

## Features

- Integrated pilot wire supervision system for current operated differential protection schemes
- Operates using conventional metallic pilot wires (0 to 2K Ohm pilot resistance)
- Inherent 5KV or 15KV isolation  
No other components required
- Integrated pilot protection discrimination timer
- Extensive self supervision features to ensure functional integrity
- Supervision alarm contacts provided at both ends of pilot
- Flush or rack mounting
- M4 screws for control wiring
- M5 studs for pilot cable connection with clear protective isolation cover

## Application

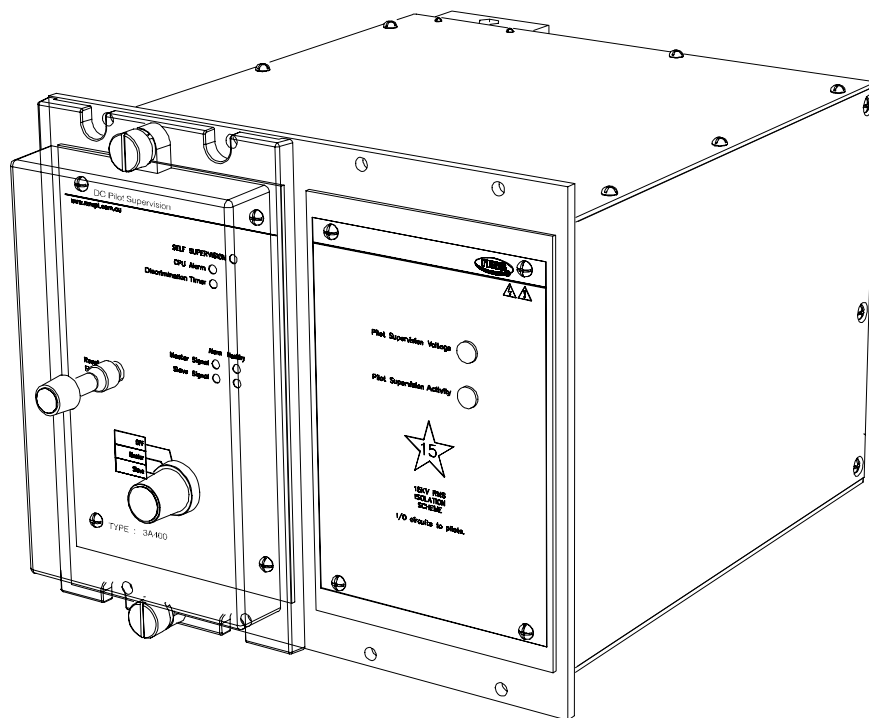
Differential protection schemes employing copper pilots remain widely used despite the increased availability of optical fibre infrastructure & numeric protection relays:

- ◆ Differential protection schemes which employ circulating current techniques & static relays are simple, reliable & low cost;
- ◆ Existing copper pilots have many years of useful life while dedicated optic fibre links are not always available, can be expensive to lease & may be subject to variable line delays due to telecoms exchange switching;
- ◆ Expansion of existing schemes requires compatible static relays & schemes.

Due to the above reasons, many utilities are reluctant to replace existing pilot wire & static protection relay schemes. Adding new 'T' feeders necessitates new matching relays to be installed which means we can expect to see traditional pilot wire protection schemes to be used for many years to come.

While very reliable, traditional DC supervision systems providing 5KV & 15KV isolation are bulky & expensive.

The 3A400 has been designed to provide an improved supervision scheme for copper pilots employed for communicating between current pilot wire protection relays.



3A400 DC Supervision Station Front Panel  
15KV isolation level size 8 case version depicted

## Description

Made in Australia

The 3A400 concept is based on the need to improve the performance of existing pilot wire protection schemes by increasing reliability & availability. With the 3A400 this can be achieved at a considerably lower cost than the replacement of the existing proven protection relays & change over to a fibre optic communication channel.

A revised protection scheme using the 3A400 comprises the following functional elements:

- ◆ The existing current differential protection relays;
- ◆ Pilot wire supervision system to monitor the pilot wire integrity;
- ◆ High voltage rated series capacitors to isolate the DC supervision voltages from the circulating AC protection signals;
- ◆ Pilot wire fail alarm contact provided at both ends of the protection scheme;
- ◆ Self supervision circuitry to monitor & alarm in event of system failure;
- ◆ A control panel for setting & displaying the system status.

### Pilot Wire Supervision

Pilot wire supervision is based on a pulsed DC signal that is initiated from a 3A400 at one end of the pilot & an acknowledge pulse returned from the 3A400 at the remote pilot end. Loss of three (3) consecutive supervision pulses will result in an alarm being initiated at both 3A400 stations. i.e. at both ends of the pilot wire.

### AC Immunity

AC filtering is employed to provide immunity to AC voltages which may be induced on the pilot & otherwise cause mal operation of the pilot fail supervision system.

### Pilot Wire Isolation

5KV or 15KV power supply isolation is provided using a compact encapsulated isolating transformer utilizing triple insulated Teflon winding wire.

### Mounting

The efficient & compact design of the 3A400 makes it suitable for 4U 19 inch rack or panel mounting & allows the use of standard sub station batteries.

### SYSTEM OPERATION

The 3A400 uses a DC/DC converter to generate an isolated & regulated DC supervision voltage. This voltage is maintained on the isolated side of the circuit & is switched onto the pilot lines under the control of an optically isolated micro controller circuit.

Refer to the typical applications shown in figure 4.

### PILOT WIRE CONNECTION

Connection of two 3A400 DC supervision stations onto a single pilot is possible as depicted in figure 3 below.

### PILOT WIRE ISOLATION

The 5KV & 15KV RMS isolation level is achieved using a compact encapsulated isolating transformer & fibre optic links.

#### Isolating Power Supply

Isolation is provided between the pilot wires & all other case terminals. This is achieved within the device using a specially fabricated high voltage isolating transformer. *No external isolating components are required.*

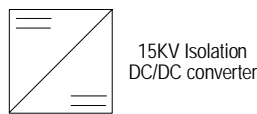


Figure 1: 5KV or 15KV rated isolating power supply

#### Supervision Signal Send & Receive

Supervision send & receive signals are transmitted across the high voltage isolation barrier using an optical transmitter, optic fibre cable & optical receiver.

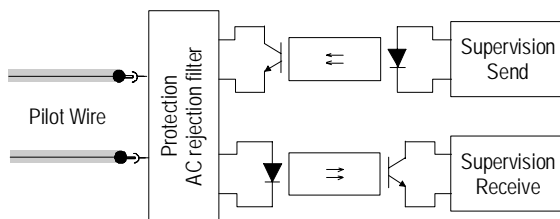


Figure 2: Fibre optic links across isolation barrier block diagram

### DE-COUPLING CAPACITORS

A 50uF 250V de-coupling capacitor must be fitted in series with one side of the pilot pair at each end of the pilot to isolate the DC supervision signals from the current protection relays. The capacitors are fitted externally to the 3A400 terminals as depicted in the wiring diagram & may be specified for supply with each relay via the order code.

### PRINCIPLE OF OPERATION

The principle of operation of the pilot wire protection scheme combined with the 3A400 pilot supervision scheme is as follows:

The pilot-wire protection relays are set up to operate as per the existing scheme except that the tripping signals are routed via the 3A400 pilot wire supervision contacts. This means there will be normal operation of the pilot protection system provided the pilot wires are healthy.

Connection of the 3A400 across the pilot wire pair introduces a shunt resistance which has the effect of shunting current from the pilot wire protection relays & causes the protection setting to be increased.

Additional shunt resistance may be fitted at each relay end to ensure the protection setting is raised above 100% of the nominal load current. This may be achieved by fitting a 7W wire wound resistor between terminals 31 & 32 with a minimum value of 1K0 ohm.

This means that in the event of a pilot wire failure there will be no mal-operation of the current differential protection relays even under maximum load conditions. It is unlikely that a through fault, causing the load current to be >>100%, will occur in coincidence with a pilot wire failure & initiate a trip.

Once detection of a pilot failure has been confirmed (8-12s delay), the trip circuit is interrupted & the integrated Protection Discrimination delay timer primed.

Once timed out the trip circuit is restored to permit operation of other pilot wire feeder protection in the event that an internal fault develops.

### PILOT PROTECTION DISCRIMINATION TIMER

The Protection Discrimination time delay setting is made by removing the 3A400 top cover plate to access a bank of five (5) piano switches. These provide a setting range of 0.1 to 3.1s in steps of 0.1s.

T1 = 0.1s	ON	<input checked="" type="checkbox"/>	OFF
T2 = 0.2s	ON	<input checked="" type="checkbox"/>	OFF
T3 = 0.4s	ON	<input type="checkbox"/>	OFF
T4 = 0.8s	ON	<input checked="" type="checkbox"/>	OFF
T5 = 1.6s	ON	<input checked="" type="checkbox"/>	OFF

$$\text{Discrimination time delay } (D_{\text{set}}) = \sum T1-T5$$

Timing will only commence after the + auxiliary supply voltage is applied to the discrimination timer initiate input. Removal of this initiate during timing will cause the timer to reset.

During timing the front panel green Discrimination Timer LED will be illuminated.

Discrimination Timer

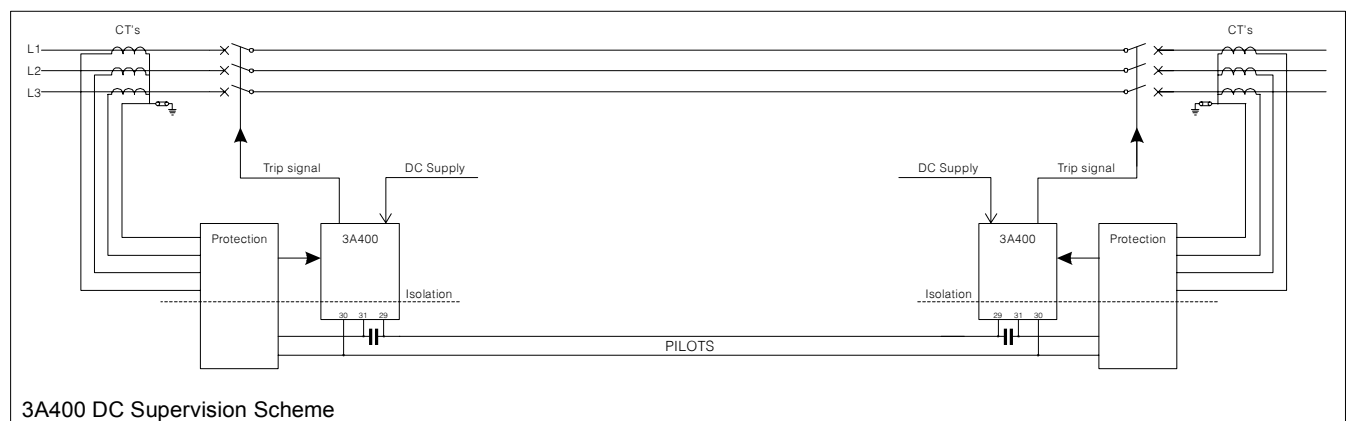
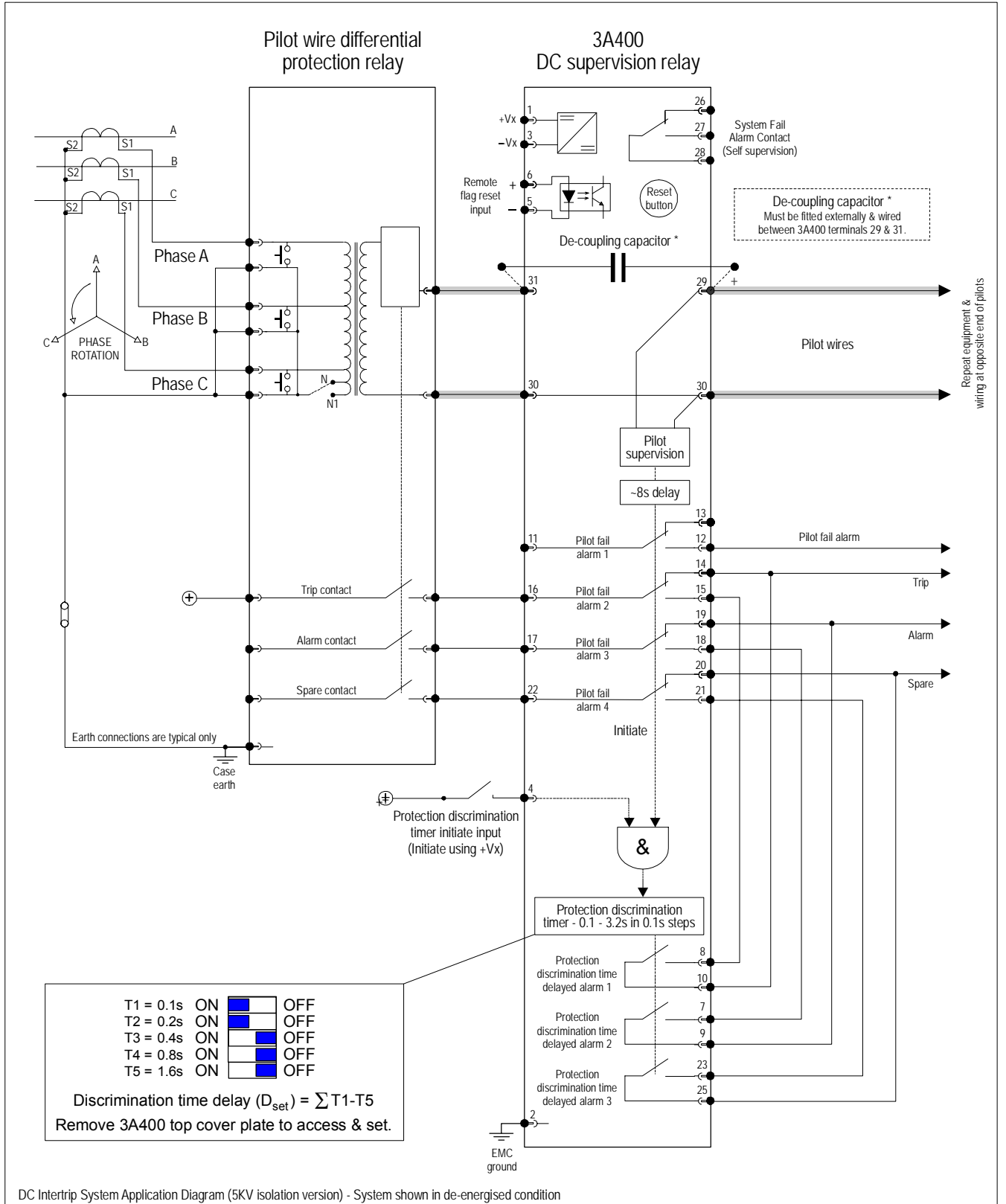


Figure 3: Single line diagram depicting a typical supervision configuration & routing of trip signals



DC Intertrip System Application Diagram (5KV isolation version) - System shown in de-energised condition

Figure 4

- Note 1:** If the 3A400 is mounted in a metal cubicle or rack the EMC ground must be connected to the chassis ground.
- Note 2:** The de-coupling capacitor is mounted externally & wired between terminals 29 & 31.
- Note 3:** Additional shunt resistance may be connected between terminals 30 & 31 to increase the protection setting. Care should be taken to ensure operation of the supervision system is not compromised.

### SUPERVISION SETTING MODE

The supervision mode is selected using the dial selection on the front panel. OFF, Master & Slave modes are available as depicted in figure 5. Unless supervision is turned OFF, one station must be set as the Master & all other station as the Slave.

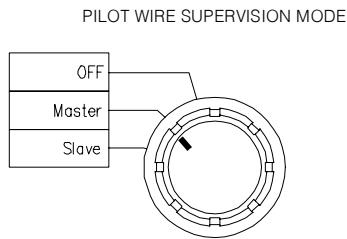


Figure 5

### PULSE MODE PILOT WIRE SUPERVISION

Figure 7 depicts the DC supervision pulse timing sequence. Upon restart the Master unit outputs a 2s DC pulse code. At the 2s point the Slave units decodes this signal as the Master supervisory interrogation pulse & establishes synchronization for the supervision sequence. After a 1s delay (Pulse gap), the Slave responds with a 1s DC pulse. Under normal conditions the Master unit detects this return DC pulse to maintain the pilot wire supervision healthy LED's (Figure 6). This sequence is then repeated with 1s DC pulses followed by 1s pulse gaps.

If either the Master or Slave station fails to detect a supervision pulse an alarm timer equivalent to three (3) supervision cycles is started. This results in a nominal supervision time delay of 8-12s. Recovery of the supervision pulse during this interval will reset the timer. Expiration of the timer will cause the supervision alarm contact to be set.

### IMMUNITY TO AC DISTURBANCES

Abnormal AC disturbance on the pilot wires for at least 4s will be tolerated before the 3A400 will signal a pilot fail alarm condition. Depending on the point in the supervision cycle the disturbance is initiated up to 8s of disturbance may be tolerated.

### SUPERVISION OFF MODE

With the pilot wire supervision mode selection switch set to OFF all of the alarm & healthy LED's remain extinguished. The alarm contact outputs remain inhibited.

# Pilot Wire Supervision

### PILOT OPEN CIRCUIT FAULT LOCATION

Both the master & slave stations are able to detect pilot open circuit faults. In the simple two station configuration (Figure 1) an open circuit fault will cause the slave to display a Master Signal alarm. The Master will display a Slave 1 alarm.

Where additional slaves are installed the alarm displayed will depend on their position on the pilot relative to the master station and the pilot open circuit. If they are on the other side of the master away from the fault they will display a Slave 1 alarm. If they are positioned after slave 1 away from the master they will display a Master Signal alarm.

### PILOT SHORT CIRCUIT FAULT LOCATION

A loss of insulation resistance across the pilot cores will lead to a reduction in the supervision voltage level applied to the pilots. A low resistance or short circuit will cause the supervision signal to be eventually lost & the associated pilot fail alarms being signaled.

### PILOT WIRE SUPERVISION ALARMS

A green Healthy & a red Alarm LED is provided to report faults for the two 3A400 station connected on the scheme.

The pilot wire supervision alarm relay contacts are normally closed and are picked up only when the pilot wire supervision alarm Healthy LED's are energized. The pilot wire supervision alarm relay contacts will drop out if any of the pilot supervision alarm LED's are energized.

Once operated all pilot fail alarm contacts (Including the protection discrimination time delayed contacts), are subject to a minimum dwell time. This dwell time delay may be selected in the ordering code section.

When a fault is detected the corresponding Healthy LED is extinguished, the Alarm LED illuminated & the alarm relays drop out to the alarm condition.

Reset is affected by pressing the front reset button or activating the remote reset status input. If the fault is persistent the alarm condition will be re-established after a short delay.



Figure 6

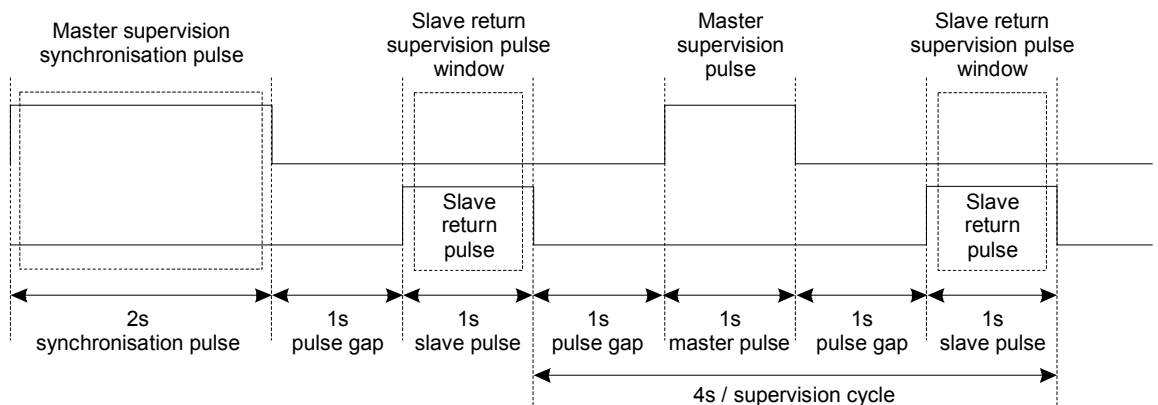


Figure 7

Timing diagram for a single supervision cycle

Supervision alarms may be cleared at each station using the front panel reset button or the remote reset status input. If the master station reset button or remote reset status input is activated for 2s a re-start will be initiated which will automatically clear alarms at all stations.

### SYSTEM RELIABILITY

System reliability is primarily achieved through the application of proven DC supervision techniques. The use of high integrity optical transmitters & receivers combined with periodic supervision minimizes the potential for un-detected failure to cause a non operation.

The DC/DC converter power supply is of robust design & incorporates considerable protection against pilot line transients & short circuit pilots. Continuous supervision of the DC pilot supervision voltage levels is incorporated.

### MANUAL SELF TEST SEQUENCE

When the 3A400 is first powered up a complete system self test routine is performed including a sequential LED test. The system monitoring described in this section then commences. A manual self test sequence can be initiated by pressing & holding down the reset button for 2s.

### SELF SUPERVISION ALARM CONTACT

Extensive self supervision features have been incorporated to monitor complete system integrity & output an alarm in the event of failure.

Detection of any system fault will cause the green Self Supervision "healthy" LED to flash & the normally energized Self Supervision fail alarm contact to drop out.

SELF SUPERVISION 

For diagnostic purposes three red alarm & three green healthy LED's are provided for fault identification. The function of these LED's are described in the following sections.


### POWER SUPPLY

#### Auxiliary Supply Rail

Failure of the power supply will cause all LED's to be extinguished & the Self Supervision fail alarm contact to drop out.

#### Supervision Send Voltage

Availability of the DC supervision voltage is required to ensure correct operation of the pilot wire supervision system. A voltage monitoring circuit is provided for this purpose. Failure of this element is reported via the Self Supervision fail alarm contact & the green healthy Supervision Send Voltage LED being extinguished. Failure is also likely to raise pilot wire supervision alarms depending on the supervision mode selected.

Pilot Supervision Voltage 

### CPU WATCH DOG

A CPU watchdog is employed to monitor the system for correct function. The CPU performs memory & program checks & if no fault is detected a check pulse is output to reset an independent alarm timer. Failure of the CPU to provide the periodic check pulse will cause the alarm timer to expire, the Self Supervision Healthy LED to be extinguished, the CPU Alarm LED to be energised & the Self Supervision fail alarm contact to drop out. This method is employed to ensure the self supervision system is fail safe in the event of its own failure.

CPU Alarm 

### PILOT SUPERVISION ACTIVITY MONITOR

A Pilot Supervision Activity LED is provided for confirmation that the supervision system is functioning correctly.

In pulse supervision mode the LED is flashed each time the station outputs a supervision pulse to indicate correct function.

Pilot Supervision Activity 



**AUXILIARY SUPPLY** Vx  
 Range B: 40-150V DC

**AUXILIARY SUPPLY BURDEN** (At 110V DC)  
 Configured as Master: <10W  
 Configured as Slave: <8W

**PILOT WIRE OUTPUT VOLTAGE** (Unloaded)  
 Supervision voltage: 30V DC +/-5% - Set as Master

**PILOT SUPERVISION RECEIVE**  
 Pilot supervision pick up: >5.1V DC  
 Pilot supervision drop off: <5.0V DC

**PILOT SUPERVISION INPUT THERMAL RATING**  
 500V DC & 350V AC continuous  
 565V DC & 400V AC for 3s

**REMOTE FLAG RESET INPUT**  
 Operate voltage range: Refer ordering codes for ranges

**PILOT WIRE SUPERVISION ALARM DELAY**  
 Non time delay controlled: 3 supervision cycles 8-12s

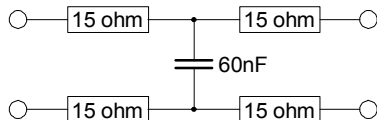
**PROTECTION DISCRIMINATION TIMER**  
 0.1 to 3.1s in 0.1s steps  
 Auxiliary supply voltage to initiate input required to operate.

**PILOT WIRE ALARM CONTACT RESET TIME**  
 Once the pilot fail alarm has activated due to the loss of three (3) consecutive supervision cycles (Refer figure 7), the supervision system can only recover once two (2) consecutive supervision cycles are correctly interpreted. This results in a minimum fail alarm contact reset time of 8s.

To avoid the possibility of a fleeting pilot alarm contact closure a dwell timer is incorporated to ensure that once initiated, the pilot alarm contact will remain closed for at least 0.5s.

**IMPEDANCE PRESENTED TO PILOTS**  
 22.5K ohm & 10nF

**PILOT WIRE RESISTANCE & CAPACITANCE**  
 The 3A400 system will operate with a maximum 'balanced' pilot line load of 2K ohm resistance & 2uF capacitance. As a guide a pilot wire pair will typically present a 60 ohm resistance & 60nF capacitance per kilometer. This load is depicted in the following figure:



Using this pilot wire characteristic a maximum end to end pilot wire length of 30km is possible.

**FRONT PANEL INDICATORS**  
 Healthy LED colour: Green energized solid  
 Alarm LED colour: Red energized  
 Discrimination timer: Green energized

Self Supervision Green  
 CPU Alarm Red  
 Pilot Supervision Voltage Green  
 Pilot Supervision Activity Green flashing

Pilot Wire Supervision  
 Master Alarm red & Healthy green  
 Slave Alarm red & Healthy green

# Technical Data

**OUTPUT CONTACTS**  
 Pilot wire supervision alarm: 4 C/O contacts  
 Discrimination timer controlled: 3 N/O contacts  
 System fail alarm: 1 C/O contact

OUTPUT CONTACT RATINGS		IEC60255-0-2
Carry continuously	5A AC or DC	
Make & carry	0.5s 20A AC or DC	
L/R ≤ 40ms & V ≤ 300V	0.2s 30A AC or DC	
Break capacity I ≤ 5A & V ≤ 300V	AC resistive	1,250VA
	AC inductive	250VA @ PF ≤ 0.4
	DC resistive	75W
	DC inductive	30W @ L/R ≤ 40ms 50W @ L/R ≤ 10ms
Minimum number of operations	10 <sup>6</sup> at maximum load	
Minimum recommended load	0.5W limit 10mA & 5V	

TRANSIENT OVERVOLTAGE		IEC60255-5 CLASS III
Between all terminals & earth	5kV 1.2/50us 0.5J	
Between independent circuits without damage or flashover	5kV 1.2/50us 0.5J	

INSULATION COORDINATION		IEC60255-5 CLASS III
Between all terminals & earth	2.0kV RMS for 1 minute	
Between independent circuits	2.0kV RMS for 1 minute	
Across normally open contacts	1.0kV RMS for 1 minute	
Between all input terminals & pilot wire terminals	5KV RMS or 15KV RMS for 1 minute	
Between all output terminals & pilot wire terminals	5KV RMS or 15KV RMS for 1 minute	

AUXILIARY SUPPLY		IEC60255-11
Allowable breaks / dips in supply	≤ 20ms	
Collapse to zero from nominal voltage		

HIGH FREQUENCY DISTURBANCE		IEC60255-22-1 CLASS III
2.5kV 1MHz common mode	≤ 3% variation	
1.0kV 1MHz differential mode		

ELECTROSTATIC DISCHARGE		IEC60255-22-2 CLASS III
6kV contact discharge	≤ 5% variation	

RADIO FREQUENCY INTERFERENCE		IEC60255-22-3
10V/m, 80 TO 1,000MHz	≤ 5% variation	

FAST TRANSIENT		IEC60255-22-4
4kV, 5/50ns, 2.5KHz repetitive	≤ 3% variation	

CONDUCTED RFI		IEC60255-22-6
10V, 0.15 to 80MHz	≤ 5% variation	

TEMPERATURE RANGE	
Operating:	-5 to +55°C
Storage:	-25 to +75°C

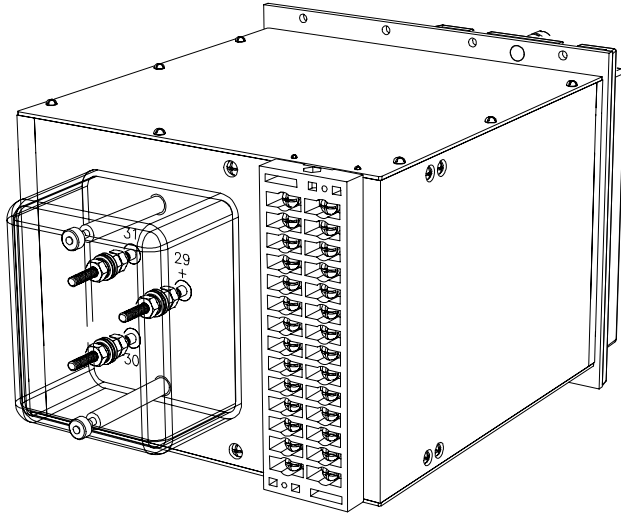
**HUMIDITY** IEC68-2-1/2  
 40 °C & 95% RH non condensing

**CASE**  
 19" rack or flush mounting: 4U high rear connection  
 5KV isolation size 6 case  
 15KV isolation size 8 case

IP rating: IP51  
 Construction: Acetal & fiberglass.  
 Separate pilot wire termination cover provided for the 15KV isolation version.

**REAR TERMINALS**  
 Pilot cables: M5 studs.  
 Secondary wiring: 28 M4 screw terminals suitable for ring lugs.





Rear view showing pilot wire & secondary terminations  
3A400 15KV version

## Ordering Information

Generate the required ordering code as follows: e.g. 3A400-BAAEA

3A400 -

### 1 AUXILIARY SUPPLY RANGE

B 40-150V DC

### 2 PILOT WIRE ISOLATION LEVEL

A 5KV RMS  
B 15KV RMS

### 3 REMOTE RESET STATUS INPUT

Opto-isolated input

A 24-80V AC/DC  
B 75-150V AC/DC  
C 150-300V AC/DC

Relay coil input

D 12V DC  
E 24V DC  
F 48V DC  
G 110V DC

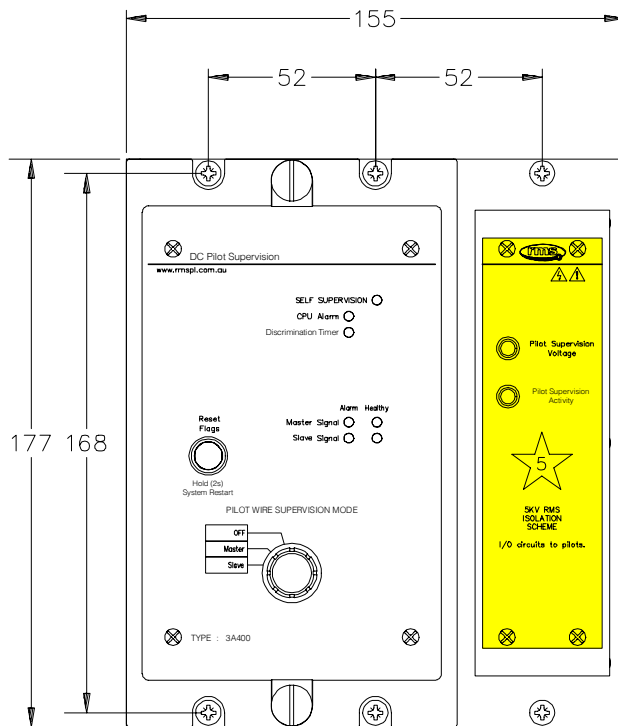
### 4 PILOT FAIL ALARM DWELL TIME

E 0.5s Default

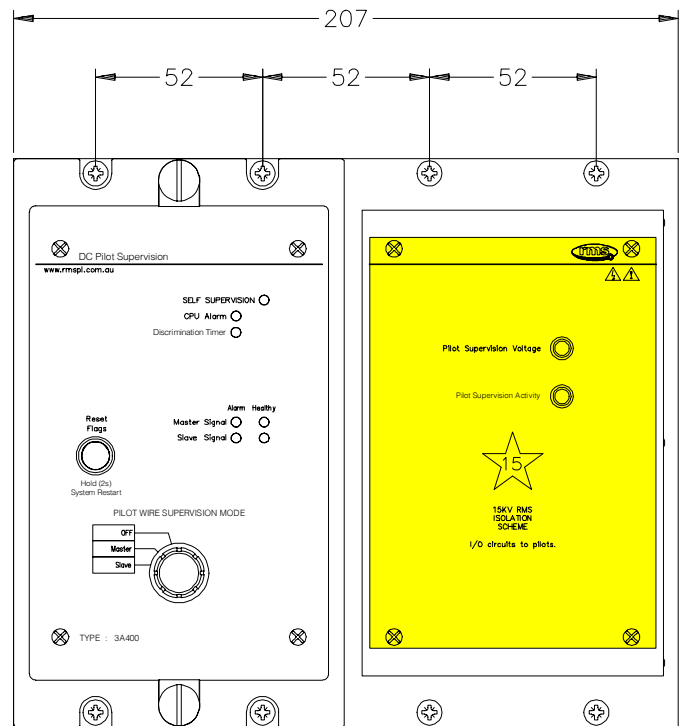
### 5 DE-COUPLING CAPACITOR

A Not required  
B Required

## FRONT PANEL DETAILS & DIMENSIONS

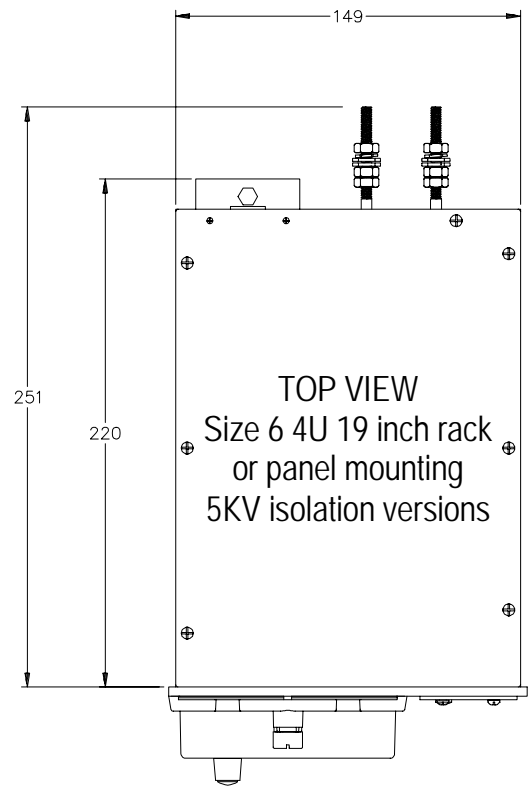
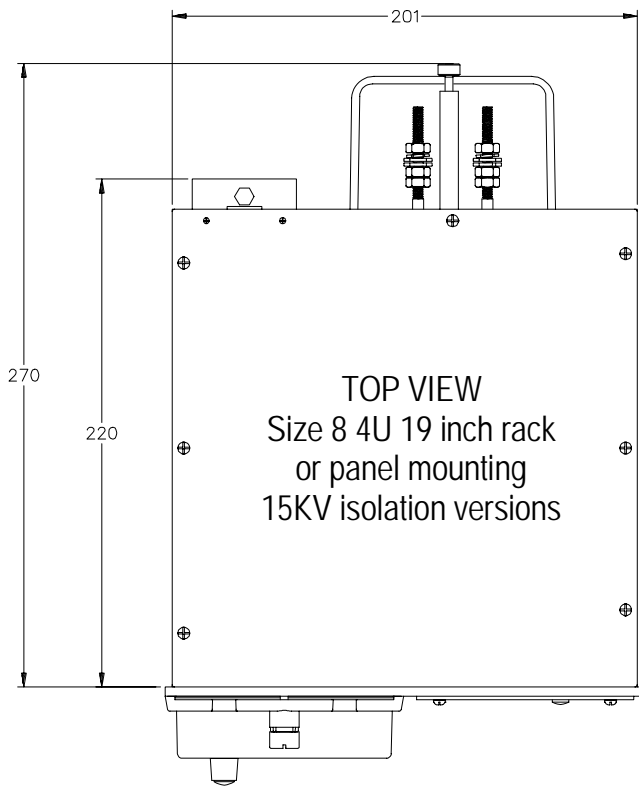
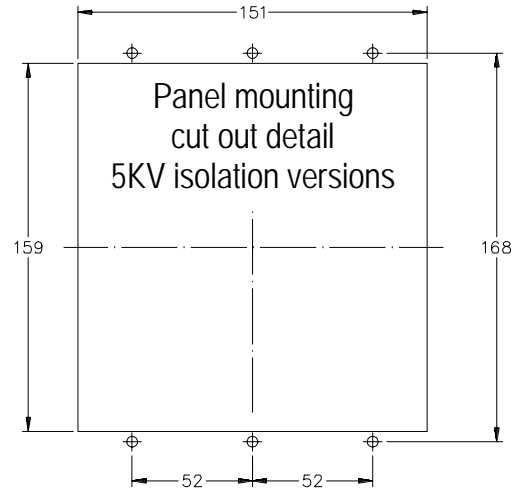
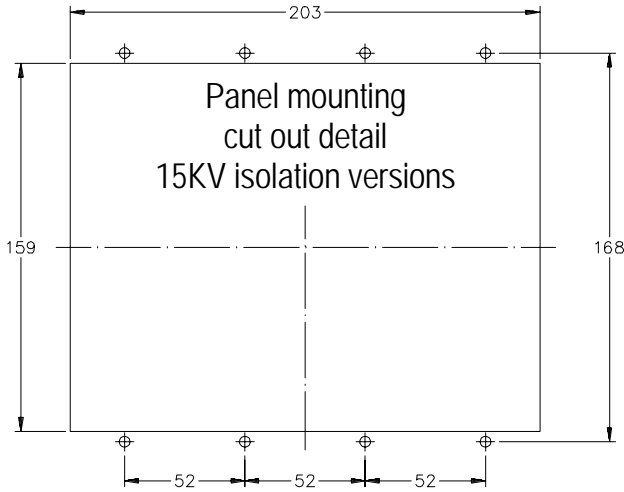


Size 6  
5KV Isolation Version

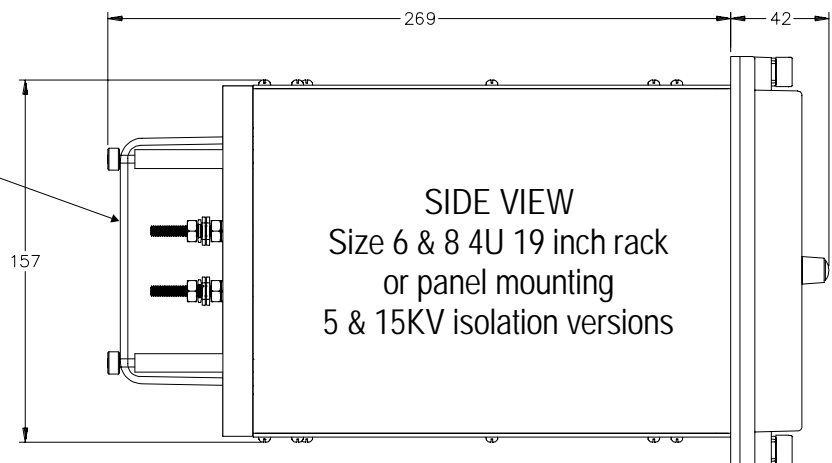


Size 8  
15KV Isolation Version

# Mounting Details



Pilot wire terminal cover  
provided with 15KV  
isolation versions only





## **Australian Content**

Unless otherwise stated the product(s) quoted are manufactured by RMS at our production facility in Melbourne Australia. Approximately 60% of our sales volume is derived from equipment manufactured in house with a local content close to 90%. Imported components such as semi-conductors are sourced from local suppliers & preference is given for reasonable stock holding to support our build requirements.

## **Quality Assurance**

RMS holds NCSI (NATA Certification Services International), registration number 6869 for the certification of a quality assurance system to AS/NZS ISO9001-2000. Quality plans for all products involve 100% inspection and testing carried out before despatch. Further details on specific test plans, quality policy & procedures may be found in section A4 of the RMS product catalogue.

## **Product Packaging**

Protection relays are supplied in secure individual packing cardboard boxes with moulded styrene inserts suitable for recycling. Each product & packing box is labeled with the product part number, customer name & order details.

## **Design References**

The products & components produced by RMS are based on many years of field experience since Relays Pty Ltd was formed in 1955. A large population of equipment is in service throughout Australia, New Zealand, South Africa & South East Asia attesting to this fact. Specific product & customer reference sites may be provided on application.

## **Product Warranty**

All utility grade protection & auxiliary relay products, unless otherwise stated, are warranted for a period of 24 months from shipment for materials & labour on a return to factory basis. Repair of products damaged through poor application or circumstances outside the product ratings will be carried out at the customer's expense.

## **Standard Conditions of Sale**

Unless otherwise agreed RMS Standard Terms & Conditions (QF 907) shall apply to all sales. These are available on request or from our web site.



## **Relay Monitoring Systems Pty Ltd**

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