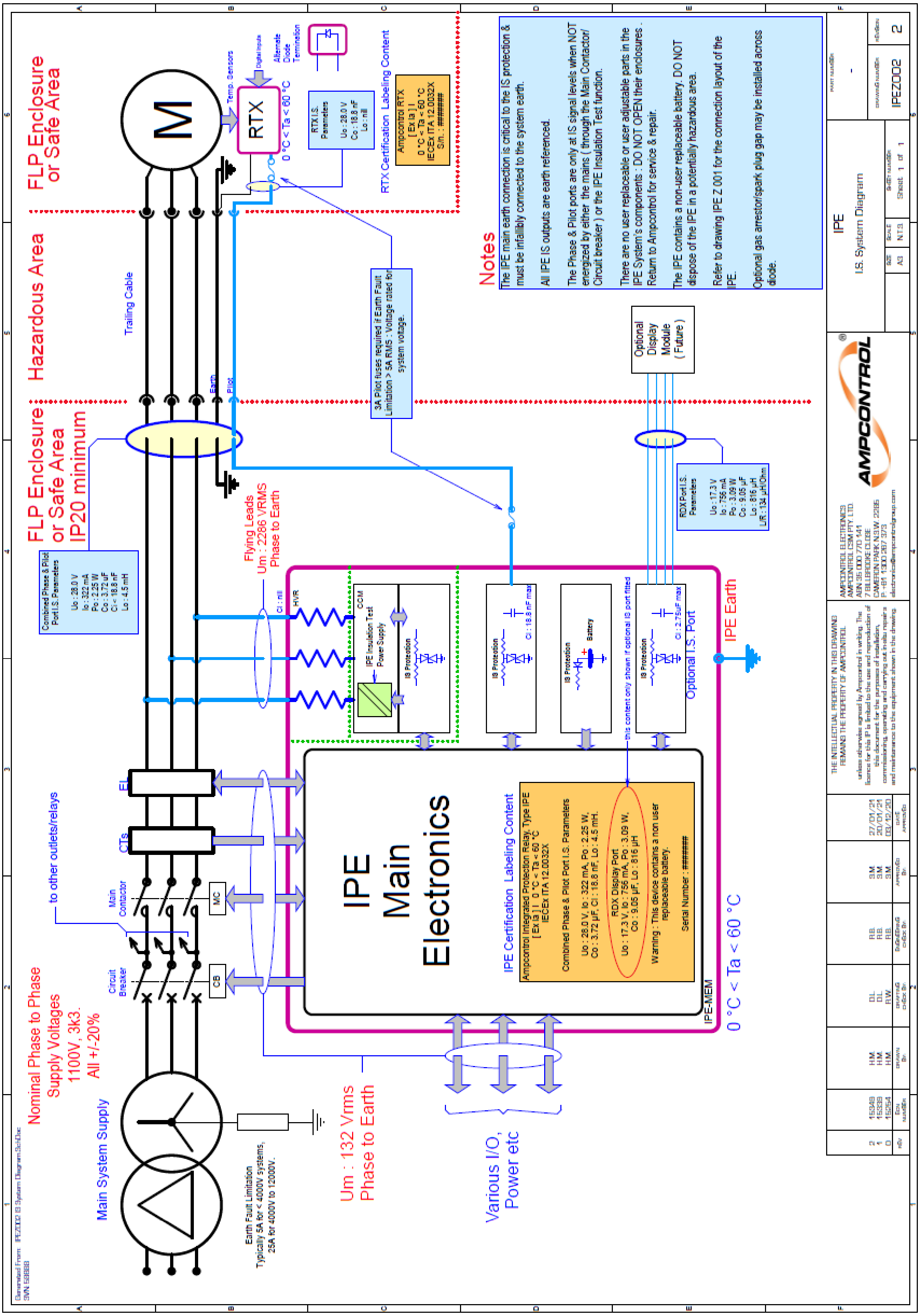
Note :

1. The per unit current is clipped to a maximum of 1250%. Therefore the trip time for input currents above this level will not decrease any further : ie, the trip characteristic 'flat lines' beyond 1250% of the selected full load current.
2. Independent of the selected TMS setting, the minimum trip times for the Overload function is nominally 100 mS.
3. The trip calculations are executed every 20 mS, so there is an additional delay and uncertainty of 25 mS +/-15 mS.

IPX MOTOR OVERLOAD AND SHORT CIRCUIT CURVES — Drawing Number IPXB013 — Revision 1 — Size A3 — Scale NTS — Sheet 1 of 1

AMPCONTROL ELECTRONICS


UA
UB
UC
CTs
DONGLE
CONTACTOR
EARTH LEAKAGE
POWER
PILOT (IS)
RDX CONNECTOR (IS)
(IF PORT FITTED)
ETHERNET
Serial number
(Legible & Indelible)
HV permanently
connected via cable
PILOT EARTH (IS)
50mm minimum
separation between
IS and Non-IS
connections
287mm Approx.
169mm Approx.
95mm Approx.
IPE Earth
RTX I/O
RTX MODULE
100mm Approx.
20mm Approx.
50 mm Approx.
LABELS ARE INDICATIVE ONLY
Specific Certification marking content as per drawing IPEZ002.
IPE
INTEGRATED PROTECTION RELAY
GENERAL ARRANGEMENT
IPEZ001
A3


FLP Enclosure or Safe Area
Hazardous Area
FLP Enclosure or Safe Area IP20 minimum
Trailing Cable
M
RTX
0 °C < Ta < 60 °C
RTX Certification Labeling Content
Notes
The IPE main earth connection is critical to the IS protection & must be infallibly connected to the system earth.
All IPE IS outputs are earth referenced.
The Phase & Pilot ports are only at IS signal levels when NOT energized by either the mains (through the Main Contactor/ Circuit breaker) or the IPE Insulation Test function.
There are no user replaceable or user adjustable parts in the IPE System's components : DO NOT OPEN their enclosures . Return to Ampcontrol for service & repair.
The IPE contains a non-user replaceable battery. DO NOT dispose of the IPE in a potentially hazardous area.
Refer to drawing IPE Z 001 for the connection layout of the IPE.
Optional gas arrestor/spark plug gap may be installed across diode.
Optional Display Module (Future)
Flying Leads Um : 2286 VRMS Phase to Earth
IPE Main Electronics
IPE Certification Labeling Content
Optional I.S. Port
IPE Earth
0 °C < Ta < 60 °C
Nominal Phase to Phase Supply Voltages 1100V, 3k3. All +/-20%
Main System Supply
Um : 132 Vrms Phase to Earth
Various I/O, Power etc
IPE
I.S. System Diagram
IPEZ002

APPENDIX D: IPE to IPD DIFFERENCES

The following aspects of the IPE differ significantly compared to the IPD protection system:

- User Interface

There is no RDM interface. Interaction with the outlet is provided through the PIP system. All control and monitoring functions are facilitated via Ethernet/IP communications.

- Control Wiring

The IPE has limited hard wired digital inputs. There are no hard wired start, stop, reset or lock digital inputs as on the IPD. All control functions are facilitated via Ethernet/IP communications. The IPE provides simplified wiring and installation and improved reliability.

- Fan Interlocking

There is no built-in support for fan interlocking. If required in the DCB or substation, this functionality is provided via the PIP or is achieved through communications through the PIP.

- Parameter Storage

All protection and control settings are stored in a parameter dongle. The dongle is attached to the wiring loom for a given outlet. This ensures that if an IPE relay is replaced in the field, all the existing protection settings are automatically applied to the new relay.

- Cable Connection Module

The cable connection module (CCM) is now integrated into the IPE relay enclosure, it is no longer a separate unit. The CCM provides a direct interface to the phase voltage conductors for voltage monitoring, high voltage insulation test and earth fault lockout testing.

- AS/NZS 2081: 2011 Compliance

The IPD relay was tested to AS/NZS 2081: 2002 whereas IPE is tested to the current version AS/NZS 2081: 2011.

- Improved rejection of false MCF trips
- Ethernet/IP communications provides real-time monitoring of the system parameters and access to data logs
- No RDM, IPSI and IKD required
- Improved robustness of the pilot system in the presence of variable speed drives and parallel feeds using new Remote Termination Unit (RTX)
- Capability for future expansion

IPD – IPE PROTECTION SYSTEM FEATURE DIFFERENCES

IPD RELAY FEATURES	IPE RELAY FEATURES
Certification: IECEx ITA 07.0018X	Certification: IECEx ITA 12.0032X
Earth Leakage: AS/NZS 2081-2002	Earth Leakage: AS/NZS 2081-2011
Earth Continuity (including remote start mode) : AS/NZS 2081-2002	Earth Continuity (including remote start mode) : AS/NZS 2081-2011
Earth Fault Lockout – LV & HV Test: AS/NZS 2081-2002	Earth Fault Lockout – LV & HV Test: AS/NZS 2081-2011
Short circuit protection: Standard and Transient addition	Short circuit protection: Standard and Long Time SC when in MOL mode only
Contactor Failure protection: AS/NZS 2081-2002	Contactor Failure protection: AS/NZS 2081-2011
Current balance protection	Current balance protection
Overload / Overcurrent protection (IEC 60255-151), Very Inverse Only	Overload /Overcurrent protection (IEC 60255-151), Very Inverse and Extremely Inverse
Motor thermal overload protection (IEC 60255-8)	Motor thermal overload protection (IEC 60255-8)
Under current protection	Under current protection
Under voltage protection	Under voltage protection
Back EMF Setting	Back EMF Setting
Hard wired Fan Interlocking	PIP Controlled Fan Interlocking
Settings via RDM	Settings via PIP HMI interface
Limited Diagnostics through RDM	All internal diagnostics available over Ethernet
120 Event Logs Stored	50 Event Logs Stored
31 Event Log Descriptions	140 Event Log Descriptions
IPD Settings lost when replaced	IPE Memory Dongle stores outlet settings
Remote Termination Unit: RTU-D3	Remote Termination Unit: RTX
4x RTD inputs into RTU-D3	5x RTD inputs into RTX
IPD/RTU-D3 Settings lost when replaced	RTX Memory Dongle stores IPE + RTX settings
Read only communications	PIP HMI can be accessed remotely
Hardwired Reset / Start / Stop	Reset / Start / Stop from PIP or Remotely over Ethernet Protocols
2x Phase Currents Monitored	3x Phase Currents Monitored

IPD – IPE ELECTRICAL COMPONENT REQUIREMENT DIFFERENCES

IPD SYSTEM FEATURES	IPE SYSTEM FEATURES
IPD RELAY	IPE RELAY
IPD RELAY BASE	IPX RELAY BASE
-	Protection Interface Platform (1 PIP for up to 16 outlets)
RDM D DISPLAY (1x per outlet)	PIPS – Panel Mount Touch Screen (Optional) (1 PIPS per PIP)
Start, Stop, Reset Wiring (1x per outlet)	-
IPSI DNET (1x per outlet)	Ethernet Connection
DNET PROTOCOL CONVERTER (1x for up to 9 outlets)	-
DNET POWERSUPPLY (1x per protocol converter)	-
IKD KEYPAD (1x per outlet)	-
IKD KEYPAD INTERFACE (1x per outlet)	-
REMOTE TERMINATION UNIT RTU D3	REMOTE TERMINATION UNIT RTX
CABLE CONNECTION MODULE (415 V or 1.1 KV or 3.3 KV CCMD) (1x per outlet)	Built into Each Protection Relay
1x EL TOROID (per outlet)	1x EL TOROID (per outlet)
2x Phase CT's (per outlet)	3x Phase CT's (per outlet)
-	IPE Dongle (per outlet)
-	RTX Dongle (per outlet)
-	PIP Dongle (per PIP)

APPENDIX E: Earth Leakage Toroid Installation Notes

Toroids (current transformers) are not ideal devices and if correct procedures are not followed during installation nuisance tripping can result. Consider, for example, a single-phase earth leakage system where active and neutral pass through a toroid then at all times currents in the two wires are equal and opposite so that the net current through the toroid is zero.

An ideal toroid would have all of the flux from each wire contained in the core and so would accurately add the opposing fluxes to get a net result of zero. A real toroid has “leakage fluxes”. That is, a very small proportion of the total flux from each cable is not contained in the core but in the space outside it and as a result it may link some turns but not others, depending on the positioning of the cables. The effect of this is that a small output may be obtained from the toroid where none would arise if the device were ideal.

The size of the error may vary from toroids of the same type because of slight differences in the core and the symmetry of the winding. Problems caused in this way increase as the toroid size increases, as currents increase and symmetry decreases. Nuisance tripping tends to occur when the total current rises, such as when a large motor is started. The following guidelines would help to avoid such problems.

D2 Toroid selection

1. Select the smallest internal diameter toroid, which will allow the cables to fit through. Avoid very large toroids (>200 mm aperture) or toroids with square apertures.
2. Only use approved toroids specified by Ampcontrol as these have been designed to minimise problems.

D3 Toroid installation guidelines

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 for symmetry.
2. Do not bring the cables back past the toroid within one diameter of the toroid. Trying to cram cables into a small space reduces symmetry and may lead to problems.
3. Avoid placing the toroid near any device that produces magnetic fields. This includes bus bars, transformers or other cables. Try to maintain several toroid diameters clearance.
4. Many small cables tend to be worse than say, three large ones. Try to position the toroid in the circuit with this in mind.
5. Toroids used for core balance earth leakage protection cannot have bus bars passed through them.
6. To prevent possible nuisance tripping it is suggested that the conductor screen of the earth leakage toroid should be earthed one end only, the relay end. If both ends are earthed the possibility exists for the shield to become an earth loop, having finite resistance and injecting noise into the toroid leads.

APPENDIX F: IPE Wiring Diagram