HPB

Integrated Protection Relay

User Manual

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Designed and manufactured in Australia by Ampcontrol Pty Ltd

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 HPB.

WARNING!

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

Ampcontrol Contact Details

7 Billbrooke Close, Cameron Park, NSW, 2285

P +61 1300 267 373 | F +61 2 4903 4888

EMAIL: customerservice@ampcontrolgroup.com

WEB: ampcontrolgroup.com

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1 SAFETY AND OTHER WARNINGS

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

WARNING!

This equipment generated dangerously high voltage levels. Because of the potential risks associated with this equipment it is essential that only qualified and experienced personnel be permitted to work in or around this equipment.

1.1 Safe Use of Equipment

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

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

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

1.1.1 Changes to Equipment

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

1.1.2 Equipment Knowledge

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

1.1.3 Manual Handling

The transformers supplied with the CCMB-22kV are heavy. Care should be taken when transporting and handling these transformers.

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

1.1.4 Installation

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

1.1.5 Operation

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

2 RECEIVING AND STORAGE

2.1 Receiving

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

Notify Ampcontrol immediately in 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.

2.2 Inspection

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

2.3 Storage after Delivery

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

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

2.4 Unpacking of Equipment

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

CAUTION!

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

ENVIRO

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

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

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

3 PRODUCT OVERVIEW

3.1 Introduction

The Ampcontrol HPB Integrated Protection Relay is an intelligent protection relay based on microprocessor technology. The Relay has been specifically designed to operate with very high interference to the pilot conductor that occurs on cables in open cut mining operations. This is more prevalent on a non-symmetric position of the pilot and earth conductors.

The integrated relay provides the necessary function required for protection electrical outlets supplying draglines, shovels, drills etc. All of the protection functions are combined into a compact, plug-in unit, which can be easily changed out to minimise down time in the event of a problem with the relay.

The HPB Relay can provide machine communication through the use of a HPB Termination Unit (HTU-1) connected between the pilot and earth at the machine end of the trailing cable. Through the use of the HTU-1 Termination Unit the relay parameters are automatically uploaded from a remote machine when a cable is inserted into a power outlet.

The relay can perform an automatic “H.V. Insulation” test on the cable prior to the closure of the main contactor. The results of the test are displayed on the HPB Display Module (HDM-1) and can be remotely monitored.

The HPB Relay has 5 digital inputs, which feed into a microprocessor unit. The microprocessor has been programmed to control three output relays. Relay MCR for the main contactor and Relay CBR for the circuit breaker. RL3 is used to control the supply to the Cable Connection Module enabling it to perform the Earth Fault Lockout test. All of the tripping logic and outlet control is performed by the microprocessor, so that only minimal external control is required. See Typical Connection Diagrams HPBE006 and HPBE013, in APPENDIX A: DRAWINGS.

Extensive information display and monitoring features are included to facilitate fault finding and system trending. This information can be read locally on the HPB Display Module (HDM-1) or remotely via a communication link.

Opto-isolated outputs are available for connection to optional LED or Relay Modules to provide additional “run” and “trip” indications (See Drawing IPAS005, in APPENDIX A: DRAWINGS). The Ampcontrol Relay Output Module (ROU) enables these indications to be interfaced with a PLC (See Drawing IPAA031, in APPENDIX A: DRAWINGS).

There are currently two HPB models available; the HPB 6.6kV, which is suitable for 6.6kV systems, and the HPB 22kV, which is suitable for 11kV and 22kV systems.

Protection Functions

- Earth Leakage Protection
- Earth Fault Lockout Protection
- Earth Continuity Protection
- Over-Current/Overload Protection
- Short Circuit Protection
- Contactor Fail Protection

Protection trips are stored in a non-volatile memory requiring a rest function before power can be restored. This remains the case even if a power down occurs following a trip condition.

3.2 Remote Display Module (HDM)

The Ampcontrol HDM (Remote Display Module) communicates with the HPB Relay via a three-wire connection. The Module consists of a two-line 16 character alpha-numeric liquid crystal display (LCD), LED status indicators and a tactile keypad.

The various display pages are arranged on levels with each level having a number of positions. The display level is changed with the Up/Down arrow keys and the Left/Right arrow keys control the display position. An Enter key is used when programming the relay. The display map shows how the movement is controlled between levels and positions (See Drawing HPBB004, in APPENDIX A: DRAWINGS).

The healthy LED located top centre of the module flashed at 3Hz (three times per second) to indicate healthy communications with the relay. A flash rate of 1Hz (once every second) indicates that the module is powered (15VDC), but no receiving data.

The module displays the following information:

a. Software version and serial number
b. HPB Status
c. Operational information from the protection functions, e.g. earth leakage current, earth continuity resistance etc.
d. System information including the line voltage and current
e. Status of digital inputs and relay outputs
f. Protection trip settings, which can be viewed at any time. Authorised personnel can modify these settings via that HDM Remote Display Module
g. Data logging information. The 120 most recent events and parameter changes are logged, with time and date, in a non-volatile memory (e.g. power-up, trip, reset, close etc.).

NOTE

A review of the first few log events is a useful tool for fault finding.

The HPB Relay status display is one of the most useful features of the relay's display system and should be viewed as the first step in fault finding.
This display shows a list of 9 prompts in order of priority indicating what the HPB Relay requires to allow the output to close. The prompts are listed as follows:

Table 1: HPB Display Messages

Display Message	Description
[RUNNING]	Outlet energised
[TESTING]	Performing EFLO Test
[TRIPPED]	Trip Condition (see HDM LEDs)
[HPB Mem Err]	HPB Relays non-volatile memory is corrupted
[HTU Mem Err]	HTU-1 non-volatile memory is corrupted
[HTU STOP]	Waiting for HTU-1 stop input to be closed
[HPB STOP]	Wating for HPB stop input to open
[HPB START?]	Waiting for the HPB Relay's start input to close
[WAITING]	Pause between successive Megger Tests

An error status indicator is also shown on the status page, which is normally zero; exceptions are as follows:

Table 2: HPB Error Status Indicator

Display Message	Description
Error # 1	Indicates corruption in the Group 1 Settings (HPB Mem Error)
Error # 2	Indicated corruption in the Group 2 Settings (HTU Mem Error)
Error # 3	Is a combination of faults in both groups

For details of Groups see Section 9.1, Parameter Groups.

4 INSTALLATION

4.1 General Warnings

These instructions have been designed to assist users of the HPB with installation and special wiring techniques required to reduce induction from high voltage circuits.

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

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

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

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

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

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

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

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

4.1.4 Modifications of any form to the HPB are prohibited.

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

4.2 Mandatory Installation Practices

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

Using the HPB 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 HPB must be powered within the specified voltage range.
- The installation of the HPB must be carried out by suitably trained and qualified personnel.
- Identification labels fixed to the HPB must not be damaged, removed or covered before, during or after installation.
- The installation is to be in accordance with the relevant installation Standards/Codes of Practice.

- Modifications must not be made to any part of the HPB. As supplied, the unit is built to, and complies with the relevant standards. Modifications to its construction will render the unit non-compliant.
- Complete and accurate records of the installation must be kept as part of the site installation.

4.3 Installation and Wiring Instructions

4.3.1 Integrated Protection Relay

The HPB Relay has a powder coated sheet steel enclosure to be mounted into existing enclosures of adequate IP rating.

The Relay is designed to operate when mounted either laid down flat or in a vertical position.

CAUTION!

Vent holes are provided at both the top and bottom of the relay to assist in the cooling of the electronics inside the relay. These vents should not be blocked or restricted in any way.

When installing the HPB Relay care should be taken to ensure sufficient space is allowed around the relay for the ease of change out during routine maintenance.

Connections to the HPB Relay are made via a plug in base. The base is to be securely fastened to the enclosure in which it is being installed. The base is clearly labelled for ease of terminal location and identification.

4.3.2 Remote Display Module (HDM)

The Remote Display Module is housed in an IP55 polycarbonate enclosure. The Module has been designed to be flush mounted, external to the switchgear it is controlling.

4.3.3 Cable Connection Module

CCMB – 6.6kV (6.6kV systems)

The CCMB-6.6kV (Cable Connection Module type B – 6.6kV) is a resistive isolation device, which interfaces between the power circuit and the HPB Relay allowing the HPB to measure both the line voltage and the insulation resistance to Earth. A 5kVDC voltage is generated within the CCMB, which under normal operation, applies up to 2.5kVDC between each phase and earth. The CCMB-6.6kV is housed in a polycarbonate enclosure.

CCMB-22kV (Cable Connection Module type B – 22kV) is an isolated device that allows the HPB Relay to interface with the power circuit to measure both the line voltage and the insulation resistance to Earth. The CCMB-22kV connects to the 11kV or 22kV power circuit via 3 x voltage transformers connected in a phase to earth through the CCMB-22kV. The line voltage is measured on the secondary side of the voltage transformers and an insulation test is performed by lifting the primary star point from earth and applying 5kVDC to the star point which passes through the primary windings and is applied to all three phases in parallel.

CAUTION!

The CCMB and the HPB Relay must be earthed to the same earth connection as the trailing cable on systems with separate earth grids. Ensure that the earth connection are reliably installed, as this is the basis of protection, for the isolation device.

CAUTION!

When installing the CCMB – 22kV, measure the resistance between the transformer primary star point and earth before applying power. Ensure that it is less that 10Ω.

4.3.4 Overload & Earth Leakage Toroids

Current transformers (CT) are not ideal devices and if correct procedures are not followed during installation, nuisance tripping can result.

If using, 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 current transformer would have all the flux from each wire contained in the core and so would accurately add the opposing fluxes to get a net result to zero. A real current transformer 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 CT when none would arise if the device was ideal.

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

Problems caused in this way become worse as CT sizes increase, as currents increase and a decrease in the symmetry of the cables.

Nuisance tripping tends to occur when the total current rises, such as when a large motor is started.

To help avoid such problems, select to smallest internal diameter CT, which will allow the cables to fit through.

4.3.5 Toroid Installation Guide Lines

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

4.3.6 Wiring Installation

The connections to the HPB Relay consist of a mix of low and high voltage supplied and relay contact circuits. To reduce induction from high voltages, care needs to be taken in the layout of the wiring and the installation.

When using a 110V HPB a power supply filter, e.g. Schaffner FN612-1106 (1A, 250VAC chassis mounted filter) or similar, should be installed adjacent to the HPB Relay. The earth should be connected to Pin 7 on the relay as directly as possible.

4.3.7 Low Voltage Signals

Care must be taken to ensure these circuits cannot come into contact with higher voltages (e.g. via insulation breakdown, or broken wires etc.). It is recommended that these circuits be run in a separate loom from the “high” voltage circuits. To ensure that interference is kept to a minimum, the following cabling is required.

Table 3: Low Voltage Signals

Duty	Pin	Signal	Cable Type
Pilot Core	6 7	Pilot Earth	Single core screened # Screen = 0V
Serial Comms Port	8 9 10 11 12	+Vsc FIO TXD RDI OV	Four core screened # Screen = 0V
Remote Display	13 14 12	Data +Vdm OV	Two core screened # Screen = 0V
Earth Leakage Toroid	1 2	EL1 EL2	Two core screened Screen = Earth
Cable Connection Module	3 4 5 7	VcmA VcmB VcmC Earth	Three core screened Screen = Earth
Current Protection Transformers	15 16 17 18	Ia1 Ia2 Ic1 Ic2	Two core screened Screen = Earth
Local Stop Button (digital input)	19 20	SpDig+ SpDig-	* Two core screened Screen = Earth
Lock Switch (digital input)	21 22	Lock+ Lock-	* Two core screened Screen = Earth
Reset Switch (digital input)	23 24	Reset+ Reset-	* Two core screened Screen = Earth
Start Switch (digital input)	25 26	Start+ Start-	* Two core screened Screen = Earth
Motor Contactor Aux Contact (digital input)	27 28	MCI+ MCI-	* Two core screened Screen = Earth

NOTE

The 0V is internally connected to the HPB Relay's earth (Pin 7).

The screen therefore must NOT be earthed at any other point.

* The HPB Relay's digital inputs could alternatively be run in a screened multicore cable (Separate cable for each HPB in multiple installations).

Where these “low voltage” circuits need to connect near the power circuits (e.g. Current transformers, cable connection module, main contactor auxiliaries etc.), care needs to be taken to ensure that the circuits are adequately separately and restrained. This ensure that the separation is maintained, even if a wire termination becomes loose etc.

4.3.8 High Voltage Circuits

The “high” voltage circuits of the HPB are the 110 VAC supply (110V version Pins 30, 31 only) and the relay contacts. Apart from keeping these separate from other wiring to the relay, there are no special requirements.

CAUTION!

The relay contacts of the HPB Relay must not be used to switch more than 190 VAC, 5A or 100VA.

4.3.9 Earthing

The HPB has two earth connections. The earth pin 7 is for the communication and pilot circuits. The earth on Pin 29 connects to the earth shield of the HPB Relay’s internal transformer (110V version only) and chassis. The CCMB-6.6kV also has an earth connection and the CCMB-22kV has two earth connection. The CCMB-22kV signal earth should be connected to the HPB pin 7. All other connections should be run back separately to the main earth point.

5 MACHINE COMMUNICATION

5.1 HPB Termination Unit (HTU)

The HTU-1 Remote Termination Unit is a microprocessor based module that is connected between the pilot and earth at the remote end of the trailing cable to provide machine communication. It is powered by and communicates via the pilot line. Its non-volatile memory stored the parameters to configure the outlet as appropriate for that machine (See Drawing HPBM013, in APPENDIX A: DRAWINGS).

The HPB Termination Unit (HTU-1) provides remote stop of the HPB Relay's controlled outlet by tripping the Earth Continuity function. The EC LED on the HDM Remote Display Module is illuminated and the Earth Continuity will need to be reset if "Pilot Latch:On" has been selected. Stop switches are connected in series with a diode between the stop and earth terminals. Alternately the internal HTU-1 Termination Module's diode can be used to terminate the stop loop.

Machine stops can be differentiated from other pilot trips in the HPB Relay's Event Log by connecting machine stops into the HTU-1 Module's "Stop" input instead of being connected in the pilot loop.

WARNING!

Emergency stops must be wired directly into the pilot circuit.

A transient protected internal diode is connected between the diode terminal and earth. When the pilot is connected to the diode terminal the machine can be used with a conventional pilot protection relay such as an Ampcontrol PCA Relay but will not operate when connected to a HPB Relay.

If the remote stop function is not required the stop terminal must be bridged to the diode terminal or the HPB Relay will not energise. The status of the Remote "Stop" input is displayed "HTU: Online Run" or "HTU: Online Stp" and can be viewed on the HDM Module's "Pilot and HTU information" page (level 2, position 1). Also displayed on this page is offline status and pilot information. The HTU-1 software version and machine type is displayed on position 2.

Level 2, position 3 displays the EC trip count (ECR), the EC shunt/short trip count (ECS), a counter (Stat) for the number of cycles the HTU has been online (max will depend on EC trip time) and the status of the HTU run input (Run) where 0 = offline, 1 = run & 2 = stop.

The Remote termination settings are programmed via the HDM Remote Display Module (Section 9, User Adjustable Settings).

5.2 Machine Type Codes

There are 5 selectable machine type codes available for use in the HTU-1 Termination Unit. The descriptive code is transmitted to the HPB Relay to identify the type of machine connected to the outlet. The codes are selected using the HDM Remote Display Module (level 9, position 1):

Table 4: Machine Type Codes

Code	Description
DrgL	Drag Line
Shvl	Shovel
Dril	Drill
PSTx	Portable Transformer
Wpmp	Water Pump

5.3 Machine Number

Machine numbers 1 to 40 can be assigned to machines (1 to 40 for each machine type). These numbers are programmed using the HDM Remote Display Module (level 9, position 2).

5.4 Receiver Sensitivity

The HPB allows the sensitivity of the HTU receiver to be adjusted to suit different installations. For installations where multiple HPB's are located close to each other the sensitivity can be reduces to prevent crosstalk between the pilot signals. In installations with long trailing cables the sensitivity can be increased.

The sensitivity can be adjusted from 1 – 32, with larger values corresponding to decreased sensitivity. For most installations starting with the sensitivity set to 8 should yield good results. If the HTU is connected through a long trailing cable and the HTU is not coming online, try increasing the sensitivity. Alternatively, if there are multiple relays installed near each other, and they do not behave as expected try decreasing the sensitivity to prevent crosstalk.

6 EARTH PROTECTION FUNCTIONS

6.1 Earth Leakage

The Earth Leakage protection function uses a toroid to measure the earth leakage current. A definite time operating characteristic is provided with an adjustable trip sensitivity and time delay.

When a fault occurs and the trip level and time delay are exceeded; a trip occurs. The trip acts in the Main Contactor Relay (MCR) logic and is latched. An earth leakage trip is treated as a special fault and requires an authorised person to perform the reset function. This is achieved by holding the lock input closed and then closing the reset button.

When an earth leakage trip occurs, the “EL” LED on the display module flashes and the open collector output on the HPB Relay is switched on the provide additional monitoring if required.

The measured instantaneous leakage current (EL) is displayed on the HDM “Earth Fault Information” page as a percentage of the trip level. When the leakage reaches 100% for the selected time delay a trip occurs.

For the HPB 6.6kV and the HPB 22kV 200mA EL, the trip level is adjustable in 100mA increments over the range 200mA-1000mA and for the standard HPB 22kV the trip level is selectable in 250mA increments over the range 500mA-2500mA. The time delay is selectable as instantaneous (<80ms) or adjustable in 40ms increments over the range of 150ms-470ms.

6.2 Earth Fault Lockout

6.2.1 HPB 6.6kV

On 6.6kV systems the earth fault lockout function tests the resistance of the 3 phase lines to earth by applying a “megger test” prior to closing the main contactor. The test is initiated by closing the start input, provided all other starting conditions are met (see Section 10.5, Operational Sequence). The HPB Relay closes its relay output, RL3, which applies 100VAC to the CCMB-6.6kV (Cable Connection Module type B – 6.6kV). This is a resistive isolation device used to interface the HPB Relay to the power conductors. A 5kVDC voltage is generated within the CCMB-6.6kV, which under normal operation applies up to 2.5kVDC between each phase and earth.

The HPB Relay measures the voltage on the line and calculates the meg-ohm resistance to earth of each phase. At the end of the test, provided the value is above the pre-set threshold, the MCR relay closes allowing the outlet to be energised. If the value is below the pre-set threshold, an Earth Fault Trip occurs.

At the completion of a test, the resistance to earth of each phase is retained in memory until the next test is carried out. This can be viewed on the HDM (Remote Display Module) (level3, position 2).

6.2.2 HPB 22kV

On 11kV and 22kV systems the earth fault lockout function tests the resistance of the 3 phase lines to earth by applying a “megger test” prior to closing the main contactor. The test is initiated by closing the start input (provided all other starting conditions are met (see Section 10.5, Operational Sequence). The HPB Relay closes its relay output, RL3, which applies 48VDC to the CCMB-22kV (Cable Connecting Module type B – 22kV). The CCMB-22kV then disconnects the primary windings of its 3 x voltage transformers from earth (they are connected to earth at all other times), and generates 5kVDC which is applied to the primary star point, resulting in 5kVDC between all three phases and earth. The HPB Relay then measures the current to earth and calculates the resistance of the line insulation to earth of all three phases in parallel. Three seconds (3s) after the end of the test, if the calculated resistance is above the present threshold, the MCR relay closes allowing the outlet to be energised. If the calculated resistance is below the pre-set threshold, an Earth Fault Trip occurs.

At the completion of a test, the result is retained in memory until the next test is carried out. This can be

viewed on the HDM (Remote Display Module) (level 3, position 2). An insulation test will yield one of the following results:

a. "Hardware Fault" – The HPB cannot detect the presence of the CCMB. Check power supply to the CCMB and all wiring

> **NOTE**
> An open circuit connection between the CMMB and power circuit cannot be detected and will not display as "Hardware Fault".

b. "< 10 MΩ" – The resistance between the power circuit and earth is less than 10MΩ.
c. A value between 10MΩ and 120MΩ - The resistance between the power circuit and earth ±10%.
d. "> 120 MΩ" – The resistance between the power circuit and earth is greater than 120MΩ.

> **WARNING!**
> The CCMB generates 5kVDC. This high voltage DC is produced, and applied to the 3 phase lines, even when the high voltage 3 phase supply is not available. Care should therefore always be taken when working close to high voltage 3 phase cables/bus etc. An audible tone is generated whenever the CCMB is active, warning of the presence of high voltage DC.

> **CAUTION!**
> Like all insulation tests, a faulty (open circuit) connection to the power circuit will create the appearance of a high insulation resistance to earth. To verify the connection to the power circuit it is recommended **that periodic insulation tests be performed, using the HPB, with a known resistance (e.g. 50MΩ) or** a short circuit to earth on the line. This should be done on an isolated system (high voltage supply disconnected) using control power only.

> **NOTE**
> The start input must be held closed for the duration of the test (including the 3 s delay on HPB 22 kV) which is adjustable between 10 and 25 seconds to allow for the charging of cable capacitance.

Setting the "EFLR Test" Value to "off" disabled the Earth Fault test. If this is done, and the system is ready to start, the MCR Relay closes as soon as the start input is closed.

6.3 Earth Continuity

The earth continuity function tests for the continuity of the earthing between the outlet and the machine, via the pilot core in the trailing cable. The pilot core is also used to transfer machine data when a remote HTU (HPB Termination Unit) is used to achieve machine communication. The pilot resistance is measured with a DC signal and communications is achieved by a high frequency AC signal.

The HPB Relay can be configured to operate in either Resistor or HTU Mode. The mode is selected in "Pilot Type", (level 8, position 1) and defines the type of termination unit to be connected between the pilot and earth at the machine end of the trailing cable being protected by the HPB Relay.

The advantage of using the resistor mode is that it uses a simple signal and a robust termination device making the system easy to fault find.

The disadvantages are:

a. An incorrect healthy Earth Continuity Indication could be produced by a pilot that has faulted to earth with a resistance within the pickup range of the HPB Relay. For example if the selected trip level is 50Ω, then the fault to earth in the range of 200Ω to 285Ω would be seen as a healthy circuit.
b. The “Machine Communication” functions of the HPB Relay are not available.

The advantages of using HTU mode are:

a. Machine communication.
b. Machine stops can be differentiated from Earth Continuity Trips in the HPB Event Log.
c. Increased security in pilot system as the HPB Relay must receive an intelligent signal from the HTU-1 Termination Module in order to deem the pilot circuit healthy.

The net disadvantage is that the increased complexity in the system may make troubleshooting difficult.

Resistor Mode

When the pilot is set to “Res” Mode the trailing cable pilot is terminated with a 235Ω resistor to earth (2 x 470Ω, 5 Watt resistors connected in parallel). The HPB Relay measures the resistance of the pilot earth loop and assumes that the pilot circuit is healthy if the resistance measured is between 235Ω and 235Ω + RTrip (the selected trip resistance). If the resistance measured is below 200Ω a short circuit fault between the pilot and earth conductors is assumed and a trip occurs, which in turn de-energises the MCR Relay.

In “Res” mode all of the relay settings are stored in the HPB Relay. If a load is moved to a different outlet (or substation) then the HPB Relay’s settings need to be checked and updated if necessary.

HTU Mode

When the pilot is set to “HTU” Mode the trailing cable pilot is terminated with a HTU-1 Termination Module. The HPB Relay measures the resistance of the pilot earth loop and assumes that the pilot circuit is healthy if the resistance measured if below the selected trip resistance level. If the resistance exceeds the pre-set level a trip will occur. The Event Log will display “EC Ω Trip”

In “HTU” mode the relay settings that pertain to the actual load connected are stored in the HTU-1 Termination Module, which is installed in the machine. If a machine cable is moved to a different outlet (or substation) then the protection settings for the machine are automatically uploaded to the HPB Relay.

The Earth Continuity Resistance (ECR) of the pilot – earth loop is displayed in ohms on the HDM “Earth Fault Information” page (level 3, position 1). The leakage (SC) between the pilot and earth conductors is displayed as OK or Trp. The Event Log will display “EC Short” if a short occurs between pilot and earth when the outlet is energised.

The Earth Continuity (EC) Trip resistance for both modes is selectable to 50, 75, and 100 ohms.

Pilot Trip Time is adjustable to allow for operation in noisy electrical environments. The following trip times are available: 300ms, 400ms, 500ms, 600ms, 800ms, 1.0s, 1.2s, 1.5s, and 2s.

A maximum of 600ms should be suitable for most installations.

CAUTION!

Long time delays should only be used where necessary. Consequences of long trip times should be thoroughly assessed from a safety point of view before using the higher values.

When an Earth Continuity trip occurs the HPB Relay de-energises the MCR Relay. The “EC” LED on the display module is illuminated and the open collector output on the relay is switched on to provide remote monitoring if required.

The Earth Continuity can be set to be latching or non-latching (See Section 9, User Adjustable Settings). This allows the user to determine if the fault is manually or automatically reset once the pilot – earth loop is healthy. The selection is either “Pilot Latch: On” or “Pilot Latch: Off”.

For Pilot Fault Finding information, see Section 16.1.

7 CURRENT RELATED FUNCTIONS

7.1 Basic Over-Current Protection

NOTE

The HPB 6.6kV Relay uses 1000:1 CTs.

The HPB 22 & 11kV Relay uses 2000:1 CTs.

Two current transformers are used to measure the three line currents. The measured currents are used to implement the following protection functions:

a. Over-current
b. Short Circuit
c. Phase Current Balance

Full load settings cover a range from 7.5 Amps to 464 Amps for the HPB 6.6kV and 15 Amps to 928 Amps for the HPB 22kV. A current range and current multiplier are utilised to select and store the full load current value in the non-volatile memory. This forms the basic reference level for the over-current protection functions.

The current range is selectable in 4 Amp increments between 60 and 116 Amps. The current multiplier is selectable at 1/8, 1/4, 1/2, 1, 2, and 4 times for the HPB 6.6kV and at 1/4, 1/2, 1, 2, 4, and 8 times for the HPB 22kV. The selected Range and Multiplier combine to give the basic level.

Example

To obtain a full load current of 152 Amps select a current range of 76 Amps and a multiplier of 2.

Two curve types can be selected. A selected time multiplier modifies the basic trip time characteristic. This multiplier is selected from 0.05 times to 1.0 times.

The instantaneous current in each of the three phases can be displayed on the display module (level 5, position 1). The display is expressed as a percentage of the selected full load current and reads between 0 and 999% (i.e. up to 9.99 times full load current).

When the load current exceeds the full load current level, a trip accumulator is incremented at a rate dependant on the current. When this accumulator reaches 100%, an over-current trip occurs.

The trip accumulator can be viewed on the HDM Remote Display Module (level 5, position 2). This may be useful to determine how close an outlet gets to trip condition during start up. If the accumulator reached almost 100% as the load gets away then this may indicate that the over-current settings are too low. Conversely, if the trip accumulator only builds up slightly on a heavy start, then the over-current setting may be set too high.

If an over-current trip occurs, the “OC” LED flashes, and the “OC” open collector output switches on to provide remote monitoring if required.

Following an over-current trip, the following conditions must be met to affect a reset:

a. The trip accumulator must be less than 80%.
b. The HPB Relay’s reset input must be closed.

7.2 Over-Current Characteristic

The current-time trip characteristics can be selected as either Very Inverse, or Extremely Inverse, corresponding to the “OC Type” value or “vlnv” or “xlnv”. The drawing, Very Inverse Over-current Curves,

HPBB003, in APPENDIX A: DRAWINGS and Extremely Inverse Over-current Curves, HPBB001, in APPENDIX A: DRAWINGS, show the trip characteristics.

7.3 Short Circuit

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.

When a trip occurs, the “SC” LED on the display module flashes and the open collector output on the HPB Relay is switched on to provide monitoring if required.

To reset the relay following a short circuit trip it is necessary to hold the lock input closed and then close the reset button.

The HPB Relay can be programmed so that a short circuit trip will operate either the “CBR” relay or the “MCR” Relay. This can be achieved by selecting the required relay at the “SC Relay” selection in the non-volatile memory (See Section 9, User Adjustable Settings). Normally the “CBR” selection would be used.

If “MCR” is selected then the user must ensure that the interrupting device that is operated by the MCR Relay has sufficient current interrupting capacity at the system voltage for the situation in which it is installed.

The short circuit trip level is adjustable from 3 to 10 times (full load current in 0.5 increments. The trip time is selectable from 40 to 160ms.

7.4 Phase Current Balance

Phase current balance protection is selected via the “Cur Bal trip” selection (See Section 9, User Adjustable Settings). The current balance measurement is displayed on the Remote Display Module and is calculated as:

$$I_{bal} = \frac{MAX\Delta \ x\ 100\%}{I_{ave}}$$

Where:

$$I_{ave} = Average\ of\ the\ 3\ phase\ currents$$

$$MAX\Delta = The\ maximum\ deviation\ of\ a\ phase\ current\ from\ the\ average$$

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

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

If the trip level is exceeded, a time is trigger. If the imbalance remains above the set level for more than two seconds the relay trips. The event logs records “Ibal” to differentiate it from a true over-current trip.

The status of the time is displayed adjacent to the “Ibal” value (level 5, position 2) on the HDM Remote Display Module. A trip condition occurs when the timer reaches 100%.

8 VOLTAGE RELATED FUNCTIONS

8.1 Main Contactor Fail Protection

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

a. Failing to open when required. This is achieved by comparing the state of the main contactor (via the Main Contactor Input MCI) against the state of the MCR Relay output. This provides a “Pilot Fail Timer” function.
b. Failing to maintain insulation across the contacts when the contactor is open. The Cable Connection Module is used to measure the voltage on the load side of the contactor. If this exceeds 10% of the rated line voltage, a trip will occur.

This function is inhibited immediately after the main contactor opens or a cable test is performed to allow for the cable capacitance to discharge.

The back EMF inhibit time is adjustable from 2 to 40 seconds (See Section 9, User Adjustable Settings).

A main contactor fail trip causes the CBR Relay to de-energise, which trips the circuit breaker. An internal battery backed indication flag in the HPB Relay is also tripped. An LED on the front panel of the HPB Relay begins to flash.

The “MCF” LED on the Remote Display Module flashes and the open collector output on the HPB is switched on to provide remote monitoring if required.

To reset the flag, access to the relay is necessary. The reset button is accessible through the front fascia of the relay and must be pressed for 1 second.

8.2 Under Voltage Trip

Under voltage protection is enabled as soon as the main contactor is closed (indicated by closing the MCI input). If any of the phase voltages drop below the selected trip setting of the nominal line voltage for 800ms then the outlet is stopped. This is recorded in the event long as “uVOLT Trip”.

The trip level is selectable from 30% to 80% in 10% increments or can be set to “Off” (level 8, position 6) on the HDM Remote Display Module.

The “Off” selection disables the under voltage trip function and is usually used for non 6.6kV installations.

8.3 Voltage Metering

The Cable Connection Module (CCMB), in addition to enabling the Earth Fault test, is used to provide line voltage metering.

The outgoing line voltages for each of the 3 phases are displayed as a % of the nominal line voltage on the HDM Remote Display module (level 4, position 1). The maximum reading is 140% for the 6.6kV systems and 120% for the 11kV and 22kV systems.

9 USER ADJUSTABLE SETTINGS

9.1 Parameter Groups

The HPB Relay has many user adjustable settings, which are stored in non-volatile memory. These can be viewed and modified via the HDM Remote Display Module. The setting are split into two groups as outlined below. The first group of parameters relates to settings, which are linked to the power system rather than the particular load connected to the outlet. These are always stored in the HPB Relay.

9.1.1 Group 1 Settings

Table 5: Group 1 Settings

Display Message	Description
Pilot Mode:	Determines if the pilot is to be terminated with a Resistor or a HTU-1 Termination Unit
EL Sens:	Sets the sensitivity for the Earth Leakage protection trip
EL Time:	Sets the trip time for the Earth Leakage protection EFLR
Test:	Sets the Earth Fault lockout level
Eft time:	Selects the test time for the Earth Fault lockout test to allow for line capacitance
U/V Trip:	Selects the under voltage trip threshold as a % of line volts
SC Relay:	Selects which HPB output relay is tripped in event of a short circuit trip
HTU rx Lev:	Adjusts the sensitivity of HTU data receiver

The second group of settings consists of parameters that are related to the load connected to the protected outlet. These settings are stored, retrieved to/from the memory in the HPB Relay or the memory in the HTU-1 Termination Unit, depending on the “Pilot Mode” setting.

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

If the HTU Pilot Mode is selected the settings are sent to and retrieved from the memory in the Remote Termination Unit.

9.1.2 Group 2 Settings

Table 6: Group 2 Settings

Display Message	Description
HTU MC Type:	Allows the HTU 1 to transmit a descriptive code to identify the machine connected to the outlet
HTU MC No:	Allows the HTU 1 to transmit an assigned machine number
OC I range:	Sets the basic current range
OC I mul:	Combines with OC range to define the full load current
OC Type:	Selects either very inverse or extremely inverse over-current curves
OC t mul:	Modifies the basic over-current time curves to achieve the desired trip times
Cur Bal Trp:	Adjusts the current phase balance trip level
SC I trip:	Sets the short circuit trip level
SC Trip t:	Sets the trip time for the short circuit function

Pilot Latch:	Determines whether earth continuity trips are self resetting or not
B emf TIME:	Adjustable time delay to inhibit main contactor fail routine following opening of main contactor
Remote Start:	No function for this version

9.2 Changing Settings

The procedure for adjusting the settings is independent of where the values are stored.

a. Ensure the outlet is stopped.
b. For Group 2 Settings in HTU Mode, ensure the HTU-1 Termination Unit is online.
c. Display the parameter that has to be changed on the HDM Remote Display Module's liquid crystal display (level 8 or 9).
d. Momentarily operate the lock input. A warning message appears.
e. Press the enter button to acknowledge the warning message and to confirm that a change is desired.
f. Use the left and right arrows to step through the allowable values until the desired new setting is displayed.
g. Press the enter button to indicate that the value shown is the required new setting.
h. Momentarily operate the lock input. The display will show a confirming message, then return to the viewing level.

If the up or down keys are operated during this procedure the HPB Relay aborts the modifying sequence.

When changes have been made to the stored values, the old value and the new value are stored in the event log. A separate log immediately proceeds this, recording the time and date that the change was made.

NOTE

When the relay has been selected for HTU Mode the HTU Remote Termination Unit must be online (shown at level 2, position 1 on the HDM) before Group 2 settings can be adjusted.

10 SYSTEM CONTROL

10.1 Digital Inputs

The HPB Relay has five digital inputs, which are all voltage free contact inputs. Shorting the two input terminals together activates them. The inputs are MCI, start, stop, lock and reset.

The status of inputs can be displayed on the HDM Remote Display Module (level 6, positions 2 and 3). The “Lnk” input shown in the display is used in tests by Ampcontrol Engineers.

10.2 Output Relays

The HPB Relay has output relays to control the main contactor and the circuit breaker (under voltage control). All relays are fail safe with respect to power supply loss and are controlled on the basis of protection functions. Relays RL3 operates to initiate the cable fault lockout test. There is one spare relay reserved for future development. The status of the relays can be displayed on the HDM Remote Display Module (level 6, position 1).

10.3 Open Collector Outputs

The HPB Relay has eight open collector outputs, which are driven through optocouplers to provide additional indication if required. These can be used to drive LED’s, or additional relay (with appropriate drive circuitry). The Ampcontrol Relay Output Module (ROU) enables these indications to be interfaced with PLC (See Drawing IPA031, in APPENDIX A: DRAWINGS). The eight outputs correspond to the LED’s on the display module, turning on whenever the corresponding LED is flashing. The signals are available on the HPB Relay’s base, pins 35-42, and the common is on pin 34.

10.4 Outlet Control

Closing the Start input energises the outlet. Both the remote and local stop buttons will turn off the outlet. If a remote stop is not required the Stop input must be bridged to earth via a diode at the HTU-1 Termination Module.

10.5 Operational Sequence

Before an outlet can be energised the following conditions must apply:

a. No protection faults present
b. Local stop input open, remote stop loop closed
c. Local Start input closed

Once these conditions are obtained a cable fault lockout test is performed automatically. The start button must remain closed during the test, which may take up to 25 seconds to complete due to the charging of the cable capacitance. If the result of this test is satisfactory the HPB Relay goes into the run mode and the MCR Relay picks up.

The “RUN” LED on the HDM Remote Display Module is illuminated and the open collector output on the HPB Relay is switched on to provide remote monitoring if required.

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

If a stop button is operated which the relay is in run mode, the run is cleared, and the MCR Relay de-energises. The event log reads “Stopped” or “HTU Stop” depending on which stop button caused the stop condition. If a stop button is operated during a cable fault lockout test, then the test is aborted.

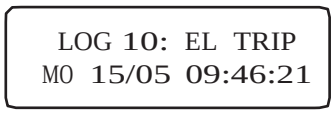
While the main contactor is closed, the MCI input is continuously monitored. If it opens, the run is cleared and the MCR relay de-energises. In this case the event log records “MC Opened” which indicates that the outlet was turned off by something other than the HPB Relay, e.g. open circuited main contactor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

11 EVENT LOG

A real time clock/calendar is included in the HPB Relay. This combines with the non-volatile memory to provide data logging. This log sequentially records the time, date and details of the HPB Relay's operations. A chronological list of the previous 120 events is stored.

The event log can be scrolled so as to view the entire log. To achieve this press "Enter" followed by the "right" or "left" arrow keys to commence the scroll. The log will scroll one log per second in the direction of the arrow key pressed. Press "Enter" to stop the scroll at the desired log.

A typical display shows:



This record shows that an earth leakage caused a trip condition on Monday, 15 May at 9.46am. Log 10 indicates that it is the 10th log in the list. Log 1 is always the most recent event. Each time a new log is recorded, the 120th log is removed from the list and all others move along one.
The following events are logged:

Table 7: Event Logs

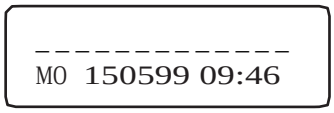
Event	Description
"Power Up"	Records the time when the HPB Relay is powered up
"Pwr Down"	Records the time when the HPB Relay loses power
"MCR Close"	Closure of the Main Contactor Relay
"Stopped"	Stopping of the outlet by operation of the local stop button
"HTU Stop"	Stopping of the outlet by operation of the remote stop button
"MC Opened"	Main Contactor has opened but not initiated by the HPB Relay
"EC Ω Trip"	Pilot/Earth continuity loop exceed the trip level
"EC Short"	Low resistance between pilot and earth
"EL Trip"	Earth leakage protection tripped
"EF trip A"	Earth Fault test has failed – A phase (HPB 6.6kV)
"EF trip B"	Earth Fault test has failed – B phase (HPB 6.6kV)
"EF trip C"	Earth Fault test has failed – C phase (HPB 6.6kV)
"EF trip"	Earth Fault test has failed – (HPB-22kV)
"SC Trip"	Trip condition of short circuit protection
"OC Trip"	Trip condition of over-current overload protection
"I bal-Trp"	Current balance trip condition
"RESET"	Records resetting of a protection trip
"Setup Mod"	Records that setup data has been modified. The log preceding this shows the old and new values
"uVOLT Trp"	Records that voltage was not present on at least one outgoing phase when the main contactor was closed
"MCF F Trp"	Internal battery backed main contactor fail flag tripped
"MCF-V trp"	Main Contactor Fail trip due to sensing voltage on the load side of the main contactor when the contactor should be open

“MCI Fail”	Main Contactor Input (MCI) shows the main contactor to be closed when it should be open
“µ-P reset”	Internal microprocessor reset
“Mem.ERROR”	Records that the relay’s non-volatile parameter memory has been corrupted
“HTU mem.E”	Records that the remote termination unit’s non-volatile memory has been corrupted or the remote termination unit has gone offline while the outlet is running.

12 TIME & DATE

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

a. Using the Remote Display Module select the time and date information page (level 7, position 1) to display the Day, Month, Year, Hours and Minutes.



b. Press the enter key. A “v” will appear in the top line above the minute section. This indicates the number to be changed.
c. Use the left and right arrow keys to move the “v” to the desired position.
d. Press the enter key. The “v” now changes to a “?” The right arrow key is used to increment the allowable value, once the desired value is obtained, press the enter key again. The “?” returns to a “v”.
e. Repeat steps (c) and (d) until the correct time and date is displayed.
f. With the “v” showing press the lock push button. The “v” then changes to “E” (This is a prompt to press the enter key).
g. Press the enter key. At that instant, the seconds are zeroed and the selected time/date information is transferred to the internal clock.

If the battery voltage is low the time will zero and the date will reset to 1st January on power up. If the battery is flat or faulty the relay is likely to trip on “main contactor fail” on power up.

13 REMOTE DATA COMMUNICATIONS

The HPB Integrated Protection Relay has the facility for connecting remote monitoring equipment. This can be in the form of either the Remote Display Module or other peripheral equipment such as PLC's. For PLC applications the Ampcontrol DNET-IP2 Serial Communications System transfers data and commands between the Host System and the modules using RS232, RS422, and RS485 protocols. Each integrated protection relay is connected to a Serial Interface (IPSI), which has its output drop connected to a DNET-IP2 Protocol Converter. The Protocol Converter provides the communications link to a PLC (See User Manual 118262 for further details).

14 SPECIFICATIONS

NOTE

An 11kV system includes the HPB 22kV Relay

Auxiliary Supply Volts	HPB 6.6kV – 110VAC ±20%, >20VA, 50Hz ± 2Hz HPB 22kV – 48VDC ±20%, >40W Recommended Power Supply: Meanwell – DR-120 Ampcontrol Part No. 143911
Earth Leakage Protection:	HPB 6.6kV – Trip Setting 200mA to 1000mA in 100mA increments HPB 22kV, 200mA EL – Trip Setting 200mA to 1000mA in 100mA increments HPB 22kV – Trip Setting 500mA to 2500mA in 250mA increments Time Delay: Instantaneous, <80ms and 150ms to 470ms (in 40ms increments).
Earth Continuity Protection:	Trip Setting 50Ω, 75Ω, and 100Ω Shunt Leakage Trip if <200Ω (Resistor Mode) Operating Time 300ms, 400ms, 500ms, 1.0s, 1.2s, 1.5s and 2s
Earth Fault Lockout Protection: Lockout Resistance: Test Time:	 HPB 6.6kV – Selectable at 2, 5, 10, 20 and 50 Meg Ohm and off HPB 22kV – Selectable at 15, 20, 30, 50 and 100 Meg Ohm and off Selectable at 10, 15, 20 and 25 seconds
Over-current Protection: Current Range: Current Multiplier: Time Multiplier:	 HPB 6.6kV – 7.5 to 464 Amps (60 to 116 Amps in 4 Amp increments, times current multiplier) HPB 22kV – 15 to 928 Amps (60 to 116 Amps in 4 Amp increments, times current multiplier) HPB 6.6kV – 1/8, 1/4, 1/2, 1, 2, 4 times HPB 22kV – 1/4, 1/2, 1, 2, 4, 8 times 0.05, 0.075, 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 1.0 times
Current Balance: Trip Settings:	 5%, 10%, 20%, 50% and OFF
Short Circuit Protection Trip Settings: Trip Time (ms):	 3.0 to 10.0 times in 0.5 increments (times full load current) 40, 60, 80, 100, 120, 160
Back EMF Timer: Trip Delay Settings:	 2, 5, 10, 15, 20, 25, 30, 35, 40 seconds
Machine Numbers:	Can be allocated from 1 to 40

Under Voltage Protection:	Selectable from 30% to 80% in 10% increments, or disabled. Trip delay 800ms
Serial Communications Port:	For information on data format and hardware see DNET-IP2 Serial Communication System User Manual 118626
Relay Contacts:	MCR, CBR 1 N/O 5A/190 VAC 100VA maximum 1 C/0 5A/190 VAC 100VA maximum RL3 1 N/O 5A/190 VAC 100VA maximum
22 kV Transformers:	Rated Voltage: 22 KV, 50Hz Insulation: 24 / 50 / 125kV Voltage Factor: 1.9 / 30 sec Ratio: 22kV / √3 to 110 / √3 Class: 0.2 VA Rating: 10VA Standard: AS60044.2 N Terminal capable of withstanding 5kVDC test voltage
11kV Transformers:	Rated Voltage: 11 KV, 50Hz Insulation: 12 / 28 / 75kV Voltage Factor: 1.9 / 30 sec Ratio: 11kV / √3 to 110 / √3 Class: 0.2 VA Rating: 10 VA Standard: AS60044.2 N Terminal capable of withstanding 5kVDC test voltage

NOTE

Transformers must be able to withstand 5kVDC on the primary side.

15 EQUIPMENT LIST

Part Number	*Description*
144069	HPB 6.6kV Integrated Protection Relay
162922	HPB 22kV 200mA EL Integrated Protection Relay
142842	HPB 22kV Integrated Protection Relay
118732	HTU-1 Termination Unit
142848	HPB Base
142845	HPB Base – 48V
118542	HDM Remote Display Module Flush Mount
117648	6.6kV Cable Connection Module
143369	22kV Cable Connection Kit
144371	11kV Cable Connection Kit
101503	IPA/IPB Relay/LED Output Module
117829	HPB User Manual
143911	48VDC, 120W Power Supply

16 TROUBLESHOOTING

If a problem is experiences with the relay use the following table to fault find the problem. Should the fault persist, remove the relay and return the relay plus a description of the fault to Ampcontrol for repairs.

WARNING!

The HPB has no user serviceable parts. All repairs must be carried out by Ampcontrol personnel only. If a fault develops return the HPB to Ampcontrol for repair. It is essential that no attempt be made to repair the HPB as any attempt to dismantle or repair the HPB can seriously compromise the safety of the unit and the consequences can be fatal.

NOTE

The Status page (level 0, position 1) should be the first step in troubleshooting. This displays what the relay requires to make it operate. Also check the first six event logs.

Symptom	Cause	Remedy
Remote Display shows a blank screen. The HDM LED indicator located on the top of the HDM module is off.	Loss of power to the Display.	Check there is power to the relay and it is correctly plugged in. Relay supplied 15VDC to the HDM. Check cable between HDM and the relay.
	Faulty Display Module	Replace module
Remote Display shows a blank screen. The HDM LED flashes at 1Hz.	Power to the HDM is healthy but there is no data.	Check data cable between the relay and the HDM.
Error indication #1 (level 0, position 1).	Corruption in the Group 1 Settings, stored in the relay.	Examine the Group 1 Settings (level 8) to check the stored parameters in the non-volatile memory. One or several settings will show '???'. Re-program list settings into the memory.
Error Indication #2 (level 0, position 1) when in HTU pilot mode	Either the HTU-1 Module is not online or the HTU-1 Module's non-volatile memory has been corrupted.	Check that the HTU-1 Module is online (level 3, position 1) i.e., a healthy pilot loop. If the HTU-1 Module is online examine the Group 2 Settings stored in the HTU Settings (level 9). One or several other settings will show '???'. Re-program lost settings into the HTU-1 memory.
Error Indication #3 (level 0, position 1).	Combination of faults causing errors #1 and #2.	As outlined above for Errors #1 and #2.
Relay will not close. EC fault indicated	Faulty pilot circuit (open or high resistance or shorted to earth)	Check pilot circuit. (See detailed fault finding information, Section 6) If still faulty replace the relay.

HPB Status page displays: [HTU Stop]	Relay is waiting for the HTU-1 Module's Stop input to be closed	Ensure HTU-1 Module's stop input is closed (through a diode to earth).
Outlet is off and the log records "MC Opened".	Outlet was turned off but not by the relay.	Check main contactor coil or control circuit.
Relay will not remain closed and cycles while the start input is held closed.	The relay's MCI input is not closing (level 6 position 2).	Check that main contactor is closing. If not check circuit. Check auxiliary contacts and wiring.
	Relay not receiving voltage feedback on all three outlet phases within 800ms of contactor closing.	Check system voltage display (level 4, position 1) as contactor closes. Compare this with the under voltage threshold.
		Check continuity from the relay, through the CCMB – 6.6kV to power conductors. WARNING! Be sure to follow the appropriate high voltage isolation procedures. HPB 6.6kV Typical reading: CCMB - 6.6kV 27 Meg Ohm.
Relay Trips on MCF on power up.	Main contactor fail condition	Check main contactor for leakage across terminals on frozen contactor condition. AA cell installed under the top cover requires replacement. It is recommended that the relay be returned to Ampcontrol for battery replacement and full testing.
	Flat or faulty battery	
Time and date incorrect. Resets to 1/01/9? On power-up.	Low battery.	AA cell installed under the top cover requires replacement. It is recommended that the relay be returned to Ampcontrol for battery replacement and full testing.
HDM Displays "Hardware fault".	CCMB has not been detected.	Check all wiring to the CCMB and earthing.

16.1 Pilot Fault Finding Information

To carry out tests on a faulty earth continuity circuit adopt the following procedures:

Open Circuit Pilot

Check the voltage between the pilot and earth at the HPB Relay (Pins 6 and 7). The reading should be 30VDC.

To determine the location of the fault continue the above test along the pilot until no reading is obtained.

Current Check

Connect a DC ammeter between the pilot and earth at the HPB Relay (Pins 6 and 7). The reading should be 45mA at the HPB Relay or at any point along a continuous pilot.

Repeat this test at the machine end of the pilot. If the voltage is normal (30VDC) but the current is less that 45mA then the loop resistance may be too high.

Tests in Resistor Mode

When Resistor Mode has been selected, the pilot is terminated with a 235Ω resistor. The voltage measured across the resistor should be 10.6VDC.

The voltage measured at the HPB Relay will vary depending on the amount of resistance in the pilot earth loop. For example, if the loop resistance is 100Ω then the voltage at the HPB Relay will increase by 4.5 volts (100 x 0.045) resulting in a reading of 15.1VDC.

Tests in HTU Mode

When HTU Mode has been selected the pilot is terminated with a HTU-1 Termination Module. The voltage measure across the Pilot and Earth terminals of the module should be approximately 20VDC.

The voltage measured at the HPB Relay will vary depending on the amount of resistance in the pilot earth loop. For example if the loop resistance is 100Ω then the voltage at the HPB Relay will increase by 4.5 volts (100 x 0.045) resulting in a reading of 24.5VDC.

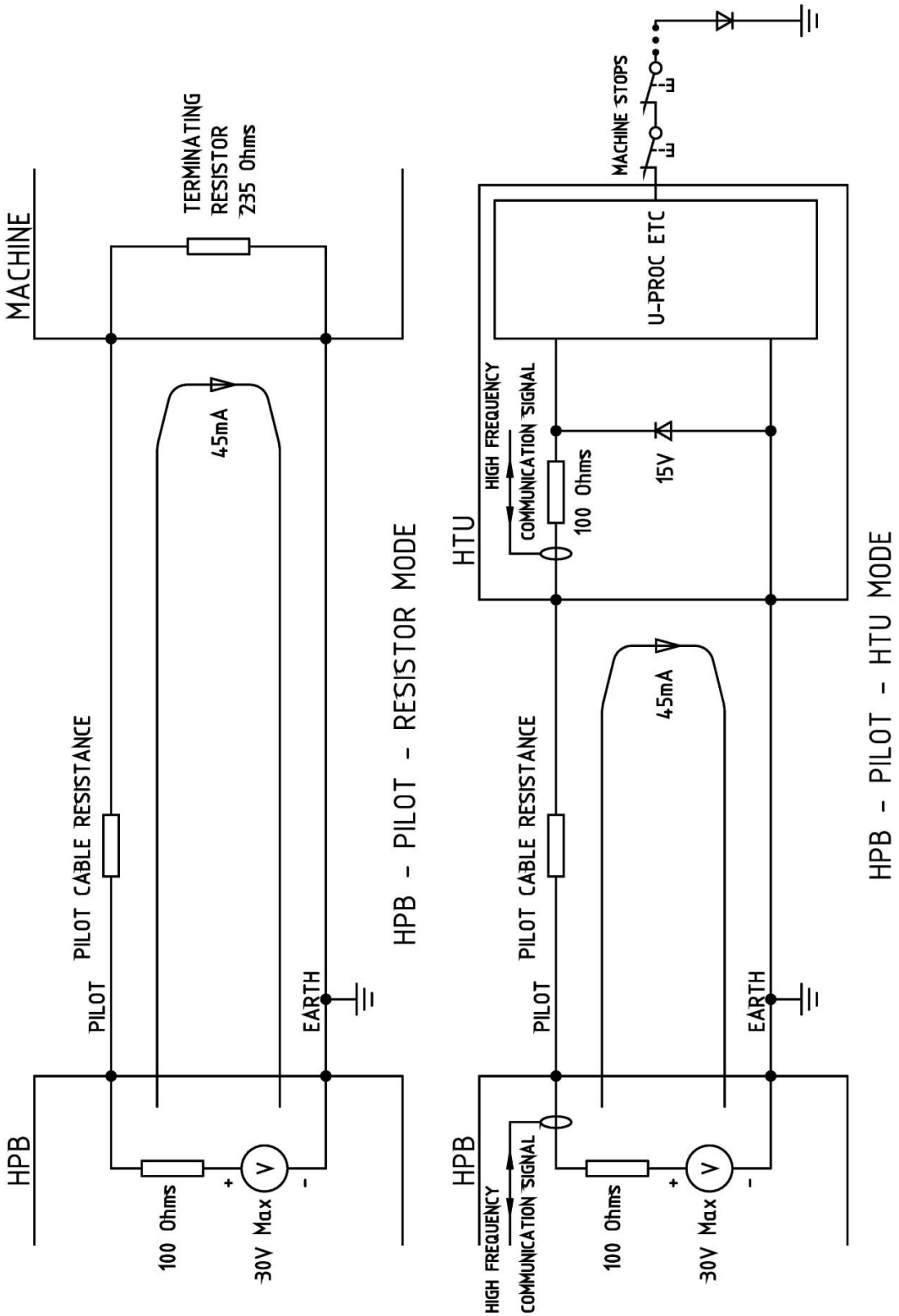
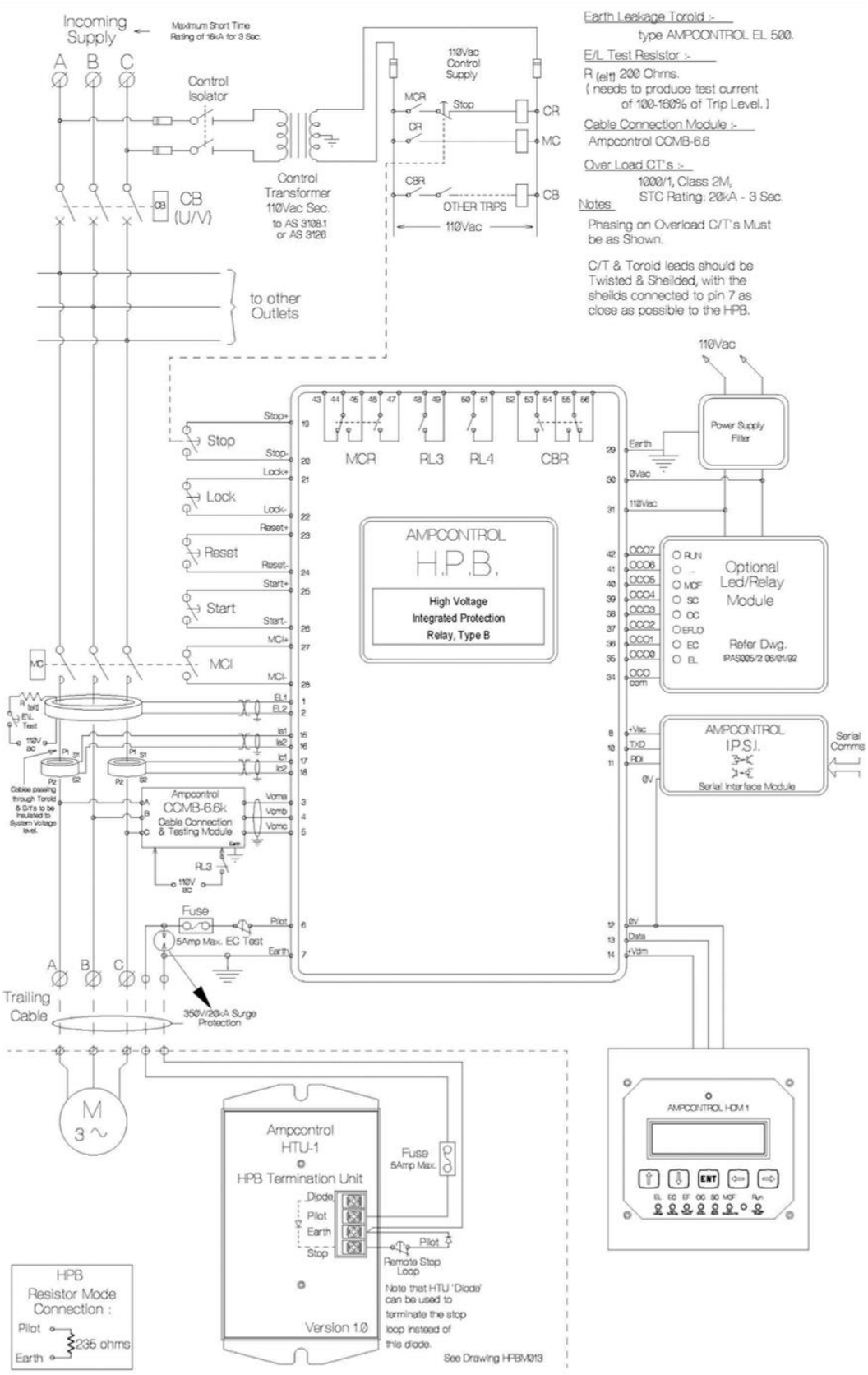


Figure 16-1: HPB - Pilot – Resistor & HTU Mode

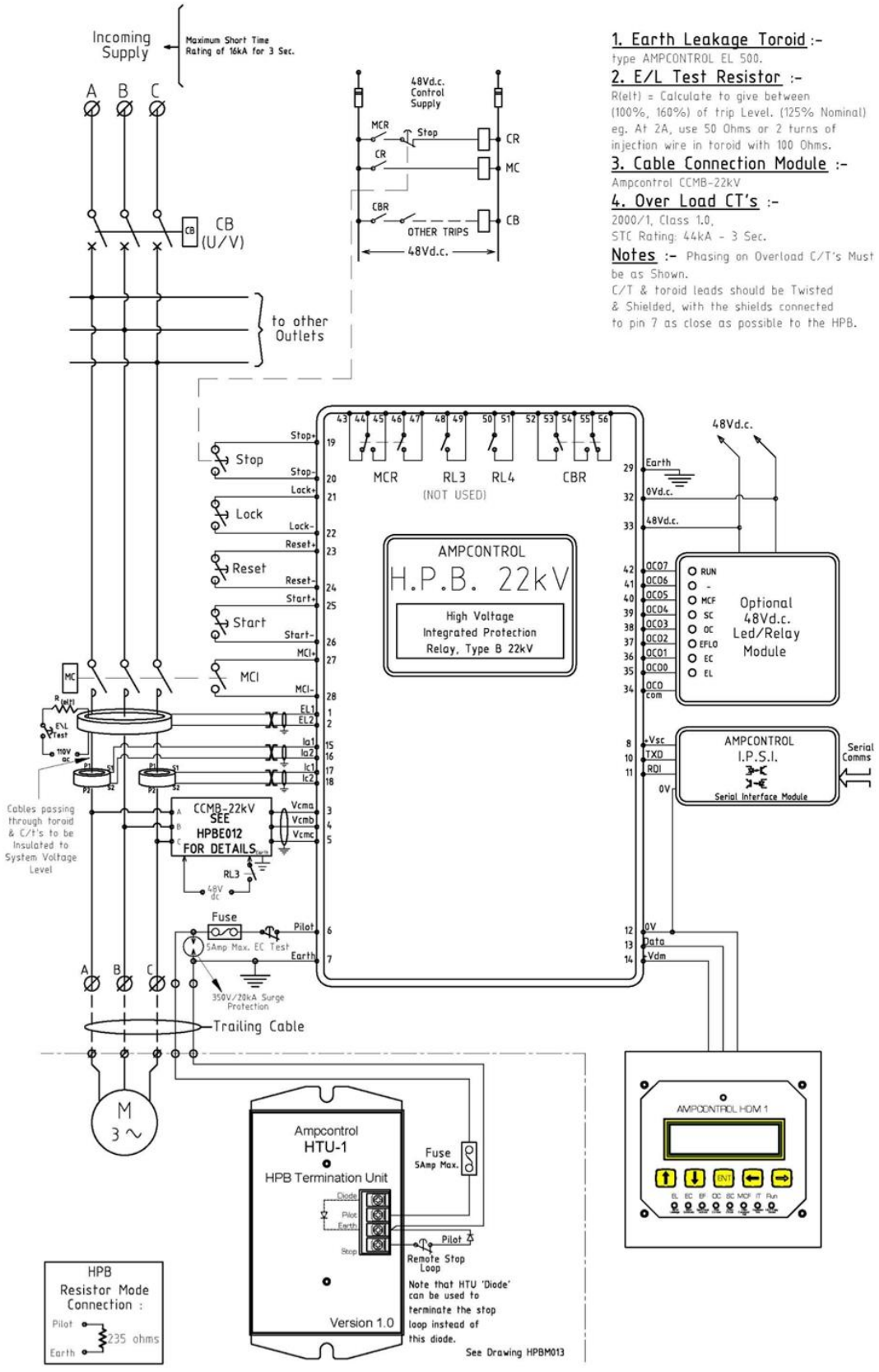
APPENDIX A: DRAWINGS

The Drawings appear in the following pages in the same order in which they are listed in the table above.

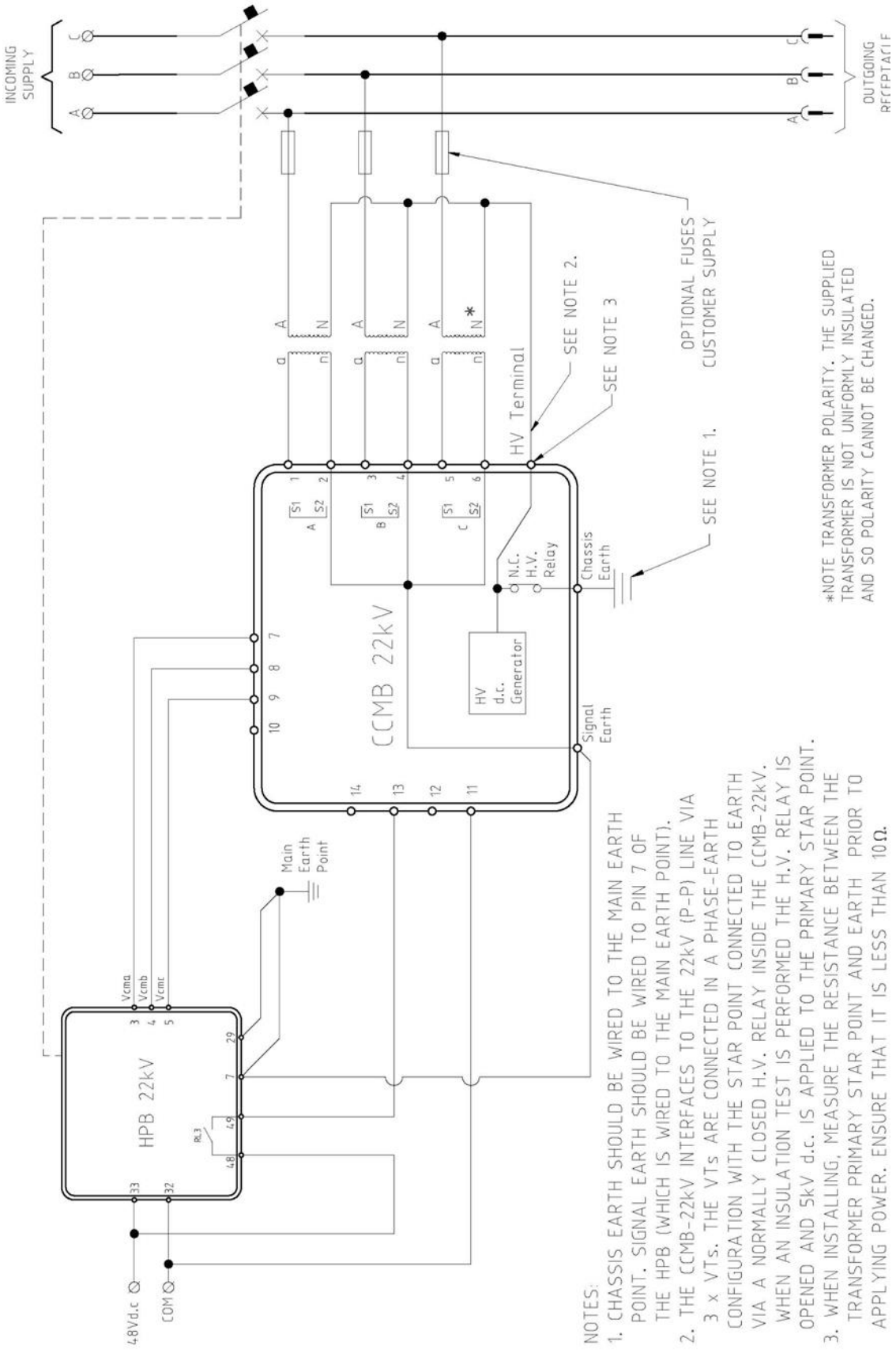
Drawing Number	Description
HPBE006	Typical Connection Diagram – HPB 6.6kV
HPBE013	Typical Connection Diagram – HPB 22kV
HPBE012	Typical Connection Diagram – CCMB 22kV
-	HPB Display Map
HPBB003	Very Inverse Over-current & Short Circuit Curves
HPBB001	Extremely Inverse Over-current & Short Circuit Curves
IPBB003	Adjustable Setting Storage
HPBM005	HPB Enclosure Dimensions
HPBM013	HPB HTU-1 Termination Unit
HPBM015	Enclosure Details – Remote Display Module HDM
HPBM030	HPB Base Connections
HPBM029	HPB 48V Base Connections
HPBM001	CCMB 6.6kV Cable Connection Module – Overall & Mounting Dimensions
HPBA018	CCMB 22kV Cable Connection Module – Overall & Mounting Dimensions
IPAS005	IPA/IPB Relay/LED Output Module
IPAA031	Relay Output Module – General Arrangement
-	11kV VT Mechanical Drawing and Mounting Dimensions
-	22kV VT Mechanical Drawing and Mounting Dimensions



TYPICAL CONNECTION DIAGRAM - HPB 6.6kV
Drawing # HPBE006
Rev. 0

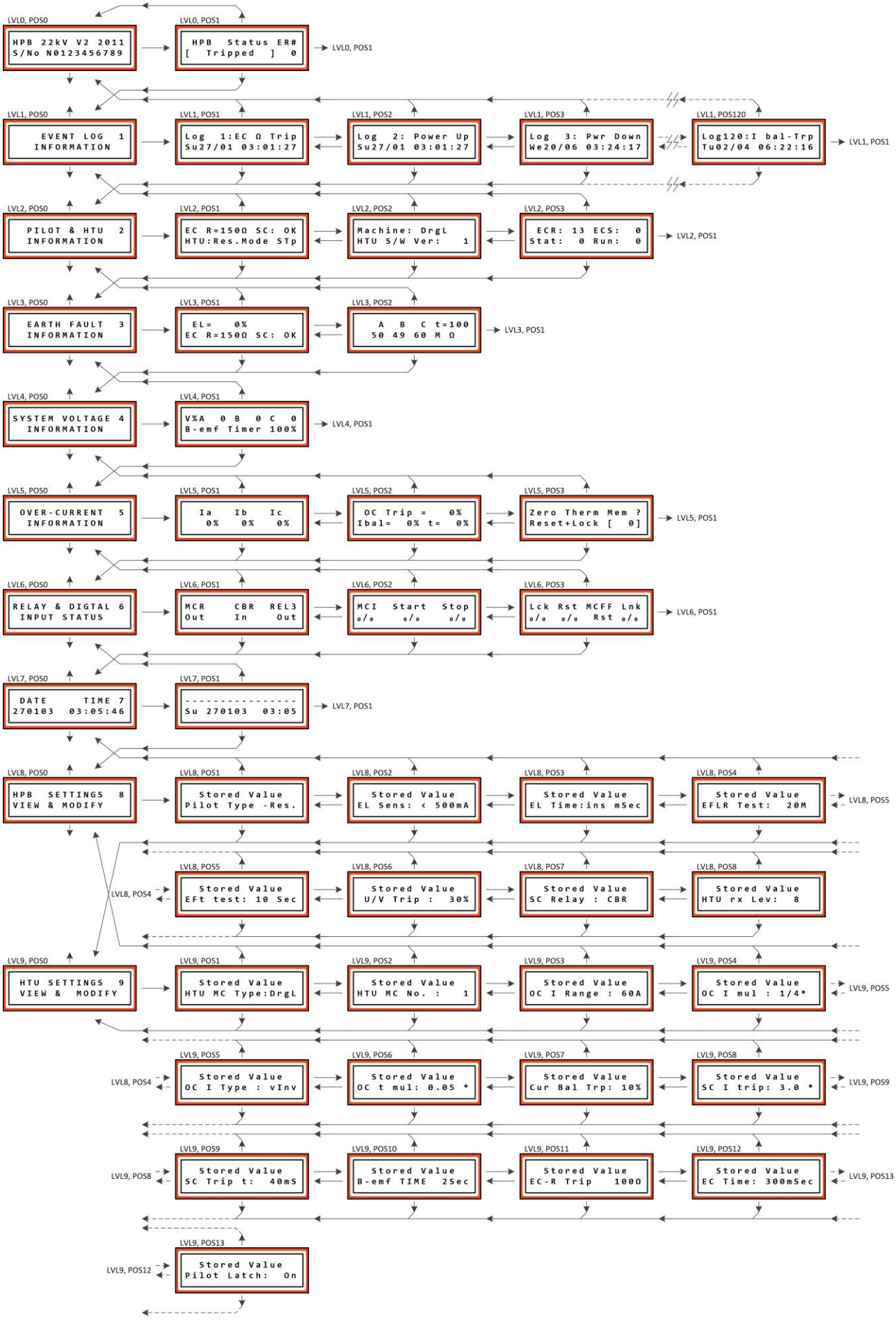


TYPICAL CONNECTION DIAGRAM - HPB 22kV
Drawing # HPBE013
Rev. 1

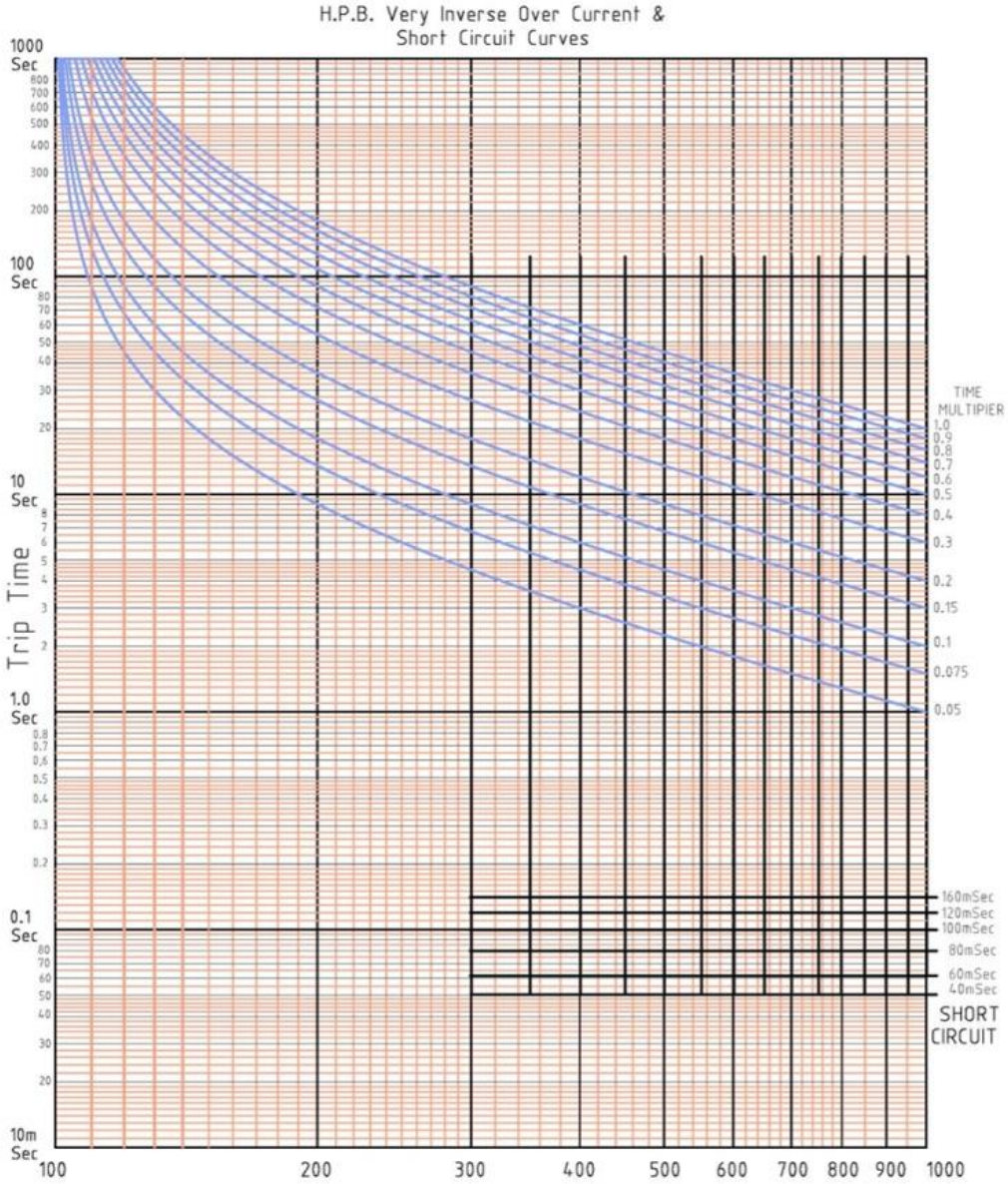


NOTES:
1. CHASSIS EARTH SHOULD BE WIRED TO THE MAIN EARTH POINT. SIGNAL EARTH SHOULD BE WIRED TO PIN 7 OF THE HPB (WHICH IS WIRED TO THE MAIN EARTH POINT).
2. THE CCMB-22kV INTERFACES TO THE 22kV (P-P) LINE VIA 3 x VTs. THE VTs ARE CONNECTED IN A PHASE-EARTH CONFIGURATION WITH THE STAR POINT CONNECTED TO EARTH VIA A NORMALLY CLOSED H.V. RELAY INSIDE THE CCMB-22kV. WHEN AN INSULATION TEST IS PERFORMED THE H.V. RELAY IS OPENED AND 5kV d.c. IS APPLIED TO THE PRIMARY STAR POINT.
3. WHEN INSTALLING, MEASURE THE RESISTANCE BETWEEN THE TRANSFORMER PRIMARY STAR POINT AND EARTH PRIOR TO APPLYING POWER. ENSURE THAT IT IS LESS THAN 10Ω.

TYPICAL CONNECTION DIAGRAM - CCMB 22kV
Drawing # HPBE012
Rev. 2



HPB DISPLAY MAP



STD HPB Range

HPB 22kV Range

Cur Range	Selected Full Load Current (SFLC) Cur Mul 1/8*	1/4*	1/2*	1.0*	2.0*	4.0*	8.0*
60A	7.5A	15A	30A	60A	120A	240A	480A
64A	8 A	16A	32A	64A	128A	256A	512A
68A	8.5A	17A	34A	68A	136A	272A	544A
72A	9 A	18A	36A	72A	144A	288A	576A
76A	9.5A	19A	38A	76A	152A	304A	608A
80A	10 A	20A	40A	80A	160A	320A	640A
84A	10.5A	21A	42A	84A	168A	336A	672A
88A	11 A	22A	44A	88A	176A	352A	704A
92A	11.5A	23A	46A	92A	184A	368A	736A
96A	12 A	24A	48A	96A	192A	384A	768A
100A	12.5A	25A	50A	100A	200A	400A	800A
104A	13 A	26A	52A	104A	208A	416A	832A
108A	13.5A	27A	54A	108A	216A	432A	864A
112A	14 A	28A	56A	112A	224A	448A	896A
116A	14.5A	29A	58A	116A	232A	464A	928A

Over Current Trip time :-

$$t(sec) = \frac{180 * m}{(I - 1)}$$

m = time Multiplier

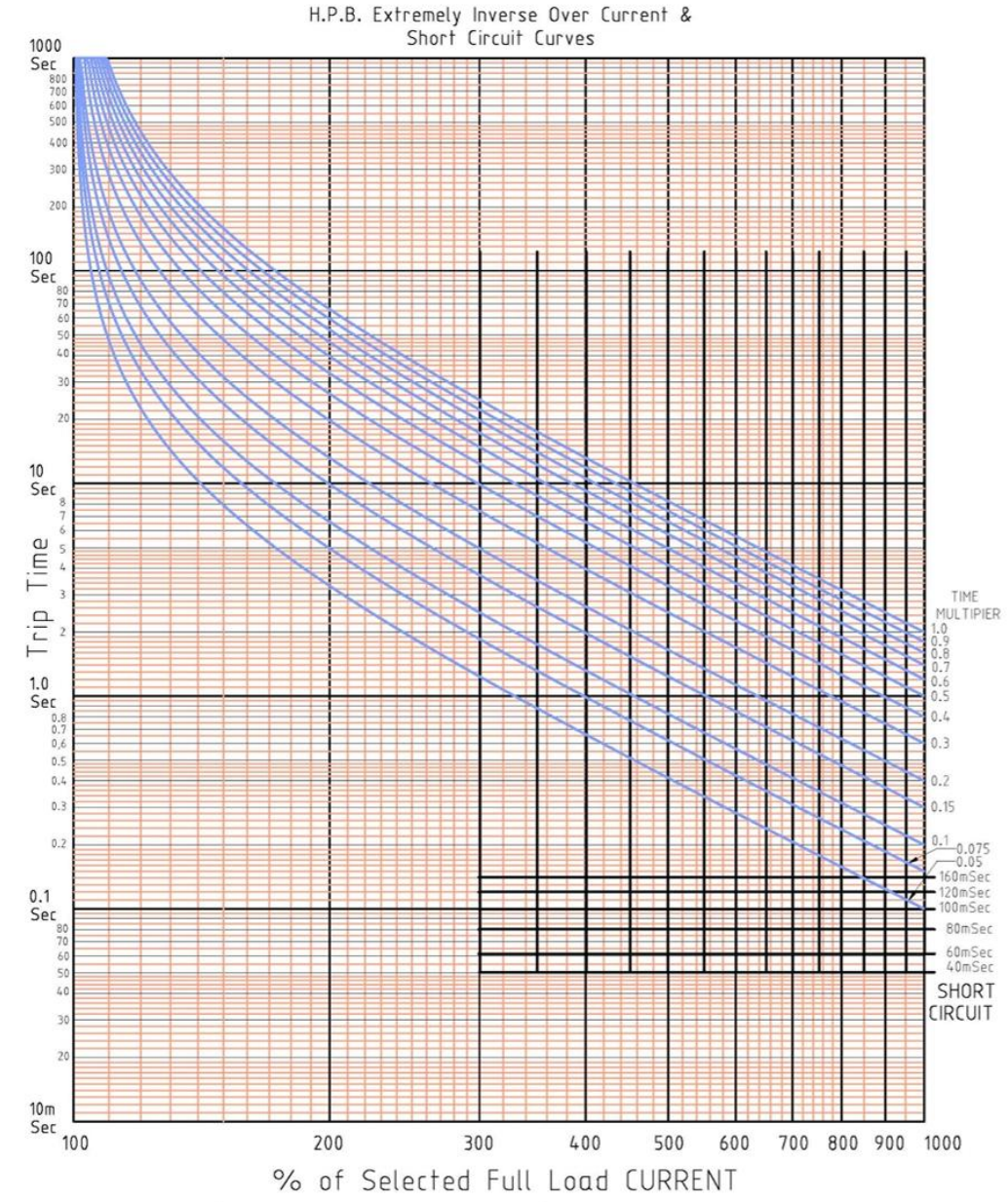
$$I = \frac{\text{Fault Current}}{\text{Selected Full Load Current}}$$

Short Circuit Selectable at -

3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5,
7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0
Times Selected Full Load Current

Times Selectable at 40, 60, 80, 100,
120 & 160 mSec.

HPB - OVER CURRENT & SHORT CIRCUIT VERY INVERSE CURVES
Drawing # HPBB003
Rev. 1



STD HPB Range

HPB 22kV Range

Cur Range	Selected Full Load Current (SFLC) Cur Mul 1/8*	1/4*	1/2*	1.0*	2.0*	4.0*	8.0*
60A	7.5A	15A	30A	60A	120A	240A	480A
64A	8 A	16A	32A	64A	128A	256A	512A
68A	8.5A	17A	34A	68A	136A	272A	544A
72A	9 A	18A	36A	72A	144A	288A	576A
76A	9.5A	19A	38A	76A	152A	304A	608A
80A	10 A	20A	40A	80A	160A	320A	640A
84A	10.5A	21A	42A	84A	168A	336A	672A
88A	11 A	22A	44A	88A	176A	352A	704A
92A	11.5A	23A	46A	92A	184A	368A	736A
96A	12 A	24A	48A	96A	192A	384A	768A
100A	12.5A	25A	50A	100A	200A	400A	800A
104A	13 A	26A	52A	104A	208A	416A	832A
108A	13.5A	27A	54A	108A	216A	432A	864A
112A	14 A	28A	56A	112A	224A	448A	896A
116A	14.5A	29A	58A	116A	232A	464A	928A

Over Current Trip time :-

$$t(sec) = \frac{198 * m}{(I^2 - 1)}$$

m = time Multiplier

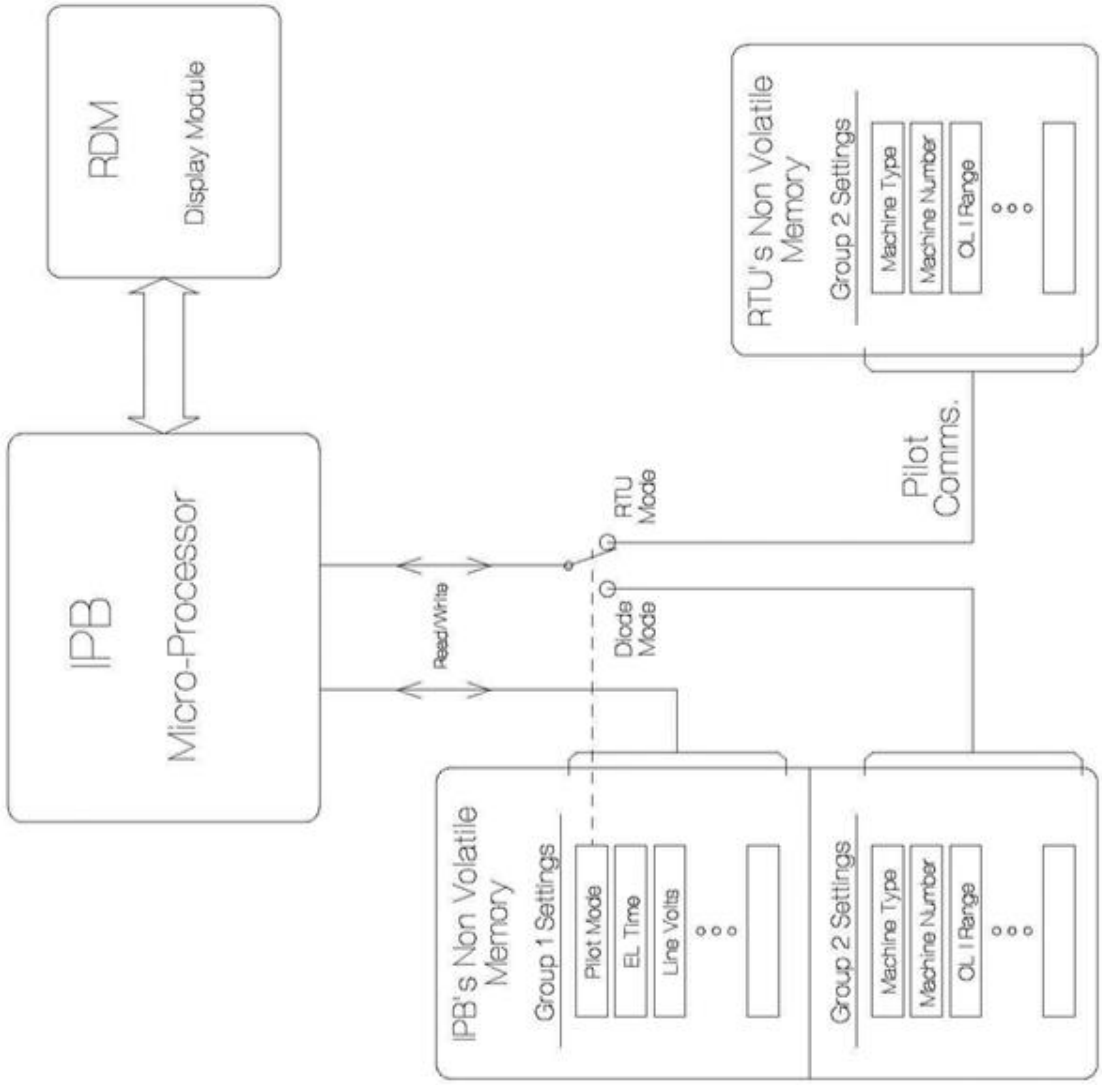
$$I = \frac{\text{Fault Current}}{\text{Selected Full Load Current}}$$

Short Circuit Selectable at -

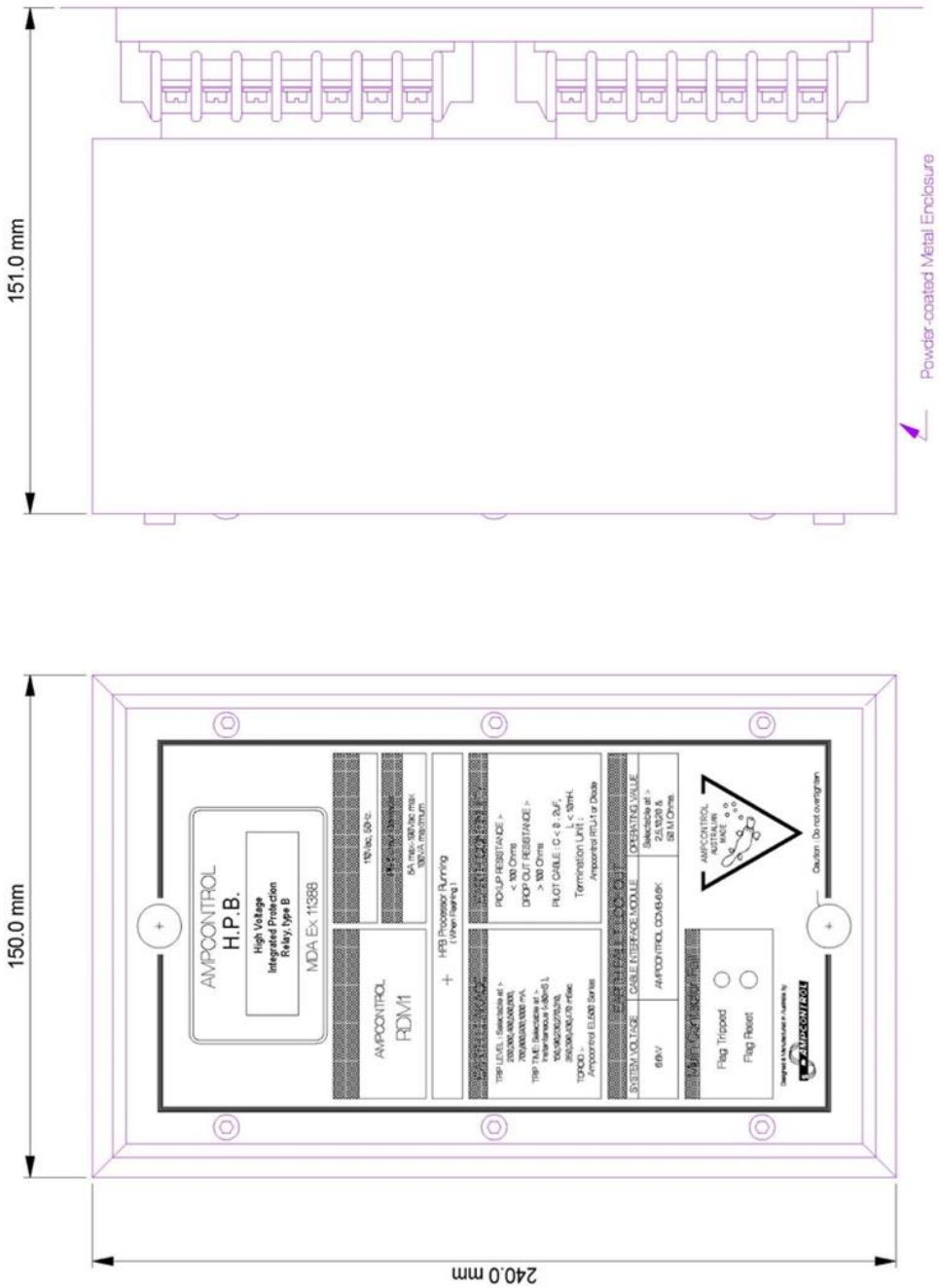
3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5,
7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0
Times Selected Full Load Current

Times Selectable at 40, 60, 80, 100,
120 & 160 mSec.

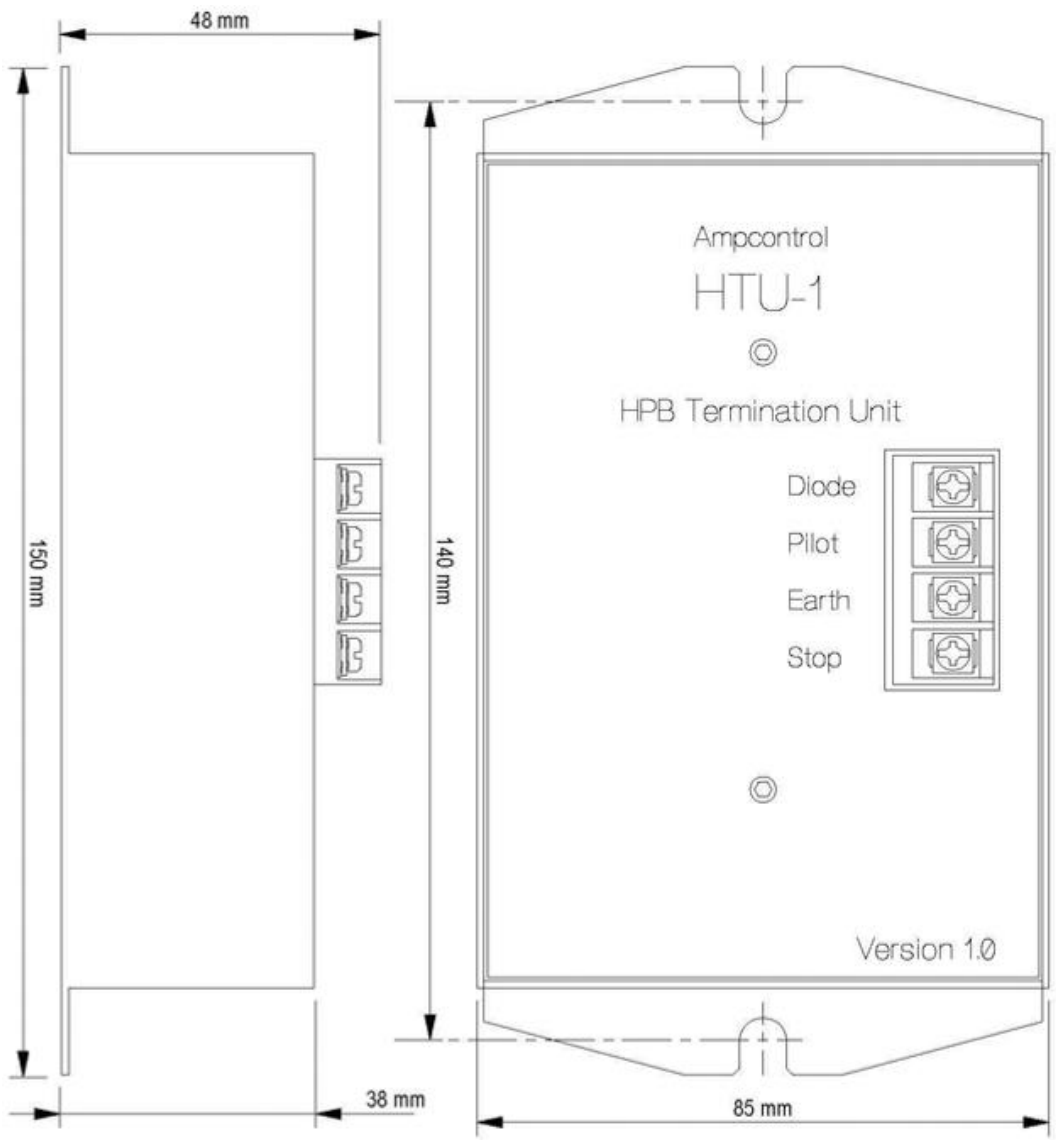
HPB - OVER CURRENT & SHORT CIRCUIT EXTREMELY INVERSE CURVES
Drawing # HPBB001
Rev. 1

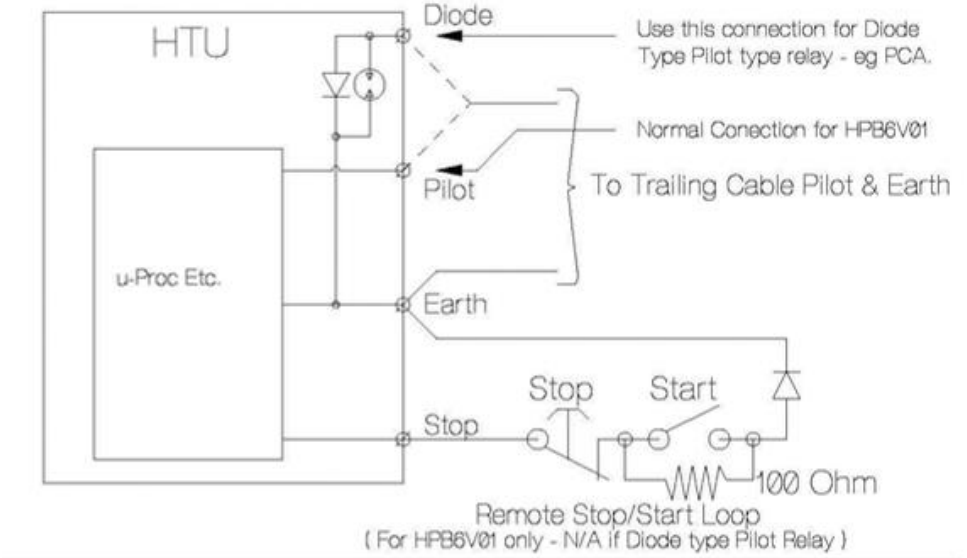


IPB - ADJUSTABLE SETTINGS STORAGE
Drawing # IPBB003
Rev. 0

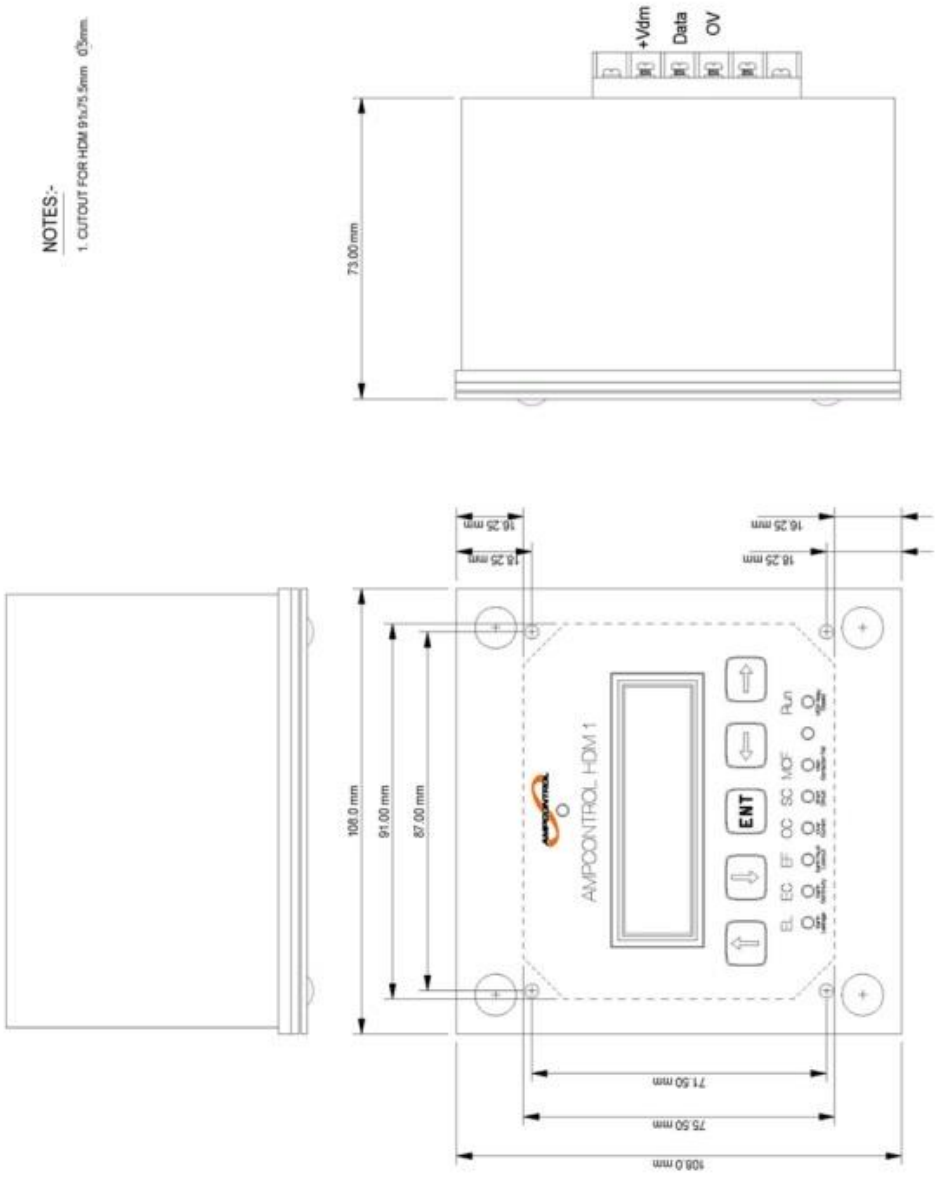


HPB ENCLOSURE DIMENSIONS
Drawing # HPBM005
Rev. 0

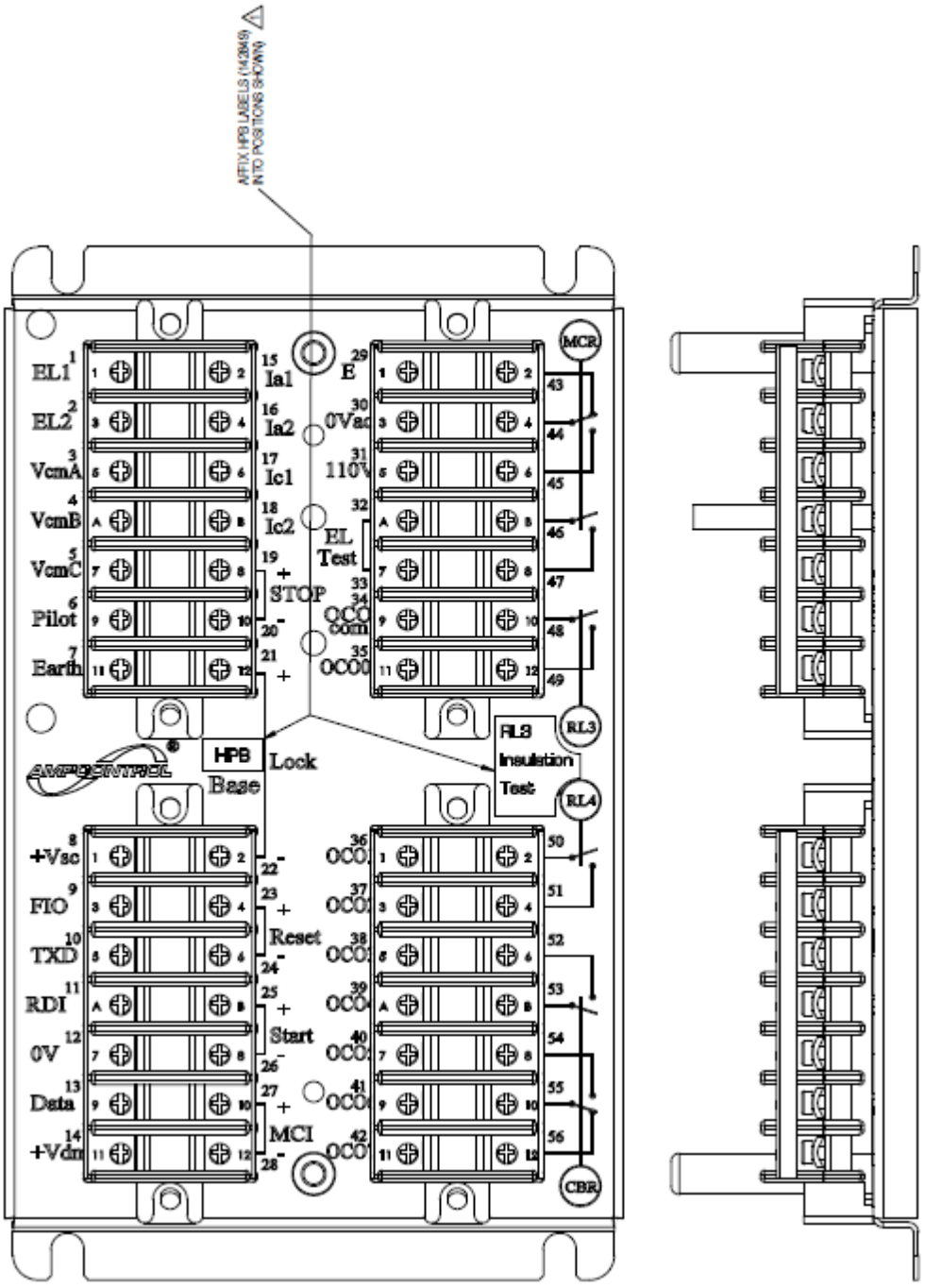




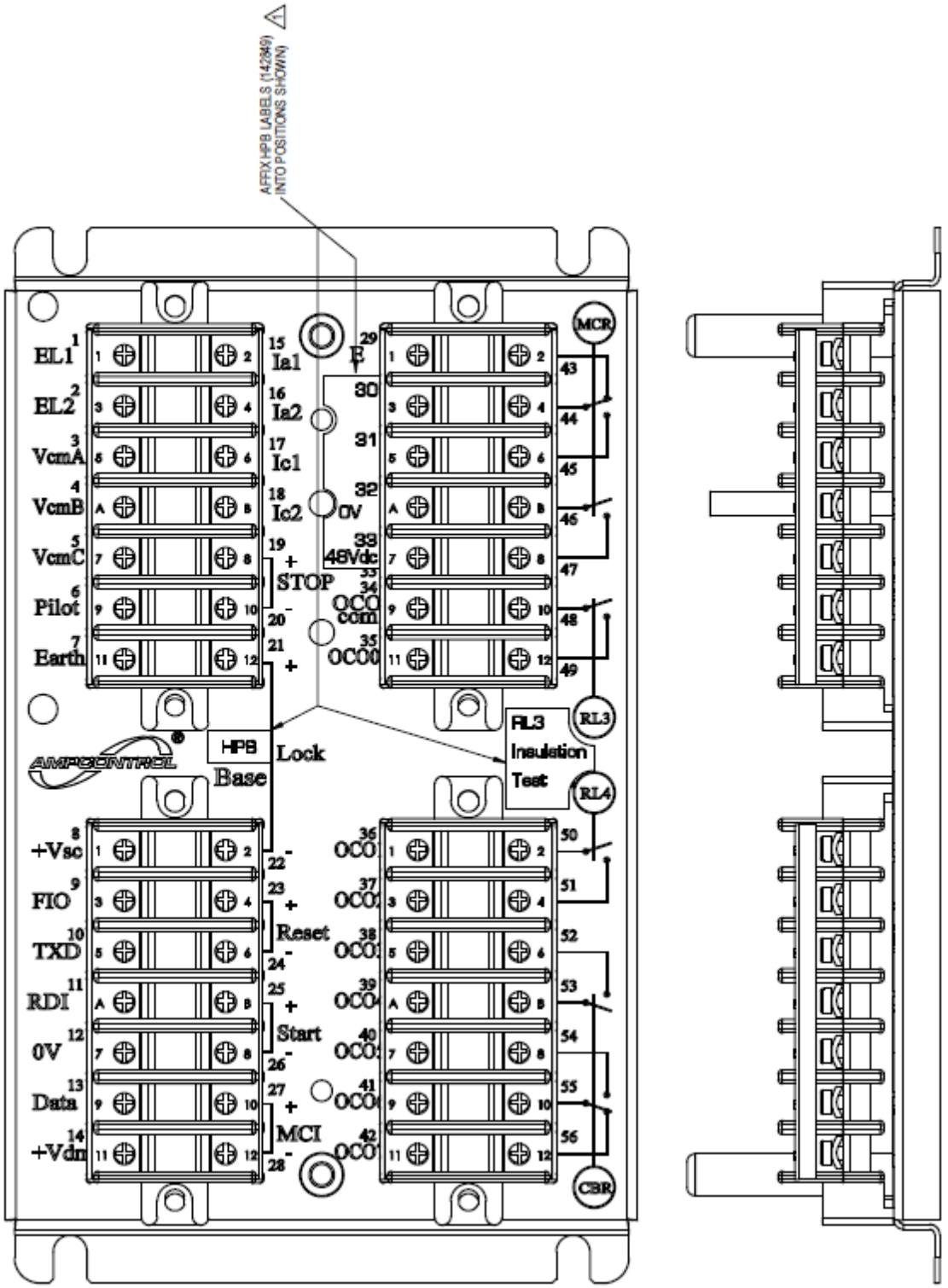
HPB HTU-1 GENERAL DETAILS
Drawing # HPBM013
Rev. 0



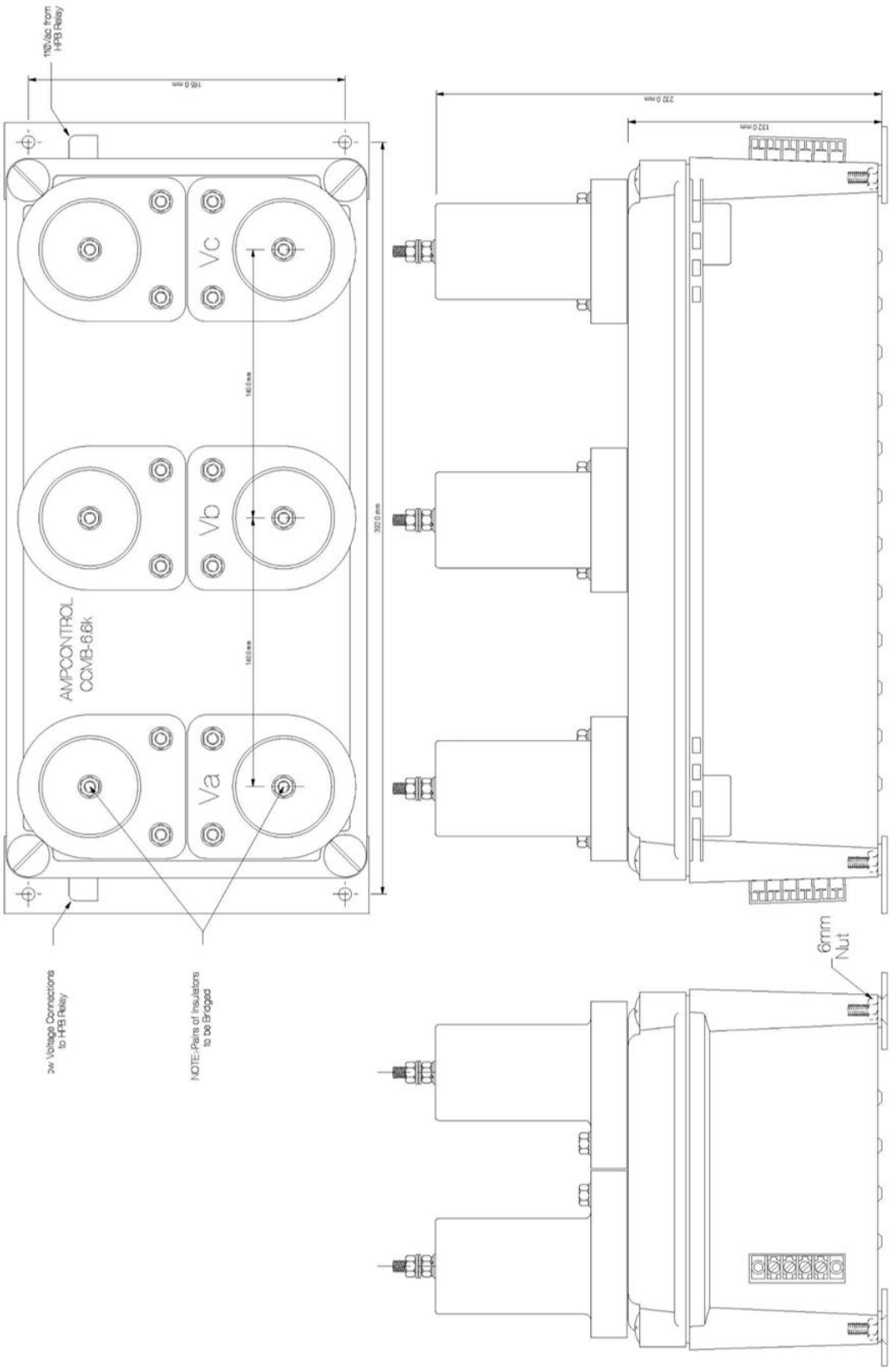
HDM-1 ENCLOSURE DETAILS
Drawing # HPBM015
Rev. 0



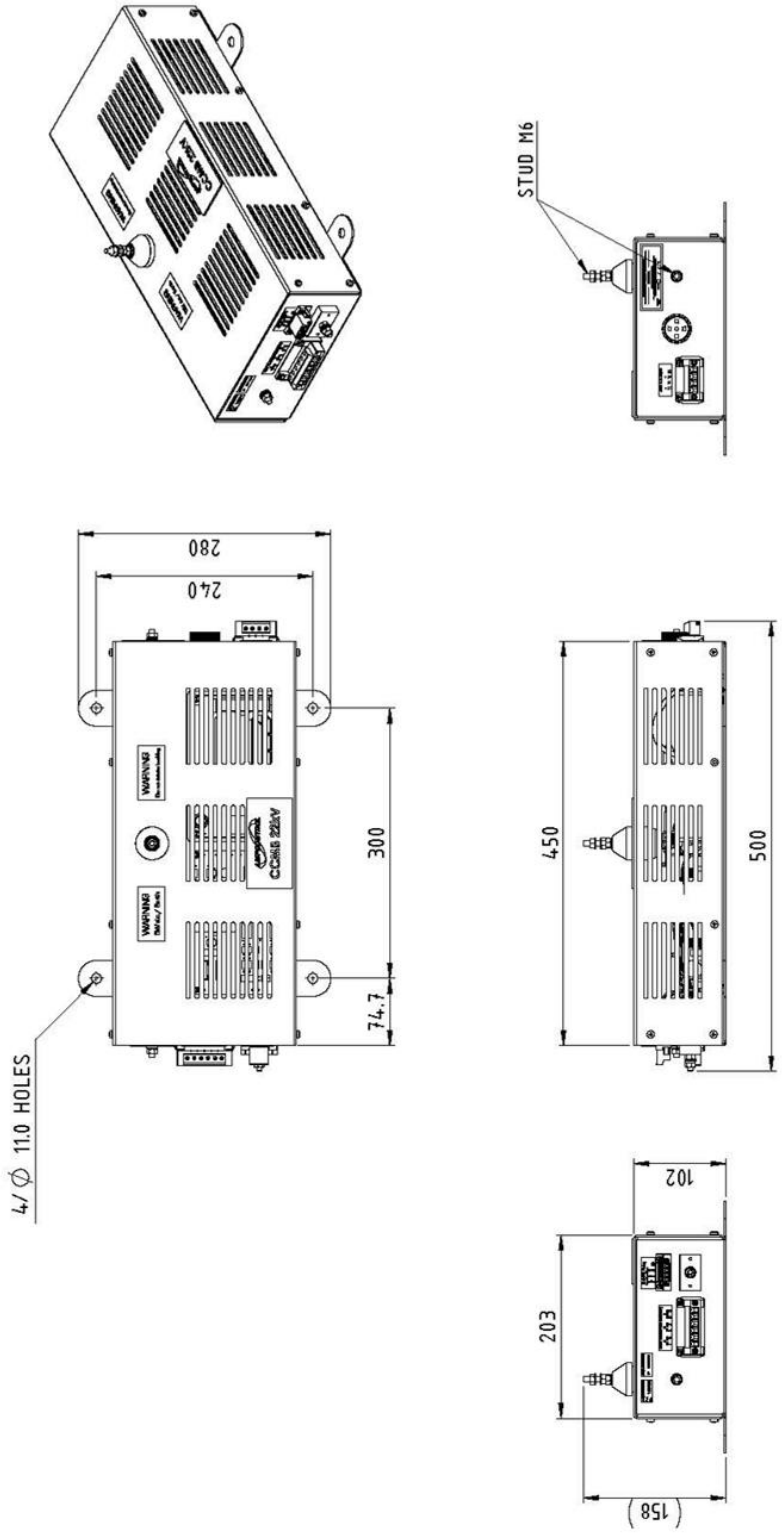
BASE HPB INTEGRATED PROT RELAY
Drawing # HPBM030
Rev. 0



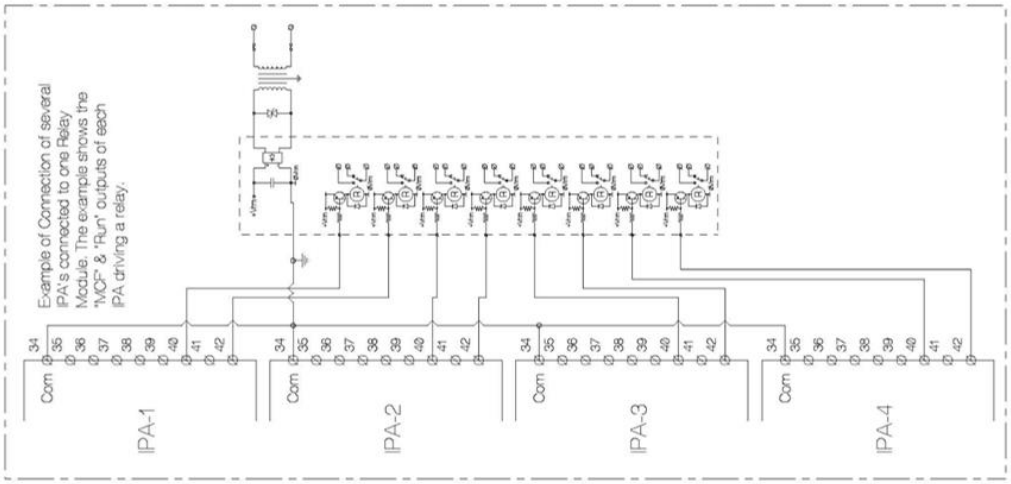
HPB 48V BASE CONNECTIONS
Drawing # HPBM029
Rev. 0

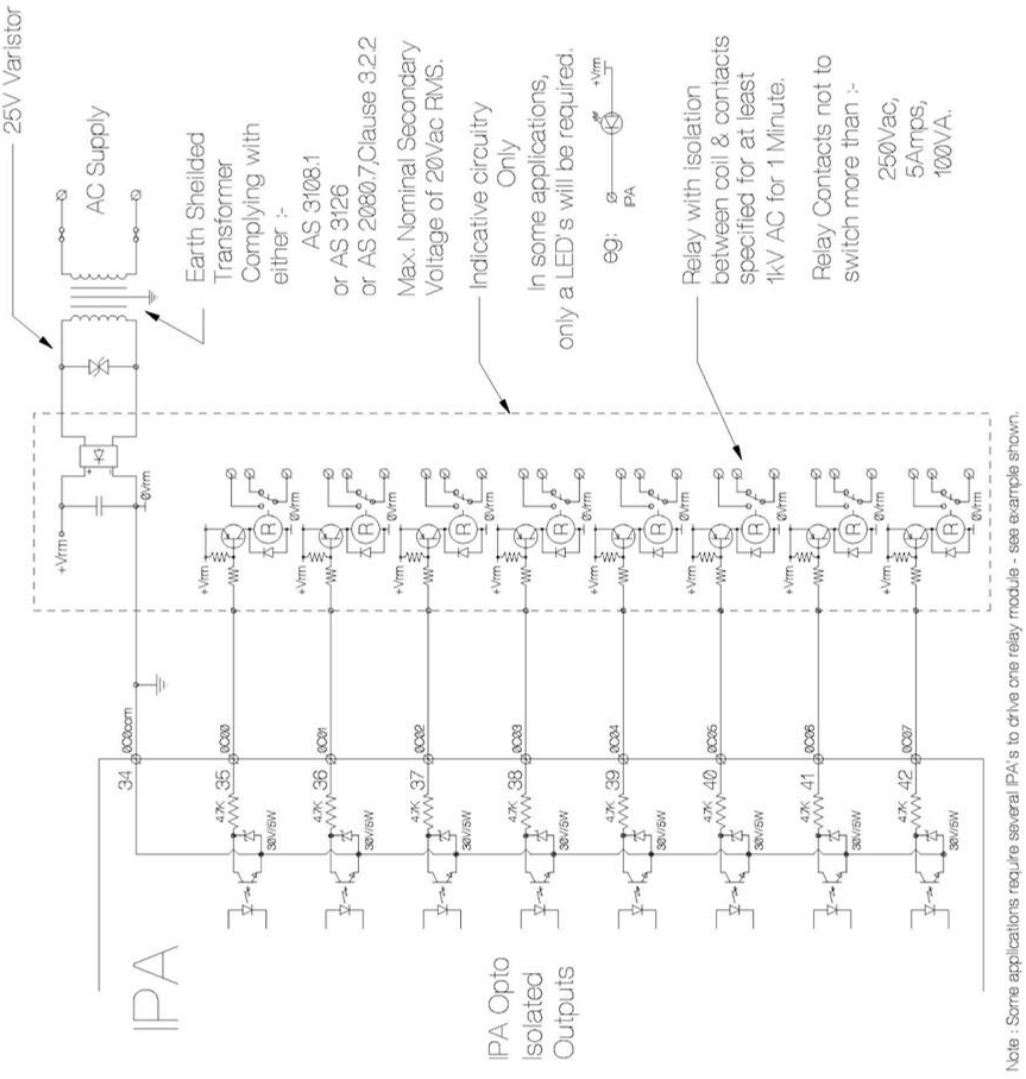


CCMB 6.6KV CABLE CONNECTION MODULE
Drawing # HPBM001
Rev. 0

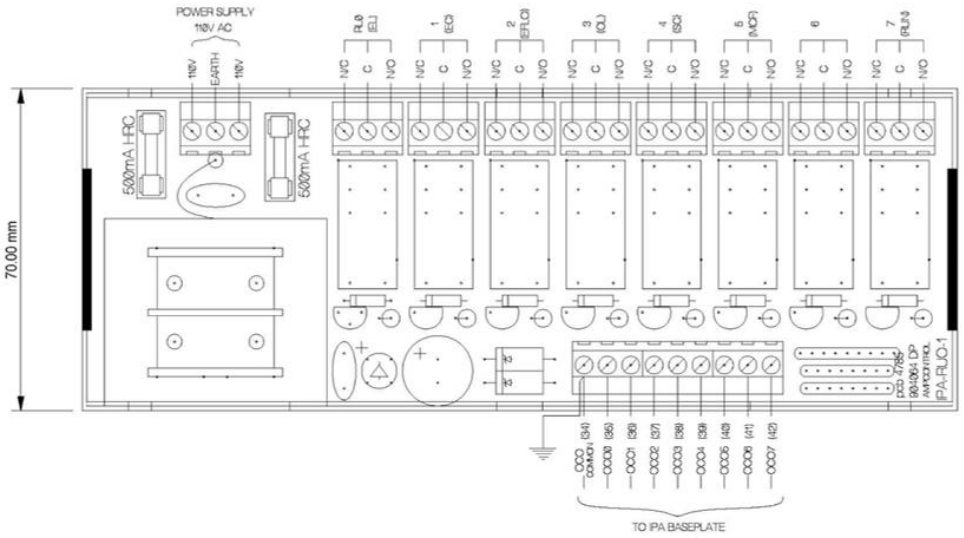


CCMB 22KV DIMENSIONS
Drawing # HPBA018
Rev. 0

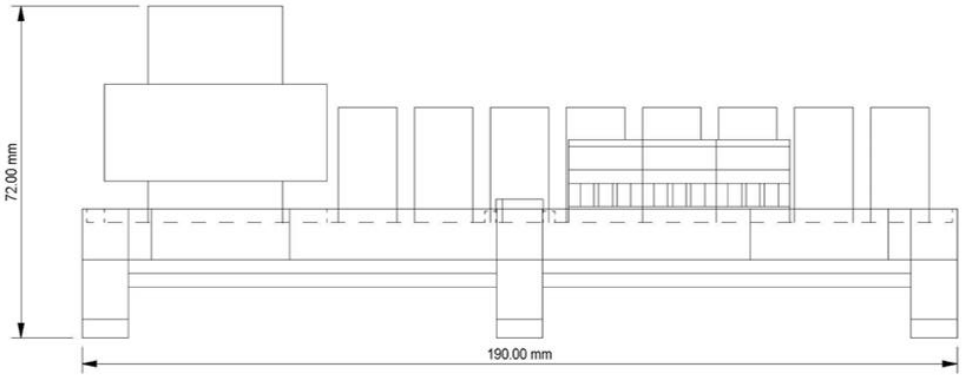




IPA RELAY LED OUTPUT MODULE DETAILS
Drawing # IPAS005
Rev. 0



TOP VIEW OF PCB & HOLDER

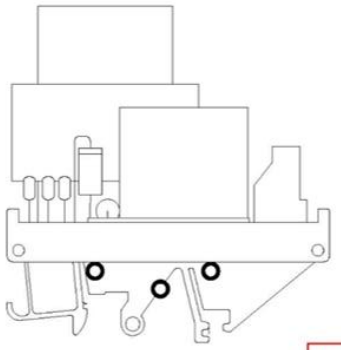


SIDE VIEW OF PCB & HOLDER

NOTES

1. MOUNT RELAY OUTPUT UNIT ON TS35 DIN RAIL.
2. TERMINAL No's 34 TO 42 ARE DIRECTLY WIRED TO BASES ON IPA BASEPLATE.
   EXAMPLE OF WIRING TO IPA - OCC0 (35).OCC0 INDICATES FUNCTION,35 INDICATES BASE PIN No.
3. RELAY CONTACTS MAX. 190V ac RMS
   190V DC
   3 AMPS

REFER TO MDA APPROVAL DRAWING
IPAS005/2 6/1/92

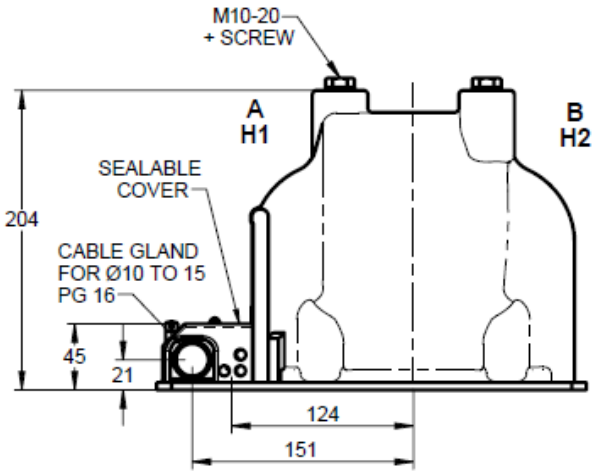


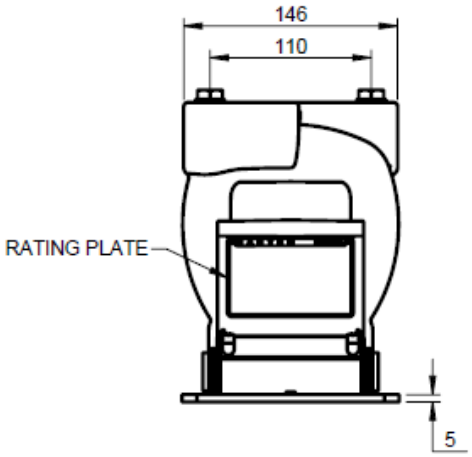
END VIEW

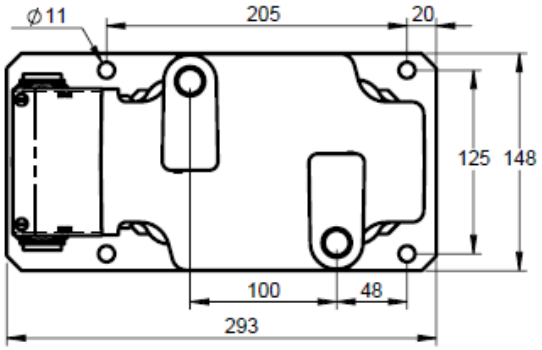
UNCONTROLLED IF PRINTED

RELAY OUTPUT MODULE PCB & CARD HOLDER GENERAL ARRANGEMENT
Drawing # IPAA031
Rev. 0

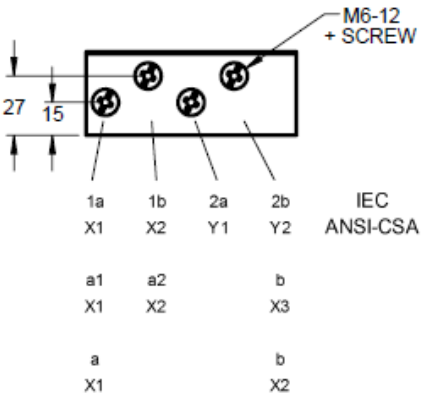
Ampcontrol Pty Ltd – ABN 28 000 915 542
HPB USER MANUAL
HPBB012 Version 9 – March/2020







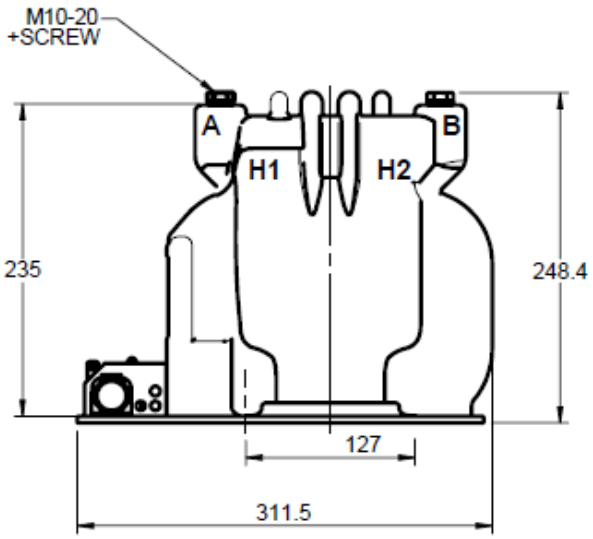
SECONDARY TERMINALS

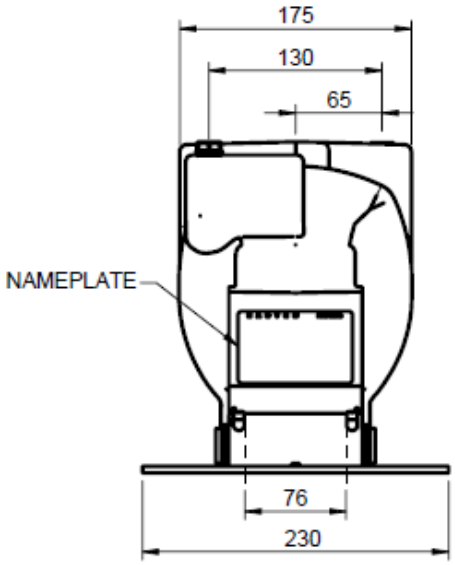


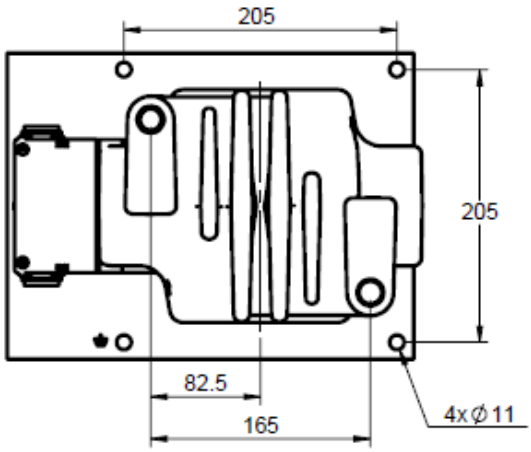
RATED TIGHTENING TORQUE (±5%)

Secondary terminals	(M6)	: 3 N.m
Primary terminals	(M10)	: 15N.m

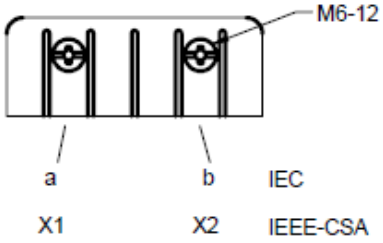
11KV VT MECHANICAL DRAWING AND MOUNTING DIMENSIONS







SECONDARY TERMINALS



RATED TIGHTENING TORQUE (±5%)

Primary terminals	(M10)	: 30 N.m
Secondary terminals	(M6)	: 7 N.m

22KV VT MECHANICAL DRAWING AND MOUNTING DIMENSIONS

APPENDIX B: APPROVALS

SYSTEMS APPROVALS PTY.LTD.

Postal Address
P.O.Box 45,
Boolaroo. NSW. 2284.

Business Address
14 Raymond St,
Speers Pt. NSW. 2284.

Phone: (049) 586811.
Fax: (049) 586827.
Mobile: (049) 018 685252.

A.C.N. 054191347.

The Manager,
Ampcontrol CSM. Pty.Ltd.
P.O. Box 304,
WARNERS BAY. N.S.W. 2282.

OUR REF Nº: SA654.

FILE REF Nº: **C92/0362.**

DATE: **16/02/1995.**

SUPPLEMENTARY APPROVAL

Dear Sir,

ITEM: **INTEGRATED PROTECTION RELAY.**

IDENTIFICATION: **HPB.**

ORIGINAL APPROVAL Nº: **Ex.11388.**

ORIGINAL APPROVAL HOLDER: **AMPCONTROL SWG.**

PREVIOUS APPROVAL Nº: **Ex.11388.**

SUPPLEMENTARY APPROVAL Nº: **Ex.11388.**

DESCRIPTION OF APPROVAL VARIATIONS

Modified for use on high voltage systems for open cut coal mines as follows:

a. Change input resistor on E/L toroid to give adjustable trips 200ma-1000ma.

b. Trip time adjustable 80-470ms.

c. Status and event log information added and provision for adjusting the trip settings at the remote display module.

d. Provision to use the machine recognition module for auto configuring of machine protection settings.

e. Change name labels to suit.

Modifications do not effect the actual operating software.

1/3

SUPPLEMENTARY APP Nº: **Ex.11388.**

FILE REF Nº: **C92/0362.**

DATE: **16/02/1995.**

ADDITIONAL APPROVED DRAWINGS

HPB-Z-001 Rev O Dated 14/02/1995.
HPB-Z-002 Rev O Dated 14/02/1995.

ADDITIONAL RECOMMENDATIONS FOR SUPPLY & USE

1. The manufacturer shall on his own responsibility carry out such tests and examinations as are necessary to ensure that the HPB module provides satisfactory operation in service.

2. No changes shall be made to the software which effect the operational performance of the relay as required by standards. Other software parameters may be changed as required by the manufacturer.

MARKING ON APPARATUS

The manufacturers name or mark and the approval number **MDA No. Ex.11388.** shall be inscribed in a durable manner in a prominent position on the apparatus.

Please find enclosed herewith the relevant approval documentation.

Yours Faithfully,

A.J.Weeks
Assessing Authority
No. MDA-A2507

2/3

New South Wales
Department of Mineral Resources
Accredited Assessing Authority MDA-A2507

COAL MINES REGULATION ACT, 1982
NOTICE OF SUPPLEMENTARY APPROVAL

SUPPLEMENTARY APPROVAL Nº: MDA. Ex.11388.

FILE Nº: C92/0362.

DATE: 16/02/1995.

It is hereby notified that the Approved Item listed herein has been assessed for compliance with the Coal Mines Regulation Act and appropriate standards or requirements, and is hereby APPROVED in accordance with the requirements of the COAL MINES REGULATION ACT 1982. This approval is issued pursuant to the provisions of Clause 6 & 7A of the Coal Mines Regulation (Approval of Items) Regulation, 1984.

This APPROVAL is issued to: **AMPCONTROL CSM. PTY.LTD.**

Address of Approval Holder: **P.O. BOX 304, WARNERS BAY. N.S.W. 2282.**

Description of Item(s): **INTEGRATED PROTECTION RELAY.**

Item Identification: **HPB.**

C.M.R.A. Approval Clause: **27(b). EXPLOSION PROTECTED.**

Specific Approval Category: **PROTECTION. Ex.**

This Approval is issued subject to compliance with the requirements of the Occupational Health and Safety Act 1983, with particular reference to Sections 15 to 17 of the said Act as it applies to USERS of Approved Items, and to Section 18 of the said Act as it applies to the MANUFACTURERS and/or SUPPLIERS of Approved Items.

The Authority issuing this Approval may, for the purposes of the Occupational Health and Safety Act 1983, append a list of recommendations (including drawings,documents etc.) that are applicable to this approved item as identified during test and/or assessment, to assist the Approval Holder and User to comply with the obligations of the Occupational Health and Safety Act 1983. The onus is on the Supplier and/or User to ensure the Approved Item, and any deviation from the list of recommendations in reference to that item is not inferior in any way to the item tested and/or assessed, this includes the supply, installation and continuing use of the approved item.

The Approval Number shall appear in a conspicuous place and in a legible manner on each approved item, unless specifically excluded.

A copy of this Approval Document together with a copy of the recommendations from the Authority issuing the Approval shall be supplied to each user of the approved item

Any Maintenance, Repair or Overhaul of Approved Items shall be carried out in accordance with the requirements of the Coal Mines Regulation Act 1982.

A.J.Weeks
Assessing Authority
No. MDA-A2507
FOR THE CHIEF INSPECTOR OF COAL MINES

3/3

Minerals & Energy House. PO Box 536, St Leonards, NSW 2065, Australia
Telephone:(02)901 8888 Facsimile:(02)901 8777