VSDguard™

WIDE BANDWIDTH EARTH LEAKAGE RELAY

Issue: R5 July 2023

USER MANUAL

Designed and Manufactured in Australia by Ampcontrol Pty Ltd

Safety and other warnings

WARNING! 	This safety alert symbol identifies important safety messages in this manual and indicates a potential risk of injury or even death to personnel. Be alert as your safety is involved. Carefully read the message that follows and inform others.

CAUTION! 	This safety alert symbol identifies important information to be read in order to ensure the correct sequence of work and to avoid damage or even destruction of the equipment and reduce any potential risk of injury or death to personnel.

NOTE 	Supplementary information not directly affecting safety or damage to equipment. Carefully read the message that follows and inform other relevant personnel.

ENVIRONMENT 	Information concerning possible impact on the environment and actions required for prevention and proper response.

Copyright notice

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Before you begin

Ampcontrol would like to take a moment to thank you for using the VSDguard wideband earth leakage relay.

To become familiar with this product and to ensure correct operation, it is recommended that you take the time to read this user manual thoroughly.

WARNING! 	To ensure the correct and safe operation of this equipment, the user should become completely familiar with the safety requirements and correct operating procedures detailed in this user manual.

Please check the Ampcontrol website for the latest revision of this User Manual.

TABLE OF CONTENTS

1. RECEIVING AND STORAGE

1.1 Receiving

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

Notify Ampcontrol within 7 days (maximum) in case of shortages or discrepancies, according to the packing list. This action will help ensure a speedy resolution to any perceived problems. Keep a record of all claims and correspondence. Photographs are recommended.

Where practicable, do not remove protective covers prior to installation. 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, especially if the wrappings are to be discarded.

Equipment that is found to be damaged or 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.

1.2 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, preferably on shelves (where practicable), and protected from the elements.

When applicable correct handling procedures must be in place to ensure that any items are moved safely.

1.3 Unpacking of equipment

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

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

ENVIRONMENT 	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.

2. GENERAL SAFETY

2.1 Personnel safety warnings

2.1.1 Relevant personnel

Ensure all personnel directly responsible or involved with the installation, operation and maintenance of the equipment reference this manual in conjunction with any relevant risk assessments to identify all hazards.

2.1.2 Safety communication

All safety instructions and design requirements within this manual must be communicated to all users. These requirements are necessary to identify and control any foreseeable risk associated with this piece of equipment. In the event of any damage or malfunction that results in the potential to harm the health or safety of any person; the owner/operator should notify the manufacturer immediately.

2.2 Safe use of equipment

The equipment supplied has been manufactured according to the state of the art and designed to ensure safe operation. The equipment may only be used within the design parameters.

The instructions within this manual must be observed as part of achieving maximum safety during operation.

The owner/user is responsible for observing the following instructions:

2.2.1 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 conditions of compliance, the integrity of the system into which it is installed and other connected equipment.

2.2.2 Equipment knowledge

Experience with, or understanding of, this equipment is essential for the safe installation, operation and removal of the equipment. If in doubt, contact Ampcontrol immediately.

2.2.3 Manual handling

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

2.2.4 Installation

Correct operation and safety depend on the 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.

2.2.5 Operation

As safety depends on the equipment functioning correctly, it is highly recommended that all safety functions of VSDguard are routinely tested to ensure correct operation.

3. MINING EARTH LEAKAGE PROTECTION WITH VARIABLE SPEED DRIVES

The mining working environment presents a range of unique challenges for electrical distribution systems due to the equipment used and associated hazards. As such various protection schemes have evolved to prevent damage to equipment and injury to personnel. In particular, these include:

a) Earth fault current limitation, usually consisting of a resistor connected between the supply transformer star point and earth, commonly referred to as a Neutral Earthing Resistor (NER).
b) Earth continuity monitoring devices.
c) Earth leakage protection devices.
d) Earth fault lockout protection.

As described in Appendix C of AS/NZS 4871.1:2012, the protection scheme is

> *intended to ensure that when persons are exposed to touch potentials, the level of voltage and time exposed before protection systems trip is limited to an acceptable level.*

The acceptable levels are given in Figure C1 of the standard for 50 Hz touch voltages.

CAUTION! 	Relays designed to operate on earth fault limited systems are not suitable for direct personal protection.

These protection systems were originally devised to protect against touch potential hazards caused by earth fault currents driven by the power supply (50 Hz). Consider, for example, that an earth fault occurs in a mobile machine powered by a trailing cable. The earth fault current will flow through the fault to the machine frame and return to the supply transformer star point via the trailing cable earth conductors. The voltage drop caused will result in a potential rise above earth on the frame, presenting a touch potential hazard. As described in AS/NZS 4871.1:2012 the system assessment must determine the earth fault limitation current that will protect people based on the achievable earth leakage clearance times and knowledge of the system in which it is installed.

3.1 Variable speed drives

Variable speed drives (VSDs) are now finding wide use in mining applications. Most of these drives use variable frequency outputs that are produced by rectifying the supply to dc and then inverting this voltage back into ac using a high frequency carrier and pulse width modulation (PWM) to produce variable frequency currents in the motor. They complicate the situation in several ways:

1) VSDs introduce a new and complex voltage source into the power system. This may mean that earth faults can now be direct current (dc) in nature or may be driven by the inverter of the drive and so have a frequency that is primarily that of the drive PWM carrier frequency (1000 Hz for example).

2) To minimise interference with protection and control systems, many drives employ electromagnetic compatibility (EMC or EMI) filters that consist primarily of a capacitive circuit between the input of the drive and earth. This provides a path for the earth currents that represents an alternative path to the NER, as shown in Figure 1 below. In fact, it is the intention of the filter to provide this alternative path for the high frequency currents that flow (through the motor and cable stray capacitances) to earth under normal conditions. They will also provide an alternative path under fault conditions, particularly if the fault is driven by the high switching frequency drive output.

   It has also been shown that when one or more drives and filters are in use, and an earth fault occurs, there can be circulating currents between the drives and filters and/or the fault location. The fault current magnitudes may then greatly exceed the nominal current limitation value (typically 5A) determined by the NER. These large currents may cause touch potentials that greatly exceed the expected values.

3) Most earth leakage protection relays approved for use in mining applications are designed to detect 50 Hz currents, not dc or high frequency currents so that the relays may not trip, or if they do trip, they may take longer than expected.

The overall result is that with standard earth leakage protection relays and electrical system assessments based only on consideration of faults driven by the supply system (50 Hz), protection performance is unlikely to be adequate when variable speed drives are used in mining applications.

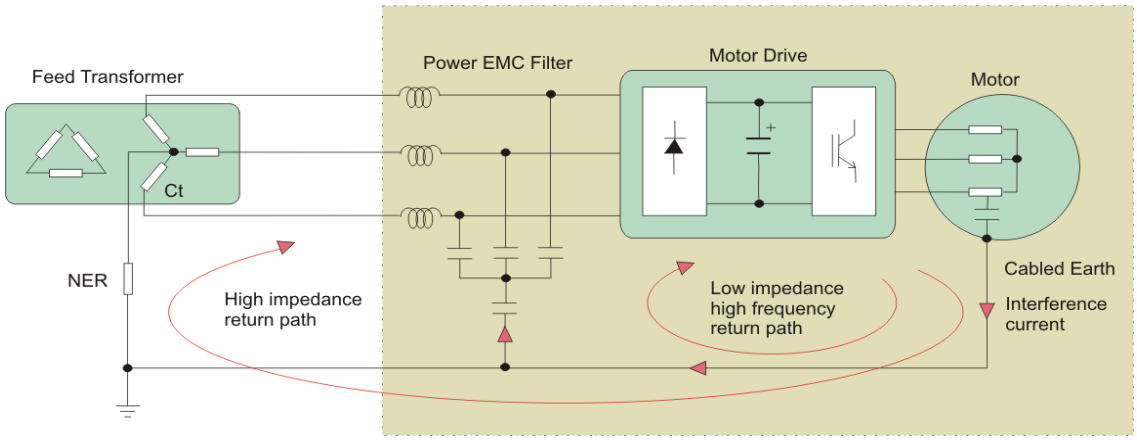


Figure 1 – Alternative earth current paths

3.2 Improving protection

The design of earth leakage relays used in mining applications in Australia and New Zealand must comply with AS/NZS 2081. The latest version of this standard (AS/NZS 2081:2011) better recognises that system protection needs to be assessed in accordance with AS/NZ 4871.1:2010 and with the changes in the mining electrical environment.

The following extracts from AS/NZS 2081:2011 provide some key statements of interest:

> ***1.1 Scope:***
>
> *Whereas this standard is based upon 50 Hz supply systems, it is envisaged that the equipment described may also be installed in systems with higher, lower or variable frequencies, or in dc supplied systems.*
>
> *AS/NZS 60479, Part 1 and 2 should be referenced for consideration of the effects of current at other supply frequencies upon the human body.*
>
> ***Appendix B:***
>
> *The diversity of operating conditions and equipment addressed by this Standard precludes reliance solely on explicitly prescribed trip levels or fault current levels, and their duration, in order to ensure a safe working environment. Rather, the onus is placed on the system designer to ensure appropriate touch voltage/ operating times when integrating the protection devices addressed by this Standard.*
>
> *B2 Voltage/duration Thresholds*
>
> *Design criteria for the protection devices have been chosen to enable compliance to the touch voltage/operating times for systems operating at 50 Hz as described by Figure B1.*
>
> *B3 Systems at other than 50 Hz Cyclic Frequency*
>
> *Where equipment is installed and operated within systems at other than a constant 50 Hz cyclic frequency, the characteristics in paragraph B2 are not immediately applicable. In such instances, individual calculation to determine requirements at the frequency or frequencies in question will be required.*
>
> *Standards AS/NZS 60479.1 and AS/NZS 60479.2 should be reference in relation to the effects upon the human body of other supply frequencies.*

What this means is that when VSDs (or other non 50 Hz sources) are used in a mining electrical system then the standard approach needs to be interpreted to ensure that protection is adequate. The key factors to consider are as follows:

1) The sensitivity of the human body to electric shock varies with frequency. In general, for a given exposure time, the allowable touch voltage magnitude increases with frequency. For example, at 10 kHz, the “let go” voltage is about 5 times the level at 50 Hz.

2) When EMC filters are used, this forms a path for earth currents alternative to the NER. When considering touch potentials at a mobile machine for example, strictly speaking the impedance of the filter at the frequency of interest should be examined in order to determine the earth fault current that will flow when a fault occurs in the machine. The earth leakage trip time must then be used to ensure that the touch voltage and exposure time guarantee a safe system. Care must be taken when multiple filters are connected to a single supply, as this presents many modes of possible earth fault that need to be considered and actual earth fault currents may exceed the current seen by any single filter.

3) An earth leakage relay must be able to accurately sense earth fault currents of any frequency from dc to the maximum frequency of interest.

It can be seen that this is not a trivial matter and it is likely that the industry will need to adapt to this new and complex environment.

4. AMPCONTROL VSDguard EARTH LEAKAGE RELAY

Ampcontrol VSDguard is a high performance, microprocessor based, wide bandwidth earth leakage relay that is capable of measuring and analysing power and switching frequency currents flowing in IT power systems.

The VSDguard uses patented technology (US20130258537) to characterise earth leakage currents giving superior fault discrimination

The VSDguard relay is designed for use with variable speed drives in mining environments. Some of the features of the relay are:

- Complies with AS/NZS 2081:2011, Section 6
- Patented earth leakage analysis method: International patent application number PCT/AU2011/000705
- Fail safe operation
- Detects earth leakage currents from 20 Hz to 8 kHz
- Wideband, narrowband and weighted frequency modes
- Adjustable trip level and trip times
- High resolution 3.2” colour LCD
- Last 20 data and event logs can be displayed on the local display
- On board memory logs last 1000 data logs and 50 events
- Ethernet communications allow real time and post event viewing of the system from an internet browser
- Continuous toroid connection monitoring.

VSDguard provides data logging to assist in fault finding. On each event trigger, the relay stores system data 2 seconds before and 2 seconds after the event including system time, earth leakage current, phase current and zero crossing of the phase current.

The VSDguard user interface has four live status screens;

1. Bar graph and numeric display of real time RMS current with colour coded trip state
2. RMS current history,
3. Plot of the real-time current seen by the earth leakage toroid (oscilloscope view), and
4. Frequency spectrum of the real time current.

The user interface can also view data on the most recent 20 data and event logs.

VSDguard includes LEDs which can be used to indicate a fault. These include a Power On LED, Trip LED, and Processor Healthy LED.

Ethernet connection to the VSDguard relay provides the ability to monitor the device parameters and real time measured current from an internet browser. All data logs stored on the unit can also be viewed.

5. INSTALLATION

5.1 General warnings

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

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

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

It is extremely important that the functionality of the equipment is fully understood to prevent incorrect installation and use which could potentially create a dangerous situation. If in doubt as to the nature of the limitations or their implications consult a competent authority such as a supervisor or Ampcontrol technical representative.

Ensure that the application into which VSDguard 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.

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

It is important to understand how VSDguard is intended to interact with other equipment within a system. For safe and reliable use, it is critical that VSDguard's operation is not compromised by incompatibility with connected equipment.

Modifications of any form to VSDguard are prohibited.

VSDguard has been designed and manufactured in compliance with the requirements of AS/NZS 2081:2011. If modifications of any form are made to the relay, the conditions of compliance will no longer be valid and the equipment will no longer be fit for use. If any modifications or damage to the relay is evident, do not use the equipment and contact Ampcontrol for advice.

5.2 Mandatory installation practice

The following information must be adhered to when installing the VSDguard relay. Failure to adhere to this information may give rise to unsafe operation and could render the product invalid against its certificate.

Using VSDguard 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 VSDguard relay must be powered with the specified voltage.
- The installation of VSDguard must be carried out by suitably trained and qualified personnel.
- Certification and identification labels fixed to the VSDguard relay must not be damaged, removed or covered before, during or after installation.
- Modifications must not be made to any part of VSDguard. As supplied, the unit is built to, and complies with standards against which it has been certified.
- Complete and accurate records of the installation must be kept as part of the site installation.

5.3 Mechanical arrangement

5.3.1 Enclosure

VSDguard is housed in a metal enclosure rated at IP20. The dimensions of the VSDguard relay are shown in Figure 2. The front panel is 155mm wide by 155mm high. The unit is 107mm deep from the front panel to the rear of the enclosure. VSDguard is designed to be panel mounted through a 135mm x 135mm cut-out. When panel mounted, VSDguard is rated at IP55.

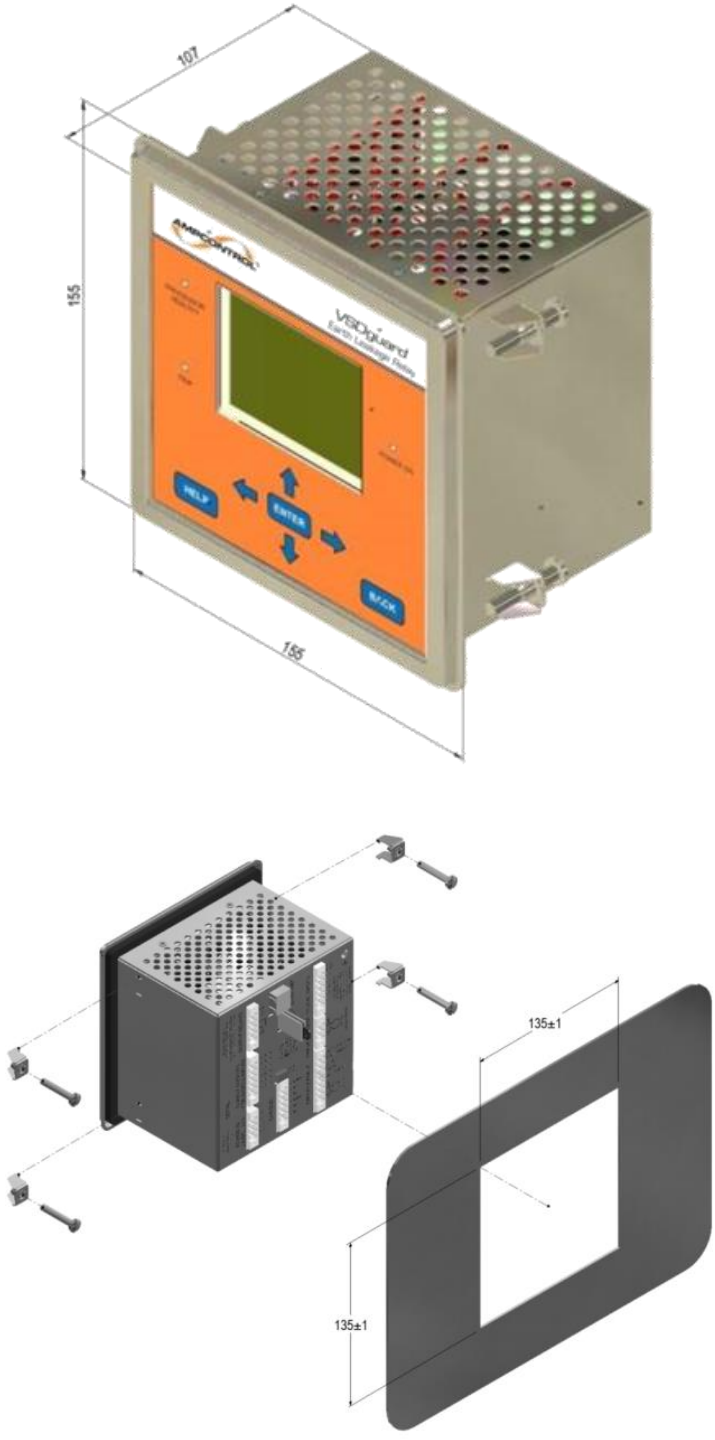


Figure 2 - VSDguard dimensions

5.4 Electrical connections

Figure 3 shows the typical connections to the VSDguard relay which are made at the rear of the unit.

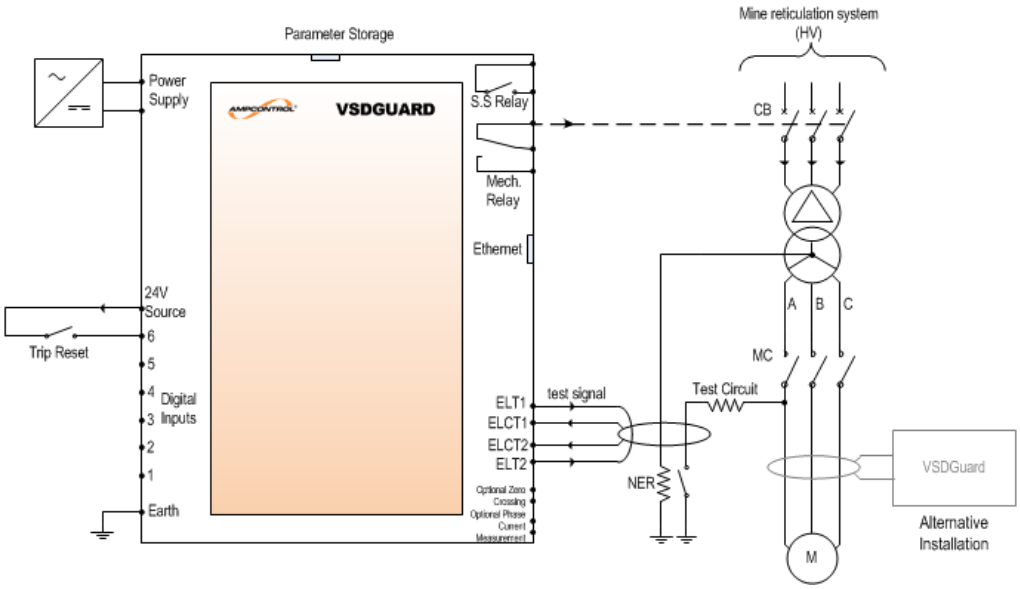


Figure 3 - VSDguard connections

WARNING! 	Ensure all connections to the relay are correct prior to putting into service. Incorrect wiring may cause damage to the relay and the systems into which it is installed.

It should be noted that all VSDguard relays will have transient suppression filters (RC combination, 22Ω + 100nF) installed across the trip outputs, see Figure 4. The transient suppression filters can allow up to 4.5mA of current when utilised with 110VAC. This current is sufficient for some OEM interposing relays with low VA ratings to hold in, see Industry Notice IN00016, and as such needs to be taken into consideration during system design. If the relay has been modified to have the filters removed, a HW label will be applied next to the trip contacts to identify the modification has been implemented and hardware removed.

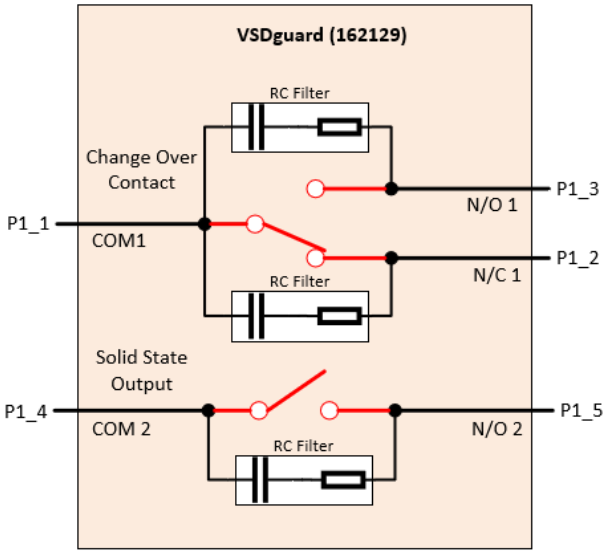


Figure 4: Trip Contact Internal Transient Suppression Filters

All relays with serial number 2308000000 or higher will not contain the internal transient suppression filters. This allows customers the freedom to select and utilise an external snubber filter network appropriate for their application.

5.5 VSDguard current transformers

The VSDguard relay has been designed for compliance to AS/NZS 2081:2011 for use on earth fault limited systems.

There are generally two locations where VSDguard may be installed:

Core balance protection performs the primary protection in an installation by protecting the outlet supplying power to a machine. In this application the relay operation time is typically set at instantaneous. The three power phases are passed symmetrically through the toroid. If there is no earth fault present, the vector sum of the currents in a three-phase supply is zero. If current from any phase flows to earth, the toroid flux becomes unbalanced. The toroid produces an output, which trips the relay.

A test current is injected through the window of the toroid to test the operation of the relay.

Series neutral protection is the backup protection method and may have an operation time up to a maximum of 500ms. In this method the neutral to earth connection is passed through the toroid. An earth fault on any of the phase conductors causes an earth current which returns, through the neutral, to the star point of the transformer and is detected by the toroid.

A test circuit can connect a test resistor between a phase and earth or inject a current through the toroid as previously described.

NOTE 	The test resistor to earth method is recommended with this type of protection as this test also proves the neutral to earth connection.

5.5.1 Earth leakage toroids

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.

The VSDguard relay is designed for use with Ampcontrol 100/1A EL500S series Toroids. They are available with window sizes 25, 60, & 112mm. A 112mm split toroid is also available.

5.5.2 Phase monitoring toroid (Optional)

VSDguard has provision for the connection of a toroid monitoring a phase current in the system by connection of a suitable toroid with a secondary rating of 5A.

NOTE 	No settings are required within the unit for the connection of this additional toroid, but the ratio of the toroid should be recorded so that when data is analysed, the actual phase current can be calculated.

5.5.3 Toroid selection

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

5.5.4 Toroid installation guidelines

i. 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
ii. 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.
iii. 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.
iv. Many small cables tend to be worse than say, three large ones. Try to position the toroid in the circuit with this in mind.
v. Toroids used for core balance earth leakage protection cannot have bus bars passed through them.
vi. 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.

5.5.5 Toroid monitoring signal

The VSDguard relay continually monitors for the presence of a toroid. When the toroid sees no signal the VSDguard relay injects a test current through the toroid primary. The test signal is every two seconds, and may be seen on the live screens and data logs.

6. TESTING AND COMMISSIONING

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

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

Ensure that the system is connected in accordance with the manufactures' instructions, and conforms to the intended design.

In the case of monitoring the NER circuit, ensure that no alternate earth paths exist that bypass the NER.

Perform an earth continuity test by injecting a current through the primary (window) of the VSDguard toroid and verify that the unit behaves as expected and that when it trips it also operates the intended circuit breaking device.

Note: During testing, the physical opening of the interposing circuit should be verified: PLC indication feedback alone does not provide adequate test coverage.

Section 7.2.8 provides more information on how to reset the relay after a trip.

CAUTION! 	Insulation Resistance or "megger" testing **MUST NOT** be done when VSDguard is wired in to the circuit. Disconnect wiring to the unit before performing insulation resistance tests.

7. OPERATION

The VSDguard relay can be configured via the user interface and keypad. The user interface and home screen are shown in Figure 5.

Figure 5 - User interface home screen

7.1 Indication LEDs

There are three (3) LEDs at the front of the unit that indicate the status of the VSDguard relay and the nature of any faults (if relevant).

- Power On LED - green
- Trip LED (latched) - red
- Processor Healthy LED (1 Hz) – green

7.2 Settings

7.2.1 Navigation

Under normal operation, VSDguard has four live status screens, as shown in Figure 6.

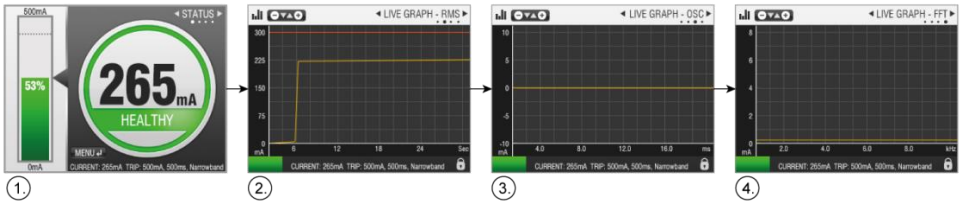


Figure 6 – Live Status Screens

These screens show:

1. Bar graph of real time RMS current with trip state (home screen),
2. RMS current history,
3. Plot of the real-time current seen by the earth leakage toroid (oscilloscope view), and
4. Frequency spectrum of the measured current.

The screens can be scrolled through using the left (⇦) and right (⇨) arrow keys on the keypad.

7.2.2 Home screen display colours

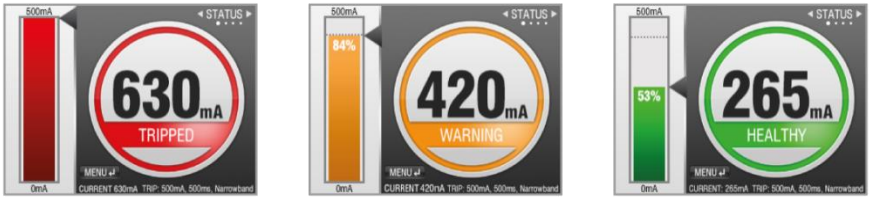


Figure 7 – Earth Leakage Indication

The home screen's side bar and orb change colour depending on the earth leakage current detected to give a simple indication of the state of the unit, as shown in Figure 7. The same colour code is used on the bottom left hand corner of every display page for quick reference.

Red:	Indicates that the VSDguard relay has tripped and is awaiting reset.
Orange:	Shows the unit has measured an earth leakage current of greater than 80% of the trip level, but insufficient to trip.
Green:	The earth leakage current is significantly below the trip level.

7.2.3 Main Menu

From the home screen, the main menu can be entered by pressing the ENTER key, and navigated using the up (⇧) and down (⇩) keys. This page is shown in Figure 8. Any page is then selected using the ENTER key.

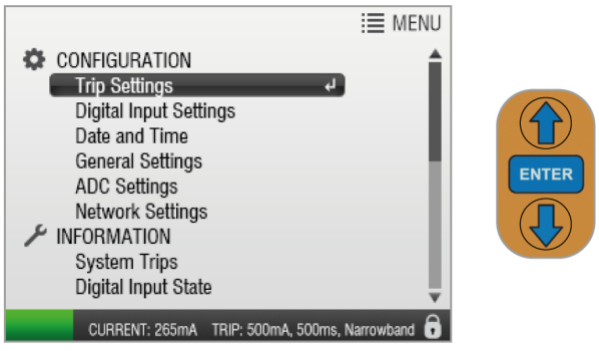


Figure 8 – Main Menu Screen

Once on a page in a submenu, the pages in that same sub menu can be moved between using the left (⇦) and right (⇨) arrow keys.

When a user presses the HELP button on the device a help screen will be shown giving contextual information on the current view. The up (⇧) and down (⇩) keys scroll the help screen information. An example of this is shown in Figure 9. To exit the screen the user is instructed to press the BACK button.

On home screen plots, the up (⇧) and down (⇩) arrow keys zoom the horizontal scale. The vertical scale automatically scales to suit.

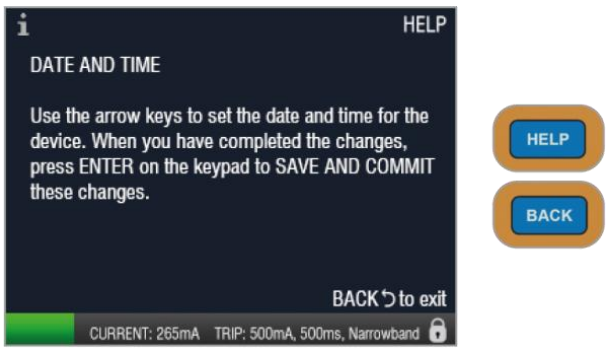


Figure 9 – Contextual Help Screen

7.2.4 Saving changes

Before any changes are saved to the settings on VSDguard the user will be presented with a screen displaying the user changes in **blue**, as shown in Figure 10. **SAVE AND COMMIT CHANGES** should be selected to save the change, or **CANCEL** for the unit to ignore the changes.

7.2.5 Personal Identification Number PIN

The VSDguard relay can be set with a PIN to prevent unauthorised changes being made to the settings of the unit. It is found under: **CONFIGURATION – General Settings – SET PIN** and is shown in Figure 11.

From the main menu, the **CONFIGURATION – General Settings** menu can be selected by pressing the ENTER key. Then **SET PIN** can be selected using the ENTER key.

If a PIN is already set in the unit, the user will be required to enter the current PIN before selecting a new PIN using the arrow keys and the prompts to save the change.

Figure 10 – Saving Changes

Once a PIN is set, the PIN must be entered to change any setting on the unit. The default PIN is **1000.** Once the password is entered the VSDguard is unlocked. This is denoted by the lock symbol in the bottom right hand corner being open.

Once the PIN is entered, the unit remains unlocked until the user navigates to the home screen, or the unit times out and automatically returns to the home screen.

Setting the PIN to **0000** turns off the password function.

Figure 11 – Change PIN Screen

7.2.6 Operating mode selection

VSDguard has three operating modes:

Wideband mode: The relay will see all currents between 20 Hz and 8 kHz and trips if the true RMS level of leakage current is above the trip level (adjustable from 50mA to 5A). This mode is compliant with AS/NZS 2081:2011 and would be used in most cases.

Narrowband (power frequency) mode: The relay will see all currents between 20 Hz and 100 Hz and trips if the true RMS level of leakage current is above the trip level (adjustable from 50mA to 5A). This mode operates as a traditional earth leakage relay.

Weighted frequency mode: This mode sets a modified form of wideband operation for demanding applications; these settings allow increased trip levels at higher frequencies to take into account the reduced sensitivity of the human body to touch potentials at these frequencies.

The operating mode can be selected on the **CONFIGURATION – Trip Settings – Trip Mode** page.

7.2.7 Trip level and time selection

VSDguard has selectable trip levels of 50mA – 1A in 50mA increments and 1A – 5A in 100mA increments.

The trip time is selectable from instantaneous – 500ms in 50ms increments.

The trip level and operating time of the VSDguard relay can be set from the **CONFIGURATION – Trip Settings** menu as shown in Figure 12.

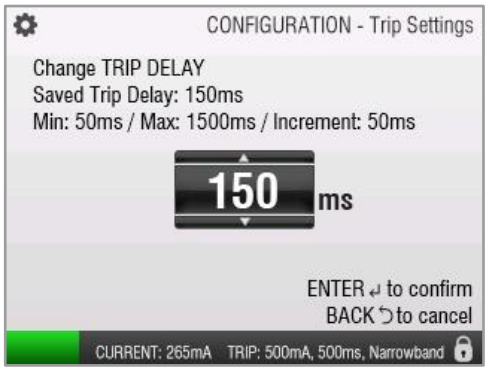


Figure 12 - Configuration - Trip Settings page

7.2.8 Resetting a Trip

Trips can be reset in three ways:

Local Reset: If the unit is password protected, the password must be entered to reset the trip. The local rest option is only available if VSDguard was set (where **CONFIGURATION – Local Trip Reset** is "On") to allow this method of reset before the unit tripped.

Pushbutton Reset: A normally open push button, when installed between the VSDguard 24V output and digital input 6, can be used to reset the trip. This option cannot be turned off, but the user may choose to not connect to the digital input.

Home trip reset: If the unit is tripped (and the **Home trip reset** is "On") the user may reset the tripped unit by holding the up and down keys simultaneously for two seconds when on the home screen.

7.2.9 Data log triggering

Data logs are triggered by a trip or alarm event, a trigger from a digital input or can be set to happen periodically.

On each event trigger, VSDguard stores system data for 2 seconds before and 2 seconds after the event, including;

- system time,
- earth leakage current,
- phase current (with connection of a toroid, 5A secondary connection, within ±5% of full-scale),
- zero crossing of the phase current (with connection of a 110Vac supply), and
- Temperature.

The last 1000 events are stored in the unit. The internal storage cannot be overwritten by the user. When the unit's memory reaches capacity the oldest entries are overwritten.

Besides being triggered by a trip, logging can be initiated in three other ways:

Digital Inputs: By a signal at digital inputs 1-5 must be set in the **CONFIGURATION – Digital Input Settings** page.

Periodically: Logging initiated by the VSDguard software at a regular interval can be set in the **CONFIGURATION – General Settings – Periodic Log Time.**

Alarm level logging: The user selects a trip level and delay below that of the unit's main trip settings; typically those of the downstream protection. This allows the user to see the operation of the downstream protection. A cool down time can also be selected to prevent the unit from continuously logging.

7.2.10 Viewing historic data

VSDguard stores the last 1000 data logs and 50 events. The last 20 of each of these logs can be viewed from the user interface in the **HISTORIC DATA** menu.

The Event Log shows the following statements for user changes next to a time stamp:

System Powered Up	When the unit received power following a normal shut down.
System Powered Down	When the unit had power removed in a normal shut down.
Loss of RTC Detected	The Real Time Clock has been lost.
Trip Reset (Local)	When the unit has been reset after a trip using the Local Trip Reset.
Trip Reset (Ext Input)	Unit has been reset after a trip using a pushbutton on the external input.
Earth Leakage Trip	Unit tripped due to detection of an earth leakage current at or exceeding the trip settings.
Ext Input Trip	Unit tripped due to a signal from an external input.
Ext Input Log	A signal change is seen at any configured input.
Periodic Log	Periodic log has been taken.
Settings Changed	User has changed settings.
Open Toroid Trip	Unit tripped because it could not sense the earth leakage current detection toroid.
Relay failed to close	Relay contacts failed to close when expected.
Relay failed to open	Relay contacts failed to open when expected.
Alarm tripped Log	Unit has made a log on the alarm level setting.

The Event Log shows a list of past logs for the user to view. Pressing ENTER takes the user to a similar set of screens as the real time data graphs. The user can zoom in and out and view the FFT of a selected range of data.

7.2.11 Real time clock (RTC)

Recorded data is stored on VSDguard with a time stamp from the on board RTC, indicating the system time when the log was made. For the purposes of aligning recorded data with other records, it is important that the user regularly checks that the time on the RTC reflects a level of accuracy acceptable to the user.

Without regular synchronisation, the RTC may become different from actual time. For example, it may be set incorrectly by the user, or the clock may drift over time.

7.2.12 Screen timeouts

When the VSDguard relay receives no input, it re-directs to the home screen and locks itself (if PIN is set). There are two timeout settings available under **CONFIGURATION – General Settings**:

Graph Timeout: The number of minutes after which the screen returns to the home screen when viewing any of the real time graphs.

General Timeout: The number of minutes after which the screen returns to the home screen when navigating the unit's menus (includes viewing historic data).

7.2.13 Ethernet Access

The Ethernet connection of the unit can be viewed at **CONFIGURATION – Network Settings,** shown in Figure 13.

If there is a DHCP server running on your local network the DHCP setting should be set to "Yes". Select "No" if you wish to manually configure a static IP address.

DHCP (Yes): Requires no further user configuration.

Static IP (No): Allows you to manually set up the required network parameters. These include IP address, subnet mask and gateway address. These are typically specified by your network administrator.

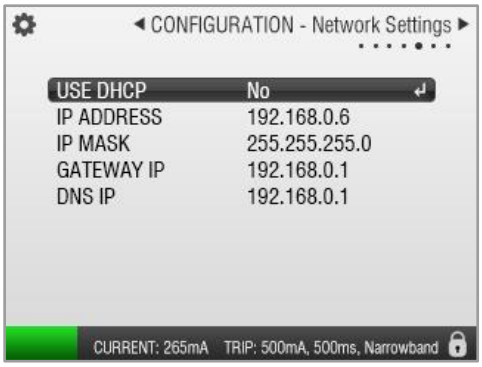


Figure 13 – Network Settings

The Network Settings page also indicates if the unit can detect an ethernet cable connection and the MAC address of the unit.

7.3 Remote access via Ethernet

The VSDguard Ethernet connection enables access to real-time earth leakage current measurements, device parameters and past data and event logs simply by using a web browser. VSDguard needs to be connected to a network that the user's browser can reach via HTTP port 80. For information on Ethernet settings, see Section 7.2.13.

NOTE	Minimum recommended browser versions for full functionality: Microsoft Internet Explorer 9, Google Chrome 20, Apple Safari 5 (or Mobile Safari from iOS 6), Mozilla Firefox 13, Opera 12

The VSDguard website has five main tabs, accessible from the left-hand side of the page. The first tab is loaded automatically when the page is visited.

The information shown in the header of the page is continuously updated. There are also two "indicator lights" on the right hand side of the page for further status information:

- If the unit trips, the indicator labelled **Tripped** changes to red. The header block and page background also change to red.
- The **Network** indicator flashes green every time a network request is made to the unit. If a network request fails, this indicator will flash red.

7.3.1 Live Graphs

The live graphs in this tab are refreshed every second; provided the **Live Update** button above the plots is activated (default is ON). Otherwise the last plot shown is held which can allow for better inspection of the data shown using the interactive features of the plots (described in Section 7.3.6). Figure 14 shows the VSDguard live graph interface.

There is also a **Help** button below the plots which allows access to online help information.

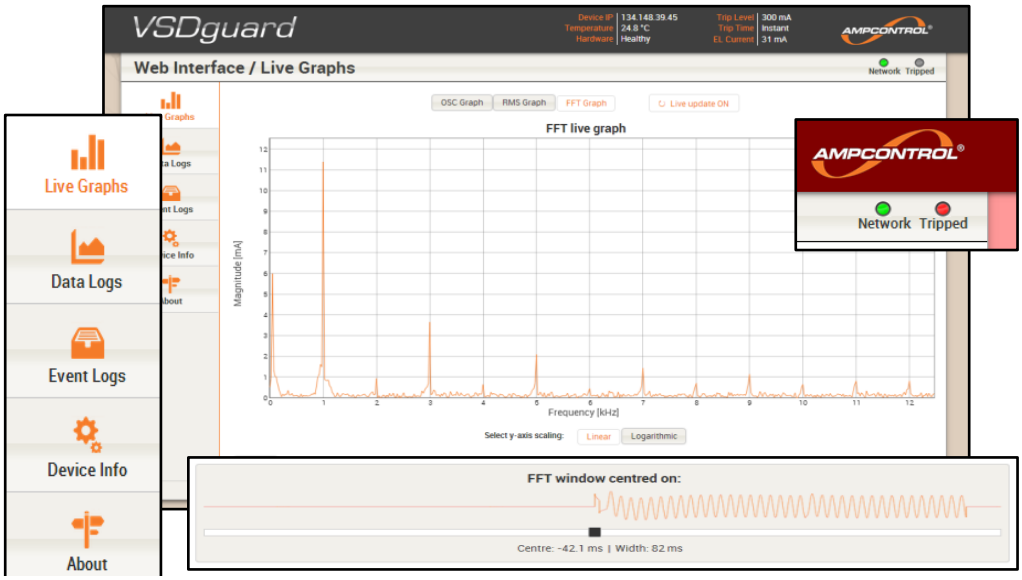


Figure 14 - VSDguard live graphs

In the live tab, three types of graphs can be shown:

OSC (Oscilloscope) graph: Plots the instantaneous values of earth leakage current measured by VSDguard. At every update, it displays the last 80ms of data.

RMS graph: In this view, Root Mean Square (RMS) values of the measured current are shown. The user is able to select the time interval on the graph by selecting from the buttons below the graph.

FFT graph: This plot shows the frequency content of the past 80ms worth of instantaneous measurements.

For information on navigating the interactive graphs see Section 7.3.6.

7.3.2 Data Logs

This tab is similar to the **Live Graph** tab, in that it allows inspection of measured earth leakage currents. However, in this tab, historic measurements from data logs stored on the VSDguard relay are shown (refer also to Section 7.2.9).

Each data log is centred on a trip or log event (i.e. the log covers the 2 seconds before and after the log initiation, making the command instant at the centre of the graph).

Once a particular log is selected from the list in the drop down menu, Oscilloscope, RMS and FFT views are available as they are in the **Live Graph** tab.

The RMS view is calculated using a running window of 300 data points.

The FFT graph corresponds to the selected 80ms of signal. To select another window over the recording, the slider below the plot, a small oscilloscope plot of the signal is provided to indicate where in the recording the data is being analysed.

Data logs can also be downloaded by clicking on the **Download Log** button (which exports the data in an Ampcontrol proprietary format).

7.3.3 Event Logs

This tab shows the 50 most recent user changes made at the unit. To export this list, use the link above the log to show the log entries in a separate popup window for printing or copy-pasting.

7.3.4 Device Information

This tab shows settings, states and measurements relating to both the hardware and software of the unit. This list is updated once a second.

7.3.5 About

Provides contact details and licensing information about the device and website.

7.3.6 Interactive graph navigation

The graphs shown on the website are interactive. The user can zoom, pan, and display values:

- To **zoom in**, click and drag either horizontally or vertically on the graph area (on mouse driven devices) or pinch in (touchscreen devices)
- To **zoom out**, double click the graph area (or pinch out on touchscreen devices)
- To **pan around**, shift-click and drag (mouse driven devices) or swipe (touchscreen devices)
- To **display signal values**, simply mouse over the plot to show the extended legend in the top right of the graph area (not available on touchscreen devices)

In the Oscilloscope and RMS graphs of an historic data log, time intervals can be determined by marking the start and end time with single clicks and then reading off the selected range from the box in the top left of the plot. To remove the marked range, click the box. To refine the selection, use single clicks near either end of the marked range to move the markers.

8. SERVICE, MAINTENANCE AND DISPOSAL

8.1 Equipment service

VSDguard requires no internal servicing during its normal operating lifetime. There are, however, a number of external system based checks that should be made on a regular basis. These 'routine inspections' must be carried out by suitably trained people with knowledge of VSDguard and the systems into which it is fitted.

Routine inspections may take the form of either simple visual only checks, or more detailed checks.

8.1.1 Visual only inspections

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

Observations would typically be:

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

8.1.2 Detailed inspection

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 such as verifying that:

i. Equipment housings, wall boxes and other mechanical fixtures are secured tightly in place. This includes the lids of terminal boxes, tightness of cable glands, the integrity of wall box mounting and security of equipment fixing.
ii. All electrical connections are secure with no loose screw terminals.

8.2 Equipment maintenance

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

It is recommended that the electrical protection system incorporating VSDguard be subject to regular functional tests at intervals determined by risk assessment or FMEA. The intervals typically coincide with periodic maintenance checks and will cover (but not be limited to) tests such as earth continuity tests.

8.3 Disposal

VSDguard should be disposed of responsibly as per typical electronics waste.

ENVIRONMENT 	VSDguard and its associated equipment 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 and human health.

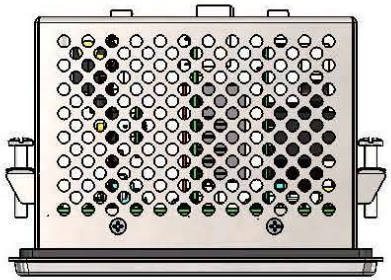
9. SPECIFICATIONS

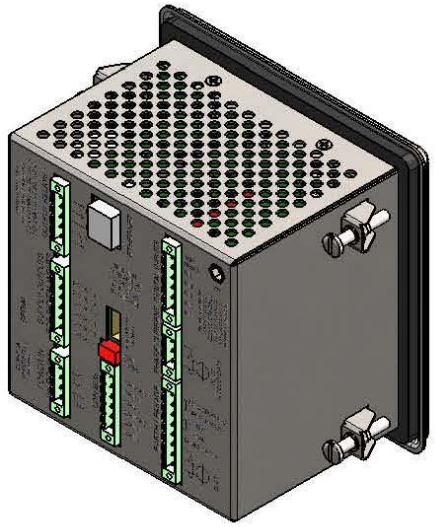
Relay supply:	
Supply Voltage:	24VDC (+/-25%)
Power consumption:	approx. 12W
Trip level and time settings:	
Trip current level:	50mA – 5A (50mA – 1A in 50mA increments, 1A – 5A in 100mA increments)
Trip operation time:	Instantaneous – 500ms in 50ms increments.
Relay contacts – fail safe:	1xCO (Mechanical) 250 VAC 1.6 A / 30 VDC 1.6 A (@50 VDC ~0.3 A) 1xNO (Solid State) 110 VAC/DC 0.2 A
Inputs:	
Inputs 1-5:	Programmable Trip/Log functions
Input 6:	Manual trip reset by external pushbutton.
Earth Leakage Toroid (CT):	Toroid 100/1A (Ampcontrol EL500S series recommended).
Phase Monitoring Toroid (CT):	Optional; 5A secondary toroid, for monitoring a selected phase current
110VAC:	Optional; Phase current zero crossing detection
Communication:	
Ethernet: Cable Connection:	10BASE-TX or 100BASE-TX - accessible via http (using a standard web browser). CAT5 UTP
CANBUS:	For future expansion (dip switches used for setting CANBUS address).
Dimensions:	
Overall:	155 W x 155 H x 113 D mm
Cut-out:	135 W x 135 H mm
Operating conditions:	
Ambient operating temperature:	0-60°C
IP Rating:	IP20
IP Rating installed:	IP55

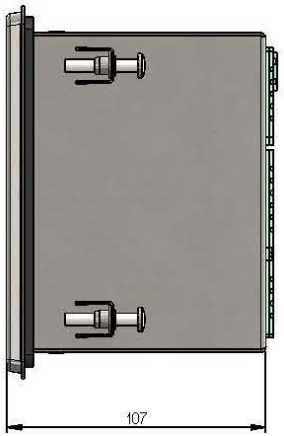
9.1 Equipment List

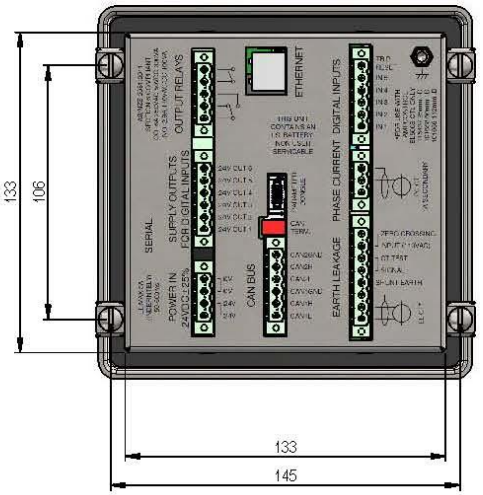
Ampcontrol part number	Description
162129	VSDguard - Wideband earth leakage relay
115437	Toroid EL500S - 25mm ID
101658	Toroid EL500S - 60mm ID
101656	Toroid EL500S - 112mmID
101653	Toroid Split - 112mmID
167291	User Manual VSDguard

APPENDIX A - DRAWINGS









No.	Details Of Revisions	By	Chkd	Eng	Appr	Date
0	10438 - ORIGINAL ISSUE	-	-	-	-	-

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electronics@ampcontrolgroup.com

GENERAL TOLERANCES U.N.O.
LINEAR |0-300| = ±0.5
LINEAR |300+| = ±1.0
ANGULAR = ±1°

AS1100
DO NOT SCALE
DIMENSIONS IN MILLIMETERS

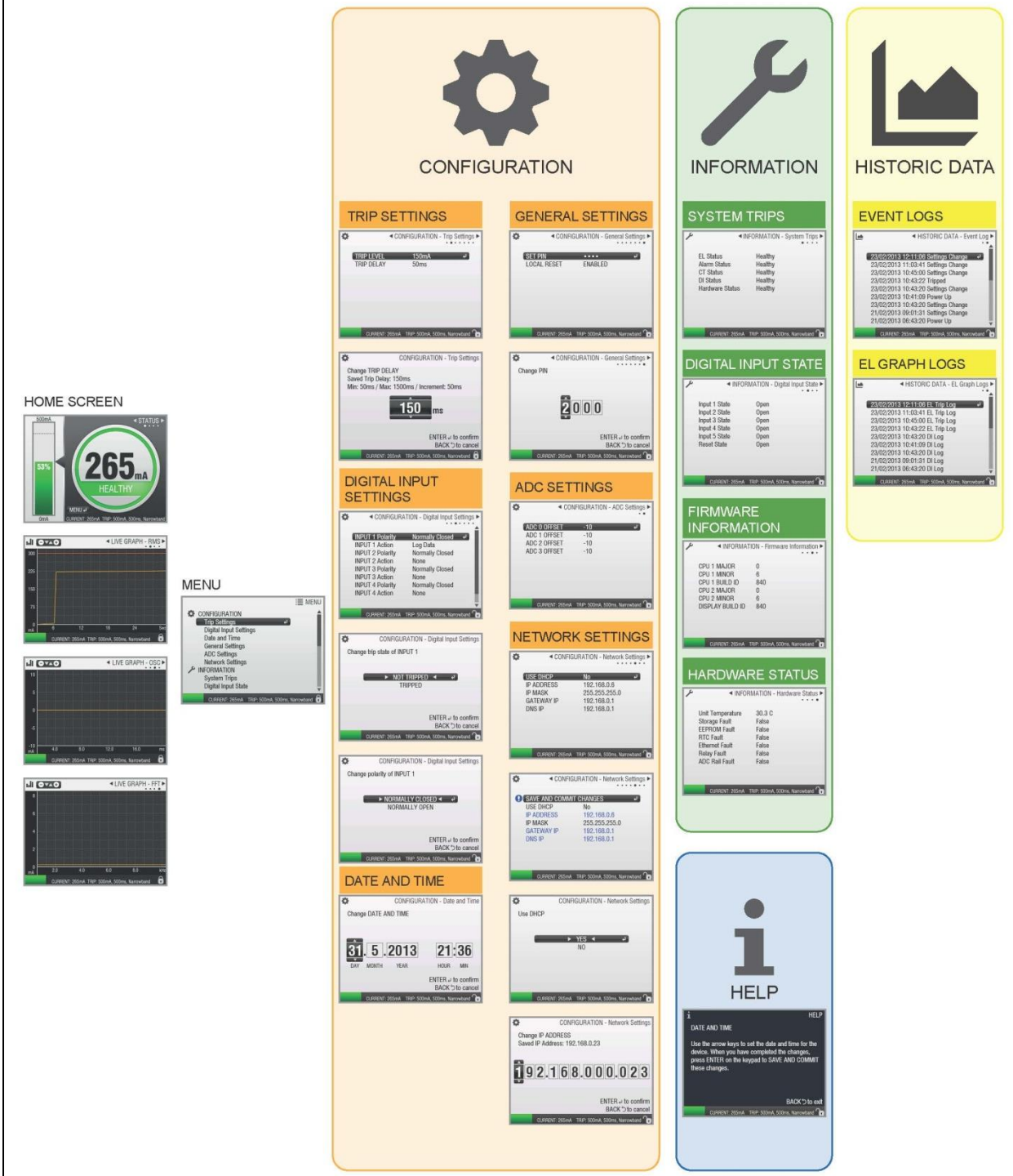
Drawn	R.W.
Drafting Check	D.L.
Engineering Check	M.G.
Approved, Date	C.L. 30/08/13
Sheet	1 of 4
Scale	1:2

VSD GUARD
RELAY HIGH FREQ. EARTH LEAKAGE
GENERAL ARRANGEMENT

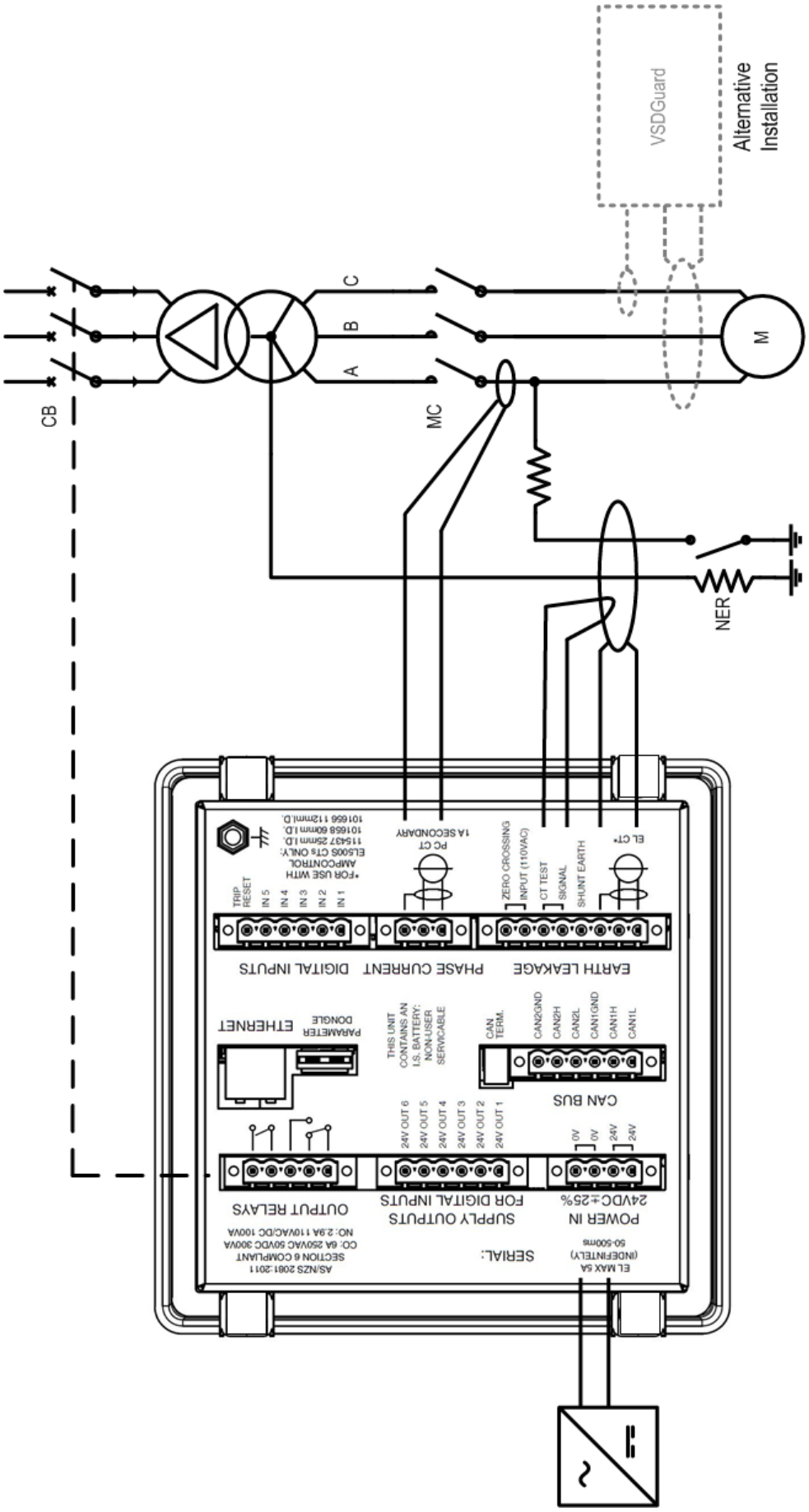
Drawing created in SOLIDWORKS

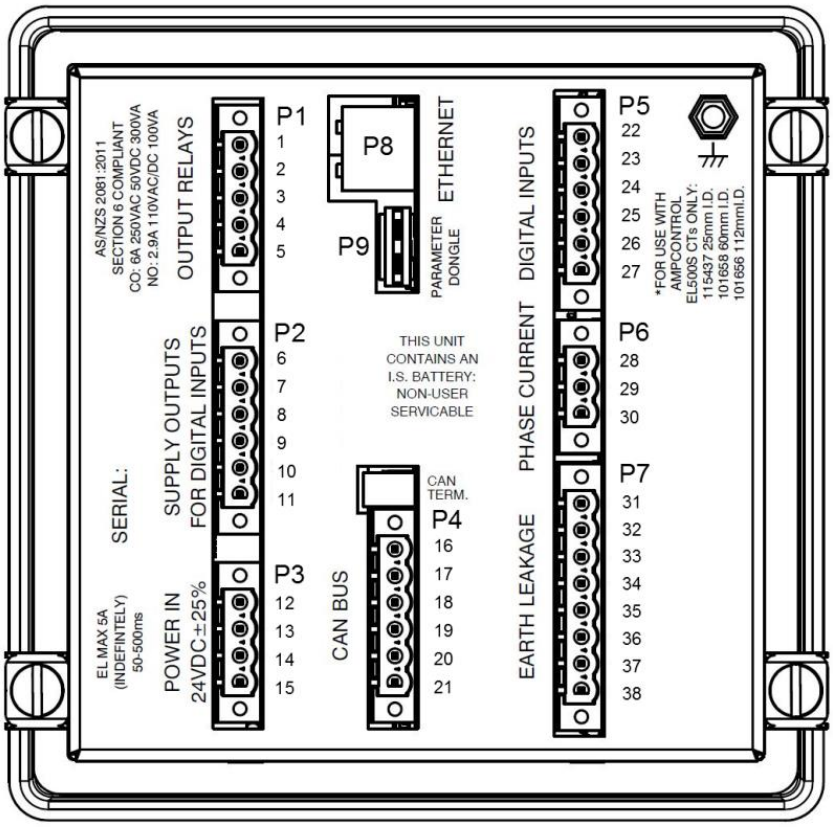
Part Number	Revision
162129	0
Drawing Number	Size
VSDA001	A3

VSDGUARD DISPLAY NAVIGATION MAP



VSDGUARD CONNECTION DETAIL




AS/NZS 2081:2011
SECTION 6 COMPLIANT
CO: 6A 250VAC 50VDC 300VA
NO: 2.9A 110VAC/DC 100VA
OUTPUT RELAYS
P1
1
2
3
4
5
P8
ETHERNET
P9
PARAMETER DONGLE
THIS UNIT CONTAINS AN I.S. BATTERY: NON-USER SERVICABLE
SERIAL:
SUPPLY OUTPUTS FOR DIGITAL INPUTS
P2
6
7
8
9
10
11
CAN TERM.
P4
16
17
18
19
20
21
CAN BUS
P3
12
13
14
15
POWER IN 24VDC±25%
EL MAX 5A (INDEFINTELY) 50-500ms
EARTH LEAKAGE
PHASE CURRENT
DIGITAL INPUTS
P5
22
23
24
25
26
27
P6
28
29
30
P7
31
32
33
34
35
36
37
38
*FOR USE WITH AMPCONTROL EL500S CTs ONLY:
115437 25mm I.D.
101658 60mm I.D.
101656 112mm I.D.