

VA TECH TRANSMISSION & DISTRIBUTION

VA TECH Reyrolle ACP Ltd

Current differential protection - Solkor-N



SOLKOR-N

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SOLKOR-N

Current differential protection



Introduction

The Solkor technique of current differential protection was developed by Reyrolle over 50 years ago, and has formed an important part of the product range ever since. It has now progressed into a microprocessor controlled, differential feeder protection system providing complete protection for overhead lines and cable feeders.

Features

- Three pole, current differential protection with two stage bias characteristic.
- Magnetising inrush detector to provide additional restraint (optional).
- Intertripping from internal or external initiation.
- Three pole, phase fault overcurrent protection - IDMTL or DTL with highsets.
- Earth fault overcurrent protection - IDMTL or DTL with highsets.
- Overcurrent protection can be configured to operate as guard and/or back-up in case of communications failure.
- Communication loop-back test modes.
- Communication link supervision.
- Trip circuit supervision.
- Circuit breaker fail protection.
- Suitable for 50Hz systems only.
- Selectable 1A / 5A current inputs.

- Ratio correction for mis-matched line current transformer ratios.
- Ability to invert current inputs to assist in commissioning.
- Seven user-programmable output contacts.
- Up to nine user programmable status inputs with pick-up and drop-off timers.
- Stores last five fault records with a time stamp.
- Stores 500 time-stamped event records.
- Stores 5 waveform records.
- Data communications to IEC60870-5-103.
- End to End communications via electrical or Fibre Optic channels.
- Local and Remote Current Instruments

Description

Protection

Current differential protection

Solkor-N performs magnitude and phase angle comparison of currents at either end of the protected feeder, and operates for faults detected within the protected zone. The three pole, phase fault differential comparators each provide two bias slopes. The first stage of bias accommodates proportional measuring errors in the system. The second stage accommodates additional spill current caused by CT saturation at high fault levels.

Figure 1 illustrates the differential protection operating characteristic.

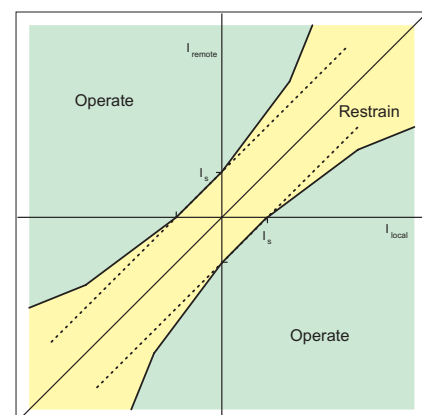


Figure 1 - Differential protection operating characteristic

It is not necessary to have the same CT ratios at either end of a protected feeder, since ratio compensation is settable. It is also possible to invert the current inputs to aid in commissioning.

Backup overcurrent protection

In addition to the differential protection, Solkor-N provides comprehensive overcurrent protection for phase and earth faults, which provide back-up IDMTL and DTL characteristics for the event of a communications link failure.

Guard relays

To add security to the differential scheme it is possible to designate any of the overcurrent elements as a guard element. The appropriate overcurrent element must then operate to allow the differential element to trip.

Intertripping

Three auxiliary signalling channels are provided for intertripping:

- One internal intertrip dedicated to the differential protection.
- Two independent intertrips which can be used for either direct or permissive intertripping from an external source.

If an internal fault is fed largely from one end, the differential comparators at both ends operate identically, but the guard at the low current end may not pick up and so block the trip. To overcome this, an intertrip is sent that can be used at the receive end to either override the guard so allowing the differential to trip, or, operate the trip contacts directly.

Protection Signalling Channels

Four types of protection signalling channel are provided as follows:

1. RS485 level electrical link for distances up to 2km.
2. 820nm optical fibre link for distances up to 4km.
3. 820nm laser optical fibre link for distances up to 7.6km.
4. 1300nm optical fibre link for distances up to 49km.
5. RS232 electrical to pilotwire interface unit for distances up to 8km (subject to engineering evaluation).

Continuous protection signalling link supervision is provided.

Two test modes are included to assist with commissioning the signalling link.

- In loop test mode the local transmit and receive terminals can be connected together, allowing the Solkor-N to be tested in isolation.
- Line test mode allows the integrity of the whole signalling channel to be checked. The Solkor-N commands the remote end to 'echo' all received data back to the local end. In line test mode, the remote differential protection is suspended.

The Solkor-N will automatically account for propagation delays in the signalling channel up to a maximum of 9.5ms. For delays in excess of 9.5ms a manual offset can be applied, with the actual delay falling within a 9.5ms window centred on the offset.

The pilotwire interface maximum distance depends on pilotwire parameters that may permit distances of greater than 8kms to be achieved.

Monitoring

Trip circuit supervision

The trip circuit is monitored by a status input with the circuit breaker in both the open and close position. This is linked to an alarm and may be configured to operate an output relay.

Circuit breaker fail

The circuit breaker fail function may be triggered by a trip signal from the Solkor-N. It operates by monitoring the current following a trip signal and issues an alarm if the current does not stop within a specified time interval. This alarm can be used to operate an output contact to backtrip an upstream circuit breaker. A further time delay enables another backtrip stage.

Circuit breaker operations counter

A circuit breaker operations count and a sum of I squared count is provided. Alarm levels can be set which, when reached, can be used as the input to a condition-based maintenance regime.

I² counter

This can provide a measure of the contact erosion and be used for planning circuit breaker maintenance schedules.

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Indications and Displays

The Solkor-N fascia includes 5 LEDs, providing the following indication:

- Protection Healthy (Green)
- Intertrip (Red) - an intertrip has been received
- I>Is (Yellow) - any algorithm detects current above setting
- Trip (Red) - the relay has issued a trip
- Signal Healthy (Green) - the signalling link is healthy

The following instruments are provided. If the Solkor-N is left untouched for a configurable period between 10 seconds and 1 hour it can display each instrument in turn.

- Local and remote end primary ammeters
- Local and remote end secondary ammeters
- Differential currents (secondary values)
- Differential starters
- Signalling link status
- General alarms
- Status inputs
- Output contacts
- Trip counter
- I² counter

System Data

Sequence of event records

Up to 500 events are stored and time tagged to 1ms resolution. These are available via the communications.

Fault records

The last 5 fault records are available from the Solkor-N fascia with time and date of trip, measured quantities and type of fault.

Disturbance recorder

The waveform recorder may be triggered from a protection function or external input and has a configurable pre-fault trigger. Up to 5 fault waveforms may be stored with associated analogue and digital values.

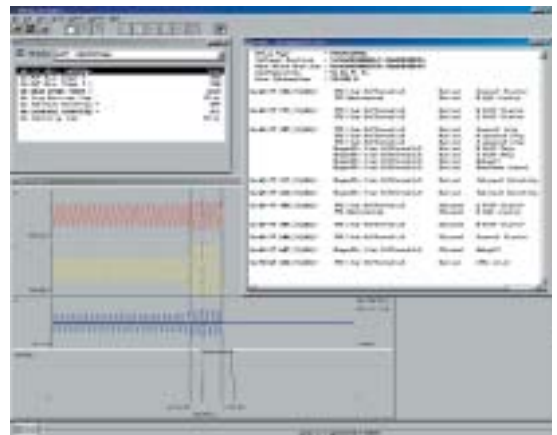
Communications

A fibre-optic communications port is provided on the rear of the relay. This will be optimised for 62.5/125µm glass-fibre using BFOC/2.5 (ST®) bayonet-style connectors.

The Solkor-N uses IEC 60870-5-103 as its communications standard.

ReyDisp evolution

This support software is common to the entire range of Reyrolle numeric products. It provides the means for the user to apply settings to the Solkor-N, interrogate settings and retrieve events and disturbance waveforms from the Solkor-N.



Technical Information

Performance data to IEC 60255-3

Characteristic Energising Quantity

AC Current	Frequency
1 A / 5 A	50/60 Hz

Auxiliary Energising Quantity

DC Power supply

Nominal Voltage	Operating Range V dc
24, 30, 48 V	18 to 60
110, 220 V	88 to 280

DC Status inputs

Nominal Voltage	Operating Range V dc
30, 34 V	18.0 to 37.5
48, 54 V	37.5 to 60.0
110, 125 V	87.5 to 137.5
220, 250 V	175.0 to 280.0

The status voltage need not be the same as the main energising voltage.

Electricity Association ESI48-4

The 30/34V and 48/54V inputs meet the requirements of ESI48-4 ESI 1. However, the 110/125V and 220/250V inputs will operate with a DC current of less than 10mA. If 110/125V or 220/250V inputs compliant with ESI48-4 ESI 1 are required, a Solkor-N with 48/54 V status can be supplied with external dropper resistors as follows:

Nominal Voltage	Resistor Value	Wattage
110, 125 V	2k7 ± 5%	2.5 W
220, 250 V	8k2 ± 5%	6.0 W

Status Input Performance

Parameter	Value
Minimum DC current for operation (30/34V and 48/54V inputs only)	10 mA
Reset/Operate voltage ratio	≥ 90 %
Typical response time	< 5 ms
Typical response time when used to energise an output relay contact	< 15 ms
Minimum pulse duration	40 ms

Each status input has an associated timer that can be programmed to give time delayed pick-up and time delayed drop-off. These timers have default settings of 20ms, thus providing immunity to an AC input signal. Status inputs will not respond to the following:

250V RMS 50/60 Hz applied for two seconds through a 0.1µF capacitor.

500 V RMS 50/60 Hz applied between each terminal and earth.

Discharge of a 10µF capacitor charged to maximum DC auxiliary supply voltage.

Protection Elements

Current differential

Level	Fixed	Variable
Phase setting	0.3 I _n	0.1 to 2.5 I _n
Phase bias 1	30%	20 to 150%
Phase bias 2	150%	30 to 150%
Bias Break point	2 I _n	0.5 to 20 I _n

Delay

Settings 0 to 10s

Phase overcurrent protection

Characteristic

IDMTL (IEC) Normal Inverse (NI), Very Inverse (VI), Extremely Inverse (EI), Long Time Inverse (LTI)

DTL

No. of elements 1

Level

Settings 0.10 to 2.50 I_n
 Accuracy Operate: 105% of setting ± 4% or ± 10mA
 Reset: 95% of operate current
 Repeatability ± 1%

IDMTL delay

Settings 0.025x to 1.600x
 Accuracy ± 5% or ± 30 ms
 Repeatability ± 1% or ± 5 ms

DTL delay

Settings 0.00 to 20.00 sec
 Accuracy ± 1% or ± 10 ms
 Repeatability ± 1% or ± 5 ms

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Reset delay

Settings	0 to 60 sec
Accuracy	$\pm 1\%$ or ± 10 ms
Repeatability	$\pm 1\%$ or ± 5 ms

Characteristic DTL

No. of elements 3

Level

Settings	0.10 to 52.5 In
Accuracy	Operate: 100% of setting $\pm 5\%$ or ± 10 mA Reset: $\geq 95\%$ of operate current
Repeatability	$\pm 1\%$

Delay

Settings	0.00 to 20.00 sec
Accuracy	± 5 ms
Repeatability	$\pm 1\%$ or ± 5 ms

Earth-fault protection

As phase overcurrent protection

Circuit breaker failure

Characteristic DTL

No. of elements 2

Delay

Settings	0.01 to 20.00 sec
Accuracy	± 5 ms
Repeatability	$\pm 1\%$

General Accuracy

Reference conditions

Parameter	Reference or Value
General	IEC 60255-3
Current Settings	100% of In
Time Multiplier	1.0
Current Input (IDMTL)	2x to 30x Is
Current Input (DTL)	5x Is
Auxiliary Supply	Nominal
Frequency	50 Hz
Ambient Temperature	20°C

General settings

Parameter	Value
Transient Overreach of Highset/Lowset (X/R = 100)	$\leq -5\%$
Disengaging Time (1)	< 42 ms
Overshoot Time	< 40 ms

Output contacts have a minimum dwell time of 100ms, after which the disengage time is as above.

Accuracy influencing factors

Temperature

-10°C to +55°C $\leq 5\%$ variation

Frequency

47 Hz to 52 Hz Setting: $\leq 5\%$ variation
Operate Time: $\leq 5\%$ variation

Harmonic content

Frequencies to 550Hz Setting: $\leq 5\%$ variation

Thermal Withstand

Continuous overload

Phase and Earth 3.0 x In

Limited period overload

3.5 x In	10 minutes
4.0 x In	5 minutes
5.0 x In	3 minutes
6.0 x In	2 minutes

Short term overload

	Maximum current (A) for:			
Input	1 cycle	1 sec	2 sec	3 sec
5A Phase/Earth	2500	400	282	230
1A Phase/Earth	700	100	70.7	57.7

Burdens

Current inputs

5A Phase/Earth ≤ 0.2 VA $\leq 0.01\Omega$
1A Phase/Earth ≤ 0.05 VA $\leq 0.05\Omega$

Note: Burdens and impedances are measured at nominal current rating.

Auxiliary supply

Quiescent (Typical) 3 W
Maximum 10 W

Output contacts

Contact rating to IEC 60255-0-2.

Carry continuously 5 A AC or DC

Make and carry

(limits: L/R \leq 40ms and V \leq 300 volts)

0.5 sec 20 A AC or DC

0.2 sec 30 A AC or DC

Break

(limits: \leq 5A or \leq 300 volts)

ac resistive 1250 VA

ac inductive 250 VA @ PF \leq 0.4

dc resistive 75 W

dc inductive 30 W @ L/R \leq 40 ms

50 W @ L/R \leq 10 ms

Minimum number of operations 1000 at maximum load

Minimum recommended load 0.5 W, limits 10 mA or 5 V

Environmental

Temperature IEC 68-2-1/2

Operating -10°C to +55°C

Storage -25°C to +70°C

Humidity IEC 68-2-3

Operational test 56 days at 40°C and 95% RH

Transient overvoltage IEC 60255-5

Between all terminals and earth or 5 kV

between any two independent 1.2/50 μ s

circuits without damage or flashover 0.5 J

Insulation IEC 60255-5

RMS levels for 1 minute

Between all terminals and earth 2.0 kV

Between independent circuits 2.0 kV

Across normally open contacts 1.0 kV

Immunity

Auxiliary DC supply IEC 60255-11

Allowable superimposed ac component
 \leq 12% of dc voltage

Allowable breaks/dips in supply (collapse to zero from nominal voltage)
 \leq 20 ms

High frequency disturbance IEC 60255-22-1 Class III

2.5kV, Longitudinal mode \leq 3% variation

1.0kV, Transverse mode

Electrostatic discharge IEC 60255-22-2 Class III

8kV, Contact discharge \leq 5% variation

Radio frequency interference IEC 60255-22-3

10 V/m, 80 to 1000 MHz \leq 5% variation

Fast transient IEC 60255-22-4 Class IV

4kV, 5/50ns, 2.5 kHz, repetitive \leq 3% variation

Conducted RFI IEC 60255-22-6

10 V, 0.15 to 80 MHz 5% variation

Emissions

Conducted limits IEC 60255-25

Frequency range	Limits dB(μ V)	
	Quasi-peak	Average
0.15 to 0.5 MHz	79	66
0.5 to 30 MHz	73	60

Radiated limits IEC 60255-25

Frequency range	Limits at 10 m Quasi-peak, dB(μ V/m)	
	30 to 230 MHz	40
230 to 10000 MHz	47	

Mechanical

Vibration (sinusoidal) IEC 60255-21-1 Class 1

0.5 gn, Vibration response \leq 5% variation

1.0 gn, Vibration endurance

Shock and bump IEC 60255-21-2 Class 1

5 gn, Shock response, 11ms

15 gn, Shock withstand, 11ms \leq 5% variation

10 gn, Bump test, 16ms

Seismic IEC 60255-21-3 Class 1

1 gn, Seismic response \leq 5% variation

Mechanical classification

Durability In excess of 10⁶ operations

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Sample Specification

The feeder protection device shall integrate the following characteristics:

- Microprocessor device
- Current differential protection
- Guard relay
- Protection signalling supervision
- Backup overcurrent protection
- 1A and 5A current inputs on same device
- Trip circuit supervision
- Circuit breaker fail detection

Current differential protection

The current differential protection shall perform magnitude and phase angle comparison of currents, on a phase-by-phase basis, although tripping shall be three-phase.

The protection shall be capable of compensating for different CTs at each end of the feeder.

The protection shall be stable for through faults at high fault levels when the line CTs saturate.

Backup overcurrent protection

The backup three-phase overcurrent protection shall provide an IDMTL element and 3 DTL elements that will provide back-up protection for the event of a communications link failure.

Guard relays

It will be possible to add an overcurrent guard to the differential protection to add security to the scheme.

Intertripping

The protection shall provide an intertrip facility capable of the following, as selected on the relay:

- A trip at the local end directly trips the circuit breaker at the remote end, or,
- A trip at the local end removes the need for a guard operation at the remote end, allowing tripping with a weak infeed.

Two additional intertrip channels shall be provided which allow external devices to directly trip remote.

Testing

Testing facilities shall be provided that allow:

- A single end to be tested in isolation,
- Both ends to be tested together to ensure integrity of the communications link, and,
- Both ends to be tested together to prove the directionality of the CTs

Signalling channel

The protection shall use one of the following methods for signalling.

- RS485 electrical link using twisted-pair cable
- Optical-fibre link at 820nm or 1300nm.
- Laser optical link
- RS232 and pilotwire multiplexor (asynchronous input) with external PWI (5kv)

Continuous supervision of the protection signalling link shall be provided.

The protection shall be capable of operating with propagation delays in the signalling channel varying up to 9.5ms.

Trip circuit supervision

The protection shall monitor the trip circuit when the circuit breaker is in both the open and closed position.

Circuit breaker fail

The protection shall provide the ability to issue a backtrip in the event of circuit breaker failure, detected by the continued presence of current, rather than circuit breaker auxiliary switch position.

Indications

The protection shall provide indication of the following:

- Protection healthy
- Intertrip received
- Protection operating
- Trip
- Signalling channel healthy

Metering

The device shall be capable of displaying the following measurements without user intervention:

- Local and remote end primary currents
- Local and remote end secondary currents
- Differential primary currents

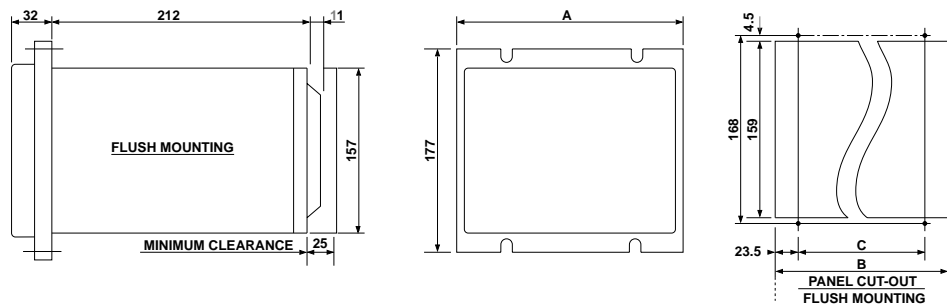
Disturbance recorder

In the event of a trip the device shall record a disturbance record of the local end currents, in primary amps, for a minimum of 1 second.

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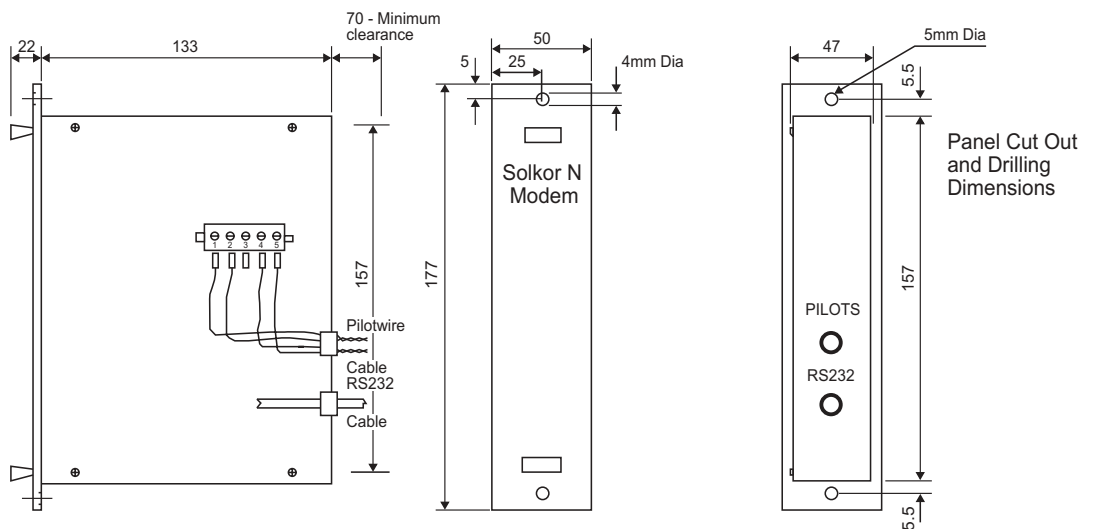
Case



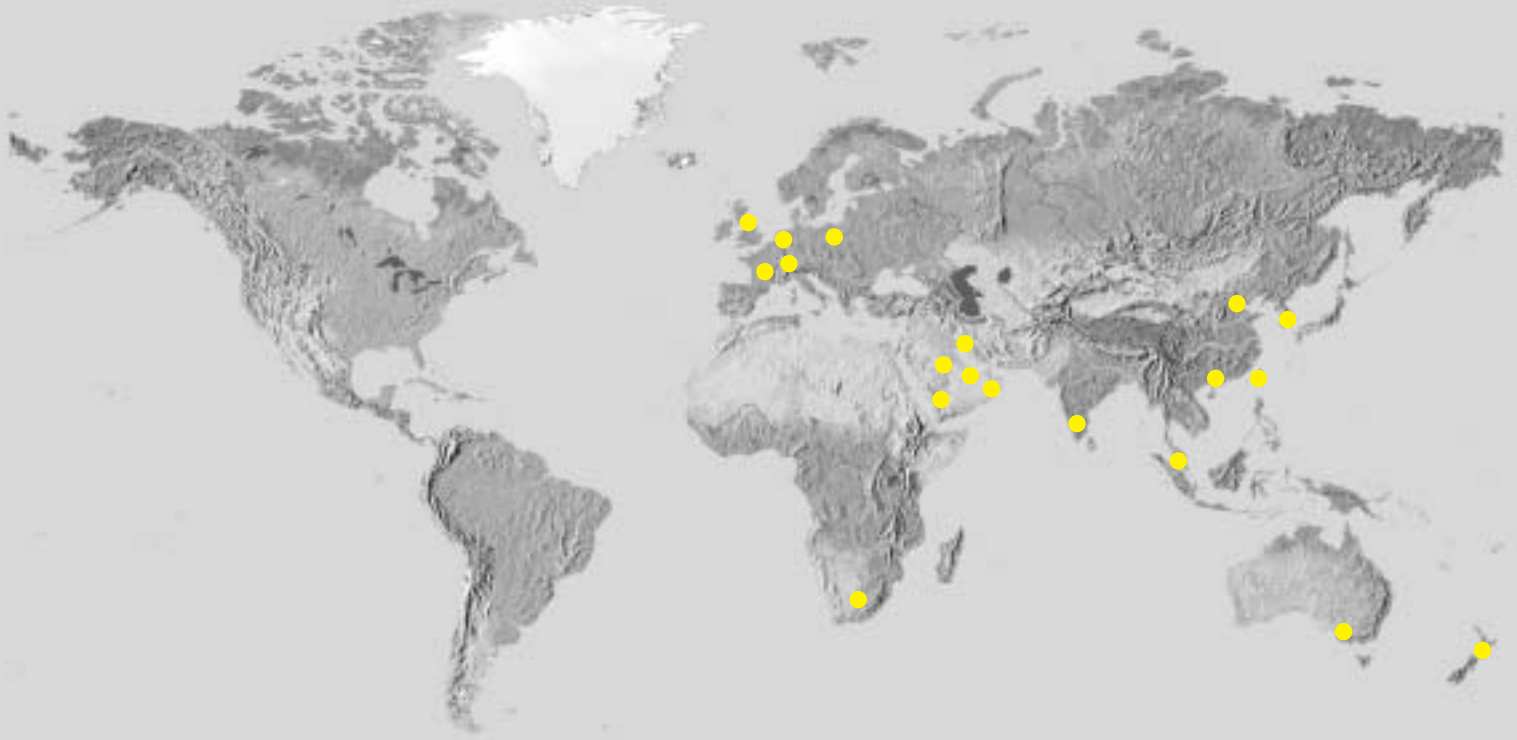
SIZE 8 CASE		
A	B	C
206	203	155.5

Solkor N - Pilotwire Modem

Case - flush or back of panel mounted with 2 x 5mm holes



Drawing for panel cut out and mounting - not to scale
Modem may also be back of panel mounted



For all of our overseas office details, please visit our website at:

www.reyrolle-protection.com

Or for our Australian partner, Relay Monitoring Systems Pty Ltd at:

www.rmspl.com.au

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