Features

- Compact, simple, rugged and economic design
- Simple wiring and DIN rail mounting
- Interface for one or two 1S30 arc fault sensors
- High speed arc fault tripping output to interface with protection relay status inputs
- Apply to initiate IEC61850 GOOSE messaging of arc fault events
- Continuous arc fault sensor supervision
- Arc fault pick up and supervision healthy indication
- 24, 32, 48, 110, 125, 220, 240 and 250V DC auxiliary versions

Introduction

Medium voltage switchgear is a key element in the power supply chain. Existing protection systems operate effectively under most circumstances, but they are too slow to handle arcing short circuits. Arcing faults can occur as a result of insulation breakdown due to equipment age and/or poor maintenance.

The degree of damage caused by arcing depends principally on the duration of the arc. If an arc lasts only 100ms, the switchgear needs to be checked and the insulation resistance measured before power can be re-established. With a 200ms arc, the power supply will be interrupted; the switchgear must be checked; power is re-established only after minor repairs. In the event of a 500ms arc the supply is interrupted, metal parts of the switchgear are destroyed and poisonous gases are emitted. A 1s arc destroys most of the switchgear and may cause a fire, injury to personnel and damage to property.

The over-current caused by an arc is, due to its resistance, lower than the over-current caused by a "metallic" short circuit. For moderate arc fault currents the trip time of the over-current IDMT stage will be too slow.

The consequence of these conditions is that a protection system based solely on over-current detection cannot effectively protect the switchgear against an internal arcing fault.

ARC Fault Protection

Arguably the greatest risk of arc fault damage exists at the CB cable termination and in the CB chamber itself due to the slow clearance times of the IDMT feeder protection. The CB cable termination is particularly at risk to ingress of moisture and rodent damage. The problem of arc faults is most prevalent in older metal clad switchgear which already has operational protection systems.

1S23 ARC FAULT INTERFACE MODULE

The Arc Fault Interface Module (ARC Module), described in this document is designed to connect one or two optical arc fault sensors to a protection relay status input. Refer to the 1S30 Technical Bulletin for details on the arc fault sensor.
SWITCHGEAR ARC PROTECTION
Risk of arc fault damage exists at the CB cable termination and in the CB chamber itself. The CB cable termination is particularly at risk to ingress of moisture and rodent damage.

1S30 Arc Sensors may be located as depicted in the single line application diagrams at right.

Modern numeric feeder protection relays provide internal logic functions that may be programmed to interface with the ARC Module. Refer to figure 6 for details.

Depending on the model of protection relay being used this input may be programmed to provide not only a high speed arc fault trip output but also an alarm message on the HMI and time stamped event record via its communications link.

This level of system integration allows the ARC Module to be back of panel mounted with the alarm indications programmed to be displayed on the protection relay front panel.

CABLE BOX PROTECTION
Figure 1 shows the trip signal being used to trip the feeder circuit breaker in the event of an arc fault occurring in the cable box provided the overcurrent relay starter logic is picked up.

CT CHAMBER PROTECTION
In circuit breakers where the CT is screened from the cable box a second sensor and ARC Module may be deployed as per figure 1.

CIRCUIT BREAKER CHAMBER PROTECTION
Arc fault occurring within the CB chamber must be cleared by the upstream breaker. This may be achieved as depicted in figure 2. Note the optional use of GOOSE messaging over IEC61850 to communicate an arc fault condition to the incoming feeder protection relays. Programmable logic may then be applied in these relays to open the appropriate up-stream circuit breakers to clear the fault.

Where trip signaling is achieved using conventional wiring, the trip output connection should be terminated in close proximity to the ARC Module and screened cable employed to transfer the trip signal to the up-stream protection relay status input.

TRIP SIGNALING OPTIONS
Hard wired or GOOSE

MULTIPLE ARC FAULT INTERFACE MODULES
Figure 3 depicts multiple Arc Fault Modules connected to a single status input. This scheme may be employed where more than one sensor is required to protect a single arc protection zone.

Figure 1: Cable box and CT chamber protection

Figure 2: CB chamber Protection

Figure 3: Multiple ARC Modules per status input
FRONT PANEL LAYOUT
Two LED’s are integrated into the front panel to provide the following status indications:

GREEN  Auxiliary supply indication
A green LED is continuously illuminated to indicate presence of the auxiliary supply and normal operation including supervision of the 1S30 sensor(s).

RED  Arc fault pick-up
A red LED is illuminated when an optical signal above the detection threshold is present. This LED will self reset when the optical signal falls below the detection threshold with a minimum dwell time of ~2s.

This feature is useful during commissioning and routine tests to verify correct operation of the system. Figure 14 provides a tabulation of the LED and output conditions to allow diagnosis of the ARC Module operating status.

ARC SENSOR FUNCTION
The 1S30 is an optical sensor that responds to the flash of light emitted during the incidence of an arcing fault. Onset of the light flash and detection by the 1S30 occurs in a few ms.

When an arc is detected, the resistance presented by the 1S30 drops to a level where the current flow increases to approximately 20mA. This increased current flow is detected by the ARC Module which responds in ~1ms to close a solid state contact to activate the arc fault input on the protection relay as depicted in figures 6 and 7.

ARC SENSOR SUPERVISION
The 1S30 Arc Sensor is the heart of the system and supervision of the circuit continuity is critical for correct operation. To monitor the integrity of the wiring between the 1S30 arc sensor and the ARC Module, a continuous 2mA supervision current flows between the units. A supervision healthy signal is output to the protection relay status input. This signal will be disabled after an ~1s time delay if the supervision current signal is lost.

An arc sensor fault will also be reported if an incorrect number of sensors are fitted to the ARC Module as follows:
- No arc sensor(s) connected
- 1 sensor connected to an ARC Module specified for 2 sensors

Arc sensor fault indication:
Where a fault is detected on the Arc Sensor circuit the front panel power LED will flash continuously until the fault is rectified.

ARC FAULT TRIPPING USING CURRENT CHECK
Fast operation of a tripping scheme usually results in reduced system security. The arc detection method can however, combine the optical detection technique with a traditional overcurrent method to maximize system security. Both conditions must coexist for the trip condition to be met as depicted in figures 6 - 7.

ARC DETECTION RESET TIME
(Effect of multiple arc trips)
A delay of >500ms is required to reset the ARC Module after an initial arc sensor trip. Subsequent arc detection will cause the trip contact to re-operate.

The application examples in figures 1 and 2 utilize this concept for enhanced security. As both the ARC Module AND the OC 50 starter logic must be picked up for a CB trip signal to be initiated. As the arc fault trip contact picks up considerably faster than the overcurrent relay starter element, the CB trip time will be dictated by the overcurrent relay performance.

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PROTECTION RELAY LOGIC

For the current check scheme to function correctly a protection relay with the following attributes is required:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Necessity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmable relay logic</td>
<td>AND gates</td>
<td>Mandatory</td>
</tr>
<tr>
<td>High speed status input</td>
<td>&lt;5ms pick up</td>
<td>Mandatory</td>
</tr>
<tr>
<td>High speed current check element</td>
<td>&lt;15ms at 2x setting</td>
<td>Mandatory</td>
</tr>
<tr>
<td>Programmable front panel indication</td>
<td>Arc trip indication</td>
<td>Desirable</td>
</tr>
<tr>
<td></td>
<td>Supervision status</td>
<td>Desirable</td>
</tr>
<tr>
<td>IEC61850 for trip signaling</td>
<td>GOOSE messaging</td>
<td>Optional</td>
</tr>
</tbody>
</table>

A suitable relay available with all of the above attributes is the Reyrolle 7SR21/22 platform multi-function feeder manager.

A screen shot of the Reydisp Manager logic programming software is shown in figure 6.

Figure 6: Reydisp Manager logic programming

ARC Fault Interface Module application diagram - Circuits shown in de-energised condition

Figure 7: ARC Fault Interface Module application diagram
**ENCLOSURE DIMENSIONS**

![Diagram of ENCLOSURE DIMENSIONS]

**ARC SENSOR INPUTS**

One or two optical arc fault sensors type 1S30 may be connected to the ARC Module. Refer to the 1S30 Technical Bulletin for mounting options.

The number of sensors specified in the ARC ordering code must be connected to ensure correct operation of the sensor supervision function.

If only one sensor is connected to the ARC-B version the supervision output will indicate a sensor fail condition.

If two sensors are connected to the ARC-A version the supervision output will indicate a sensor fail condition.

**TERMINATIONS**

4x M4 screw terminals suitable for heavy duty ring lugs.

- Terminal 1: DC negative
- Terminal 2: DC positive
- Terminal 3: 1S30 arc fault in (Non polarized)
- Terminal 4: 1S30 arc fault in (Non polarized)

2x 2 metre flying leads with 0.75 sq. mm conductor.

- Blue lead: Arc fault trip output - negative
- White lead: Supervision status output - negative

**MOUNTING**

DIN rail mounting of multiple DIN rail modules allows for a compact installation close to the protection relay status inputs. Wiring should be kept as short as practical to minimize the circuit resistance and possibility of noise on the protection relay status input.

![Diagram of MOUNTING]

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OPTICAL SENSITIVITY

-10,000 Lux* for white light at normal incidence to the detector window(s) as depicted in figure 12:

As the illuminance of diffuse ambient sunlight falls in the range 5,000 to 10,000 Lux, this will not normally be sufficient to trigger the ARC Module. The luminous intensity from the sun at noon at the equator however is ~100,000 Lux which will be sufficient to trigger the ARC Module so measures should be made to avoid this situation.

DETECTOR SPECTRAL RESPONSE

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Relative Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>50%</td>
</tr>
<tr>
<td>700</td>
<td>60%</td>
</tr>
<tr>
<td>800</td>
<td>70%</td>
</tr>
<tr>
<td>900</td>
<td>80%</td>
</tr>
<tr>
<td>1,000</td>
<td>90%</td>
</tr>
<tr>
<td>1,100</td>
<td>100%</td>
</tr>
<tr>
<td>1,200</td>
<td>90%</td>
</tr>
</tbody>
</table>

* Due to the relatively high sensitivity of the detector to IR wavelengths the type of light source employed for sensitivity testing will have a major effect on the results obtained. Sensitivity testing should therefore be conducted using a 50-75W halogen lamp with an integrated aluminum reflector.

SYSTEM SUPERVISION

A CPU software watchdog monitors the system and in the event of an abnormal condition will automatically perform a soft restart.

Should this restart not clear the abnormal condition the system will revert to a safe mode with the outputs disabled. This will cause the self supervision healthy signal to be lost and the abnormal condition detected and reported by the protection relay via it’s ARC supervision status input.

A front panel green LED is illuminated on the ARC Module under normal conditions. This LED is switched off in safe mode.

MINIMUM ARC DURATION

The minimum arc “flash” duration required to guarantee operation of the output contacts is 0.5ms.

TRIP SIGNAL RESET TIME

Once operated the trip output signal is self reset with a minimum dwell time of 100 to 120ms.

AUXILIARY SUPPLY BURDEN

(At 110V DC)

Monitoring mode:  Less than 0.75W
Arc fault detected: Less than 1.5W for 2s

AUXILIARY SUPPLY

The ARC Module is suitable for use with the following nominal auxiliary supplies. A tolerance of -20% to +20% must be maintained to ensure correct operation and to avoid thermal damage.

<table>
<thead>
<tr>
<th>CODE</th>
<th>Vx</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>24V DC</td>
</tr>
<tr>
<td>B</td>
<td>32V DC</td>
</tr>
<tr>
<td>C</td>
<td>48V DC</td>
</tr>
<tr>
<td>D</td>
<td>110V DC</td>
</tr>
<tr>
<td>E</td>
<td>125V DC</td>
</tr>
<tr>
<td>F</td>
<td>220V DC</td>
</tr>
<tr>
<td>G</td>
<td>240V DC</td>
</tr>
<tr>
<td>H</td>
<td>250V DC</td>
</tr>
</tbody>
</table>

OPTICAL ARC FAULT DETECTION OPERATE TIME

An arc fault trip signal is output in less than 1ms.

OUTPUT CIRCUITS

Dedicated non-isolated outputs are provided to connect to overcurrent protection relay status inputs as shown in figure 6. Upon detection of light intensity greater than the pick-up threshold a solid state switch connects the 0V rail to the relay status input.

OUTPUT RATINGS

IEC60255-0-2

The ARC Module outputs are designed for connection to dedicated protection class binary status inputs only. They are not suitable for direct tripping applications of auxiliary relays or circuit breaker coils.

The following ratings are conservative and are suitable for application with status inputs employed on many modern protection relays such as the Reyrolle RC and RM platforms.

Supervision output

Open circuit voltage: 125% of nominal
Maximum current: 15mA for 20 ms
Arc trip output

Open circuit voltage: 125% of nominal
Maximum current: 15mA for 20 ms

AUXILIARY SUPPLY

IEC60255-11

Allowable breaks / dips in supply
Collapse to zero from nominal voltage  ≤ 20ms

HIGH FREQUENCY DISTURBANCE

IEC60255-22-1 CLASS III

2.5kV 1MHz common mode
1.0kV 1MHz differential mode

No mal operation

ELECTROSTATIC DISCHARGE

IEC60255-22-2 CLASS III

8kV air discharge

No mal operation

RADIO FREQUENCY INTERFERENCE

IEC60255-22-3

10V/m, 80 TO 1,000MHz

No mal operation

FAST TRANSIENT

IEC60255-22-4

4kV, 5/50ns, 100KHz repetitive

No mal operation

INSULATION COORDINATION

IEC60255-5

Impulse voltage withstand test
5kV 1.2/50us 0.5J
Dielectric test
2.0kV RMS for 1 minute

Between all terminals and earth
The earth point is defined as the DIN rail mounting bracket
There is no isolation between any of the output terminals or flying leads. They should be considered as the same group.

CONDUCTED RFI

IEC60255-22-6

10V, 0.15 to 80MHz
No mal operation

TEMPERATURE RANGE

IEC68-2-1/2

Operating: -10 to +55°C
Storage: -25 to +75°C

HUMIDITY

IEC68-2-78

40°C and 93% RH non condensing
### Ordering Information

Generate the required ordering code as follows: e.g. 1S23-AD

**1S23 - [ ] [ ] ARC Fault Interface Module**

#### 1 OPTICAL SENSOR INTERFACE
- **A** Single 1S30 sensor input
- **B** Dual 1S30 sensor inputs

#### 2 AUXILIARY SUPPLY (Nominal)
- **A** 24V DC
- **B** 32V DC
- **C** 48V DC
- **D** 110V DC
- **E** 125V DC
- **F** 220V DC
- **G** 240V DC
- **H** 250V DC

#### 1S30 ARC FAULT SENSOR
Refer to the 1S30 Technical Bulletin for ordering information on the 1S30 arc fault sensor.

---

<table>
<thead>
<tr>
<th>Fault Condition</th>
<th>RED LED</th>
<th>Trip Output</th>
<th>GREEN LED</th>
<th>Supervise Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>One (1) Sensor open circuit</td>
<td>OFF</td>
<td>OFF</td>
<td>FLASH</td>
<td>OFF</td>
</tr>
<tr>
<td>Two (2) Sensors open circuit</td>
<td>OFF</td>
<td>OFF</td>
<td>FLASH</td>
<td>OFF</td>
</tr>
<tr>
<td>One (1) Sensor short circuit on power up</td>
<td>OFF</td>
<td>OFF</td>
<td>FLASH</td>
<td>OFF</td>
</tr>
<tr>
<td>Two (2) Sensors short circuit on power up</td>
<td>OFF</td>
<td>OFF</td>
<td>FLASH</td>
<td>OFF</td>
</tr>
<tr>
<td>Arc trip &gt;500ms (Continuous arc pick up)</td>
<td>ON</td>
<td>OFF</td>
<td>FLASH</td>
<td>OFF</td>
</tr>
<tr>
<td>Arc trip current limit exceeded</td>
<td>ON for 2s</td>
<td>OFF for 100ms</td>
<td>OFF for 2s</td>
<td>OFF for 2s</td>
</tr>
<tr>
<td>Supervise output current limit exceeded</td>
<td>OFF</td>
<td>OFF</td>
<td>FLASH - PAUSE - FLASH</td>
<td>OFF</td>
</tr>
<tr>
<td>Power supply fail</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>CPU fail</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Single sensor software identification</td>
<td></td>
<td></td>
<td>Three (3) flashes at startup</td>
<td></td>
</tr>
<tr>
<td>Dual sensor software identification</td>
<td></td>
<td></td>
<td>Four (4) flashes at startup</td>
<td></td>
</tr>
</tbody>
</table>

Figure 14: ARC Module status table
Relay Monitoring Systems Pty Ltd design, manufacture and market a wide range of electrical protection and control products for application on high voltage power systems. The company’s depth of manufacturing and engineering expertise is backed up by many years of experience since the formation of its predecessor, Relays Pty Ltd (RPL), in 1955. This experience combined with a broad base of field proven product types enables RMS to service specific customer needs by producing relays on demand and with typically short lead times.

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RMS holds NCSI (NCS International Pty Limited) registration number 6869 for the certification of a quality system to AS/NZS ISO9001:2008.

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