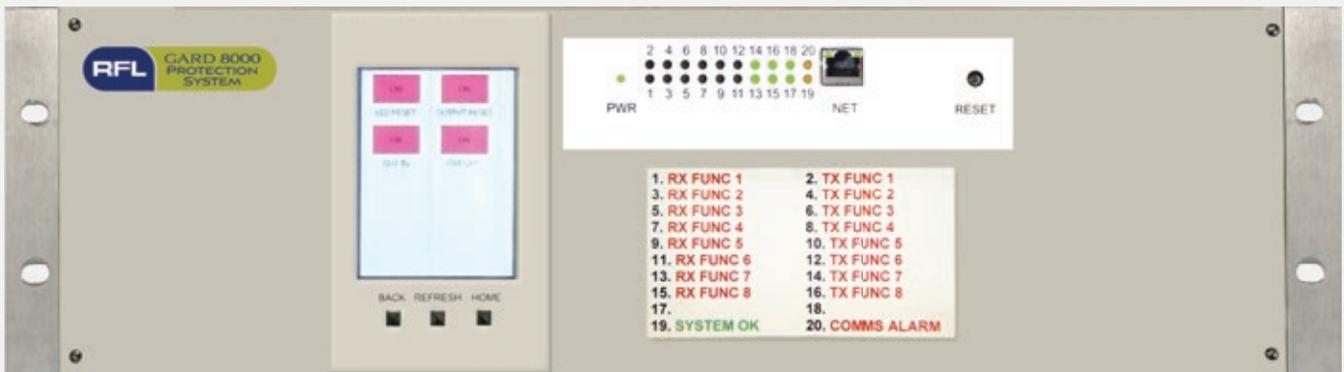




SOLUTIONS FOR AN EVOLVING WORLD

RFL GARD 21RL

DISTANCE RELAY





Your world is changing and so are we.

At RFL, we know your needs change much faster than your infrastructure. Our comprehensive line of solutions meets you wherever you are to help you bridge the gap from yesterday to tomorrow.

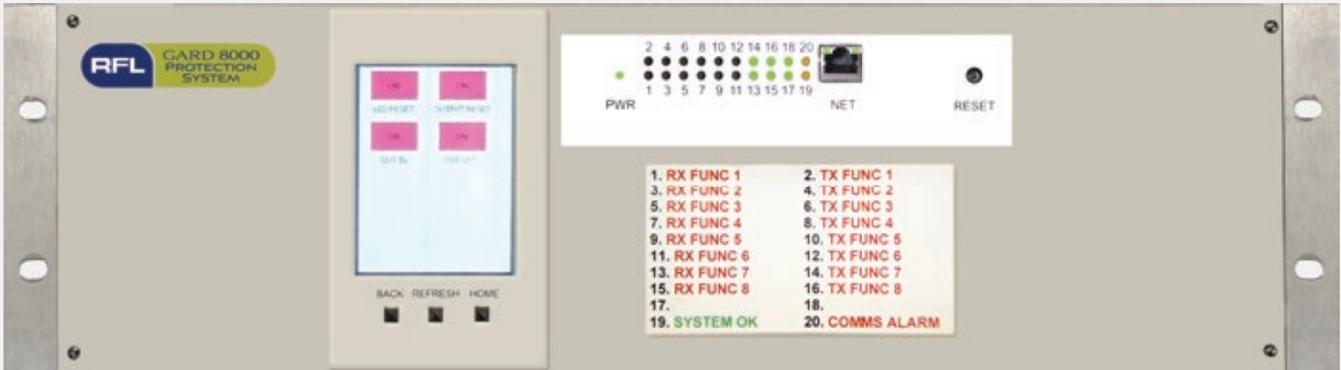
We aren't just engineering products. We are continuously innovating to give legacy equipment the advantage of today's technologies. Our highly adaptable solutions offer more features for more flexibility and a custom fit for your specific needs.

When we deliver, we also deliver our reputation. So when you open that box, you're opening a custom-engineered solution, factory-tested and ready for deployment.

And as long as you own that equipment, you own the attention of RFL. We see you as our partner and we want to ensure that our solution is working for you - now and over the long haul. RFL - delivering solutions that work. Period.

GARD 8000

Distance Relay



System Features

Plug-in Line Distance Protection in the GARD 8000 Protective Relay and Communications System

Use as a stand-alone Line Distance Relay or as a communications independent back-up for a GARD 8000 Current Differential Protection Module

Stepped Distance Protection or Distance Pilot Protection using the GARD 8000 System's communication interfaces which include audiotone, digital, fiber optic, or Power Line Carrier

Eliminates the need for external teleprotection channel devices for pilot communications

Eliminates relay-to-teleprotection wiring

Simplifies pilot protection system commissioning and configuration

3U or 6U chassis depending on number of functional modules included

Dual breaker application by combining the distance relay with breaker modules

Synchrophasor measurement

Supports NERC/FERC security standards

4 Zones, all 4 reversible

Phase-phase and phase-ground mho characteristic

Selectable quadrilateral characteristic

Built-in logic for permissive (PUTT, POTT, DCUB) and blocking (DCB) pilot schemes

Out-of-step block and trip

Loss-of-potential block

High-set and inverse time overcurrent elements

Breaker failure protection

Reclosing and synch check

Under- and overvoltage elements

Under-, over-, and rate-of-change frequency elements

Accurate Fault Locator

Digital fault records directly in COMTRADE

Optional Single Pole Trip Logic

10 Year Warranty

System Description and features

System Description

The Distance Protection Module in the GARD 8000 System is a full-featured Line Distance Relay with all protection functions required for a complete line protection terminal. It can be used as a stand-alone Main protection, to provide channel independent back-up for the current differential protection, or operate in parallel with the Current Differential Module, providing an independent, different, measuring principle.

The Distance Protection Module has four measuring zones, where all zones can be set Forward or Reverse. A Reverse Zone 4 is used in pilot schemes and/or as a back-up zone for bus faults behind the relay.

The Distance Protection Module can operate as a channel independent stepped distance relay or applied in a pilot scheme, selectable to permissive, unblocking or blocking. Weak infeed and transient block logic is included. The Distance Relay Module may use any communications interface in the GARD 8000 System. The channel interface can be dedicated to the Distance Relay or be shared with a Teleprotection System and/or a integrated Current Differential Protection Module.

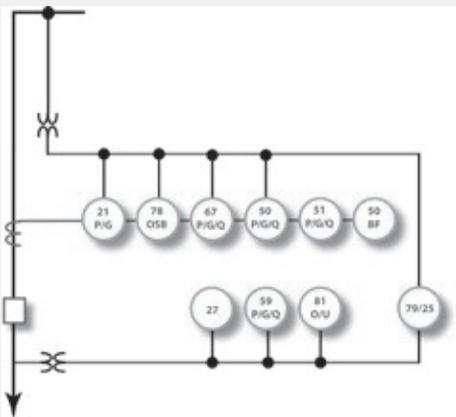


Figure 1. Distance Module Functional Diagram

Protection Features

The Distance Protection in the GARD 8000 System resides on a plug-in module with its own input transformers and protection processor. The protection function is independent from other functional modules in the system and uses the GARD 8000 platform's power supply, inputs, outputs, communications interfaces, HMI and logic processor.

Distance Protection

The GARD 8000 Distance Protection Module provides 4 distance zones with separate measuring elements for all types of faults.

Phase and ground elements have individual timer settings for each zone.

The mho characteristic is polarized by the positive sequence voltage of the corresponding phase providing a dynamic characteristic that expands with the source impedance.

The quadrilateral phase-ground elements are polarized with the negative sequence current of the corresponding phase. This provides load compensation of the reactive limiting line which will 'tilt' according to the direction and amount of load flow, eliminating underreach and overreach of Zone 1 ground distance elements.

Quadrilateral characteristic is available for all zones.

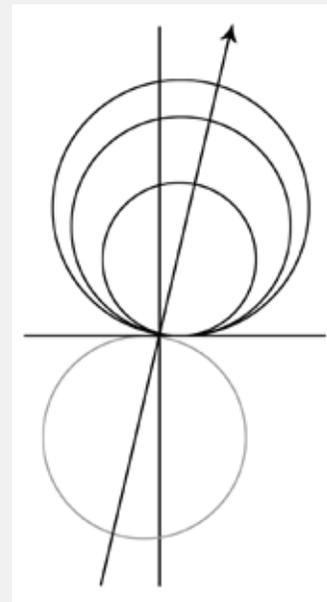


Figure 2. Distance Protection Characteristic

Operating Times

The GARD 8000 Distance Relay is using 32 samples for distance measurement. The following curves show Zone 1 operating times for SIR (Source to Line Impedance Ratio) of 0.1, 1 and 10 for different fault types. (A System frequency of 60 Hz and solid state outputs were used for all tests).

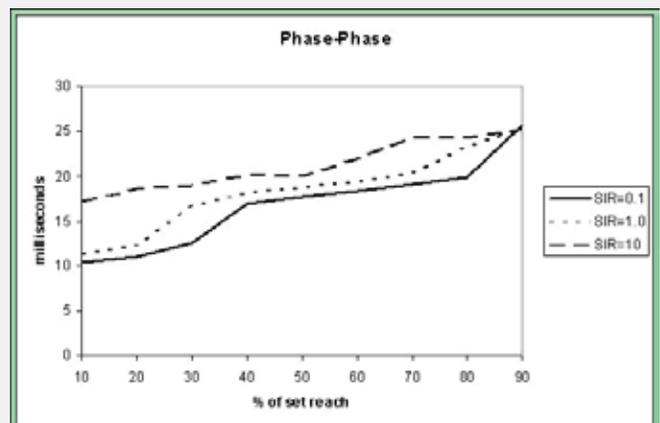


Figure 3. Phase-Phase Fault Operating Times

System Description and features (continued)

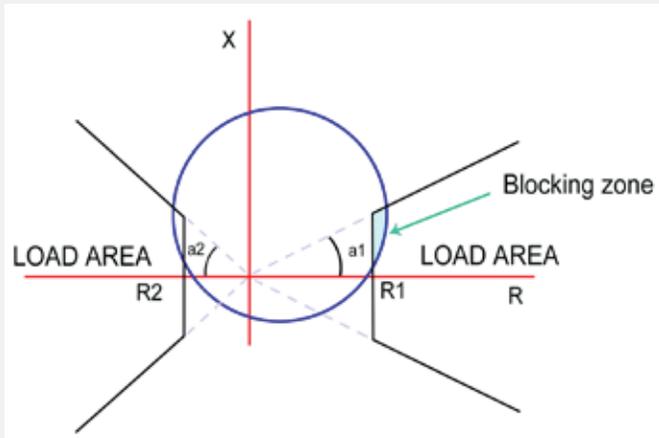


Figure 7. Load Enchroachment Characteristic

Loss-of-Load Trip

The Loss-of-load trip logic provides high-speed trip from an overreaching Zone 2 element in case the remote breaker trips. Detecting the loss-of-load in one or two phases activates the permission to trip after a set time from Zone 2 operation.

Close-into-Fault Operation

When line side potentials are used, the close-into-fault logic will provide instantaneous trip in case a fault is detected following the breaker closing. The close-into-fault logic asserts when the positive sequence voltage is below 50 V and the positive sequence current exceeds the set value. A settable 2nd harmonic restraint is applied to the current measurement.

When the positive sequence voltage exceeds 50 V, polarizing voltage is available for the distance elements and the close-into-fault logic will initiate instantaneous trip from the overreaching Zone 2 or Zone 3 elements.

Fault Locator

The GARD 8000 Distance Protection Module includes an accurate fault locator based on an algorithm with load compensation. The distance may be expressed either in miles (or kilometers) or as a percentage of line length.

Loss-of-Potential (Fuse Fail) Detector

A secure Loss-of-Potential Detector is provided in the GARD 8000 Distance Protection Module. Operation is based on low phase voltage, presence of current in the same phase and no fault present. The supervision by a fault detector ensures that the Detector will not operate during a fault condition.

The logic will detect any type of loss-of-potential condition; one phase, two phases or all three phases, provided that the load current exceeds the 0.75 A threshold required for activation.

Frequency Elements and Load Shed Functions

The GARD 8000 Distance Protection Module includes a number of frequency elements:

- 81M overfrequency, 3 steps
- 81m underfrequency, 3 steps
- 81D rate-of-change of frequency, 3 steps

The ability to freely combine these frequency measuring elements with undervoltage and overvoltage elements, and out-of-step detection allows implementation of flexible load shedding schemes tailored to the application.

Recloser

The GARD 8000 Distance Protection Module has an integrated recloser.

The reclose initiate function is set for each Zone as well as for time-delayed and instantaneous overcurrent trips.

Each reclose attempt has an individual dead-timer setting. Counters and Reset timers are also included.

When the Single Pole Trip Option is included in the GARD 8000 Distance Protection Module, additional reclosing modes are available.

Synch Check

Each of the three reclosing attempts can be supervised by the internal synch check function, according to setting.

The Synch Check unit compares the voltage magnitudes, phase and/or angles on both sides of the breaker. Each of these three conditions has their own threshold setting and ENABLE/DISABLE setting. If set to DISABLE, the condition is not checked as part of the synch check criteria.

Voltage Check

For the synch check unit to allow energizing of a dead line or dead bus, a voltage check element is included. The setting options are:

- HLHB - Hot Line Hot Bus (synch check only)
- HLDB - Hot Line Dead Bus
- DLHB - Dead Line Hot Bus
- DLDB - Dead Line Dead Bus

Breaker Failure Protection

The breaker failure protection has a re-trip and back-up trip function with associated timers. When the GARD 8000 Distance Protection Module is supplied with the Single Pole Trip Option, the breaker failure protection is provided with separate phase and ground breaker failure timers.

System Description and features (continued)

Breaker Monitoring Functions

The GARD 8000 Distance Protection records the interrupting current for each trip and accumulates it as kiloamperes squared. This number is proportional to the accumulated power actually interrupted by the breaker.

This function has two settings:

- (1) Sum (kA²) Cumulative Value
- (2) Excessive number of trips

The Cumulative Value is updated each time a breaker opening takes place. The Distance Protection Module adds up all interrupting power for the actual breaker, and may be modified to set an initial value by the user. This value can be reset to zero following breaker maintenance.

The excessive number of trips function prevents an uncontrolled sequence of openings and closings that may damage the breaker. If the set number of operations (1 - 40) is exceeded during a 30 minute period, an alarm output signal is generated. This signal can be used to operate a breaker lock-out relay.

Dual Breaker Applications

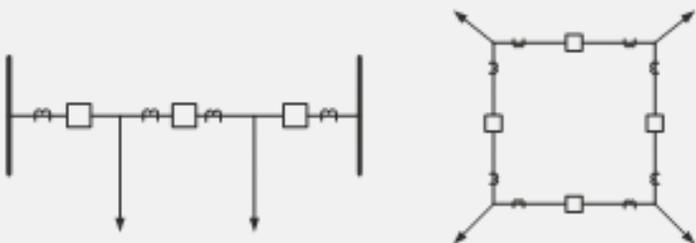


Figure 8. Breaker and a half and Ring Bus applications

A distance line protection operates on the total line current, summed from two ct's in breaker and a half or ring bus applications. However, the breaker failure relay and other breaker related protection elements need to use the individual current inputs from the ct's. The GARD 8000 System therefore complements the distance line protection with independent Breaker Modules for these additional functions. The Breaker Module includes breaker failure relay, recloser and synch check, overcurrent, voltage and frequency elements. The GARD 8000 System logic makes it easy to combine the protection modules as required by the application.

For a breaker and a half application, a GARD 8000 System can include two Distance relays, one for each line, and three independent Breaker modules, one for each breaker.

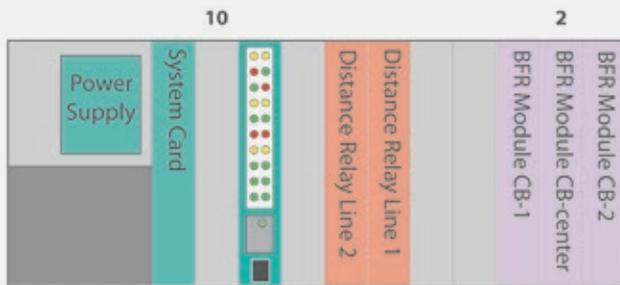


Figure 9. GARD 8000 Distance Protection for a Breaker and a half application

Synchrophasor Measurement

The Distance Protection module in the GARD 8000 System can be supplied with a Synchrophasor option. Features are:

Synchrophasors reported at a programmable rate up to 50/60 per second

C37.118 Frame format

Selectable Phasor format

Polar or rectangular

Integer or float

Phasors selection

Phase voltage and currents

Sequence voltage and currents

Message containing:

Phasors, frequency (absolute and rate of change)

Up to 8 analog values (V, I, P, Q, S, PF...)

Up to 16 digital signals

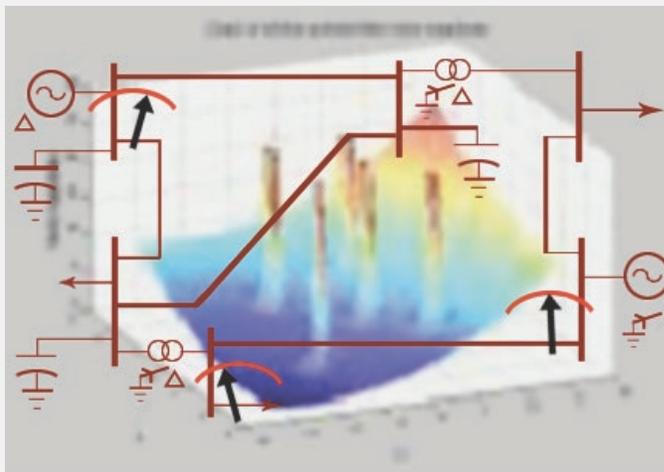


Figure 10. GARD 8000 Synchrophasor Measurement

Modules

Sequence of Event Records

The Distance Protection Module provides 100 events in addition to the 600 events provided by the GARD 8000 System SOE. Each of these 100 records give a summary of the event, including triggers and fault voltages and currents. These records are accessible directly from the Distance Relay SOE page in the web browser.

Time stamp by use of IRIG-B or the optional GPS receiver enables 1 ms event resolution.

The Distance Protection also provides 15 detailed Fault Records to help with quick fault analysis. These fault records give information about type of trip, distance to the fault and pre-fault and fault currents and voltages.

Digital Fault Records

The Distance Protection Module has an internal Digital Fault Recorder (DFR). All analog channels used by the distance protection function are recorded with 32 samples per cycle. Protection and measuring element status are available as digital channels, facilitating comprehensive fault analysis.

The fault records are stored in standard COMTRADE format and are retrieved via the GARD 8000 System web browser interface. Any compliant COMTRADE viewer can be used to display the records. RFL can provide a reader on request.

The 15 seconds memory used for DFR records accommodates from 1 to 64 records storage in non-volatile memory, depending on the set duration of the oscillographic fault record. Pre-fault time can be set to 1 - 25 cycles and the length to 5 - 240 cycles. Additional protection modules (distance or current differential) can provide additional DFR functions in the GARD 8000 System.

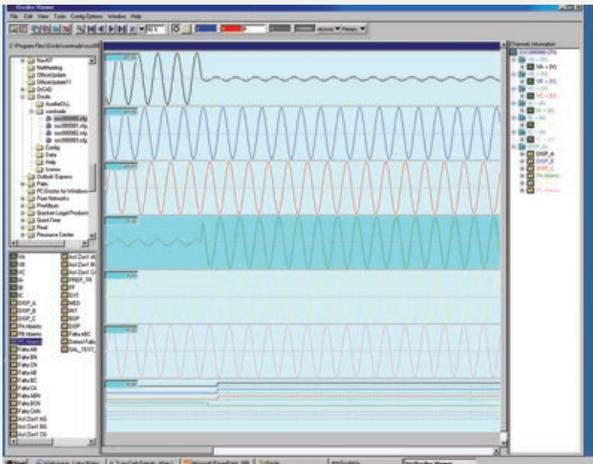


Figure 11. Digital Fault Record

Pilot Applications

The GARD 8000 Distance Protection Module is supplied with integrated pilot communications. The Base System has a multi-protocol digital interface, additional communications modules can be included as required for your application:

- More digital interfaces for redundant communications
 - Direct Fiber interfaces
 - Audio Tone
 - Power Line Carrier, FSK or On/Off selectable
 - IEC 61850 compliant Ethernet tripping module
- In addition to cost savings of 20 - 55% as compared to a conventional distance relay with external teleprotection channel device, the GARD 8000 offers increased pilot protection performance. Because of the integrated pilot logic and interface, any delays due to de-bounce timers are eliminated.

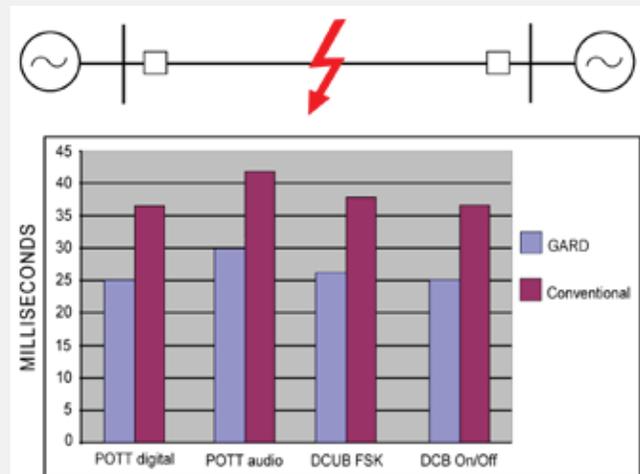


Figure 12. End-to-End Trip Times

Installation costs are reduced as there is no wiring required between relay and teleprotection; all 'wiring' is done in logic. Depending on the scheme, and communication media used, end-to-end trip time improvements of 40-85% can be expected.

Protection

Power-Line Carrier Applications

The GARD 8000 can be supplied as a Distance Protection System with built-in Power Line Carrier Module. A Distance Relay and a Power Line Carrier can be housed in one 3U chassis, or in the 6U chassis that also allows for redundancy and/or added functional modules.

Combining the Distance Relay and PLC in one package eliminates external wiring and delays associated with external interfaces, providing a faster and more reliable pilot protection system.

The GARD 8000 PLC module emulates the well known RFL 9780/9785 in one package with selectable FSK or ON/OFF operation.

Distance Protection Specifications

AC Current Inputs

Nominal	1 or 5 A
Continuous	4 times nominal
One second	100 times nominal
Burden	<0.2 VA for 5 A nominal <0.05 VA for 1 A nominal

AC Voltage Inputs

Rated voltage	120 Vac @ 60 Hz 110 Vac @ 50 Hz
Continuous	2 times nominal
Burden	<0.05 VA

Frequency

Frequency	50 or 60 Hz
-----------	-------------

Metering Accuracy

Voltages	+/- 0.1% (60 - 300V)
Currents 5A nominal	+/-2 mA/0.1% (0.5-160A)
1A nominal	+/-0.5 mA/0.1% (0.1-30A)
Phase angle	+/-0.3 deg
Power factor	+/-0.001
Frequency	+/-0.001 Hz
Active/reactive power (5A nominal and >1A load current)	
0-180 deg	0.3%
+/-15 or 165 deg	0.5% active, 5% reactive
+/-45 or 135 deg	1% active, 1% reactive
+/- 75 or 115 deg	5% active, 0.5% reactive
+/-90 deg	0.3% reactive

Distance Elements

Zone	1 - 4	5A nominal	0.01 - 100 ohms
		1A nominal	0.05 - 500 ohms
Resistive reach		5A nominal	0.01 - 100 ohms
		1A nominal	0.05 - 500 ohms

Overcurrent Supervision Elements

5A nominal	0.20 - 7.50 A
1A nominal	0.04 - 1.5 A

Instantaneous/Definite Time Overcurrent Elements

5A nominal	0.10 - 150.00 A
1A nominal	0.02 - 30.00 A
Time delay	0.00 - 300.00 seconds

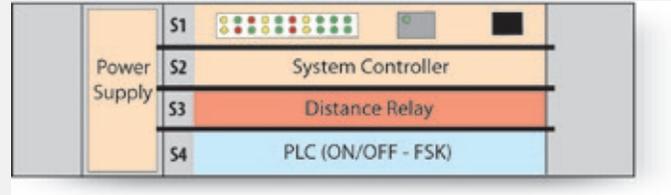


Figure 13. Distance Relay with Power-Line Carrier

All adjustments are made by use of the web browser user interface including settable transmit and receive frequencies; 30 kHz to 535 kHz.

Keying inputs, trip and alarm outputs are all making use of the GARD 8000 System's I/O modules and/or internal logic.

Directional Overcurrent Unit

Characteristic angle	0 - 90 deg
Minimum polarizing voltage	0.05 - 10.00 V
Negative or Zero sequence ground directional polarization	

Time Overcurrent Elements

5A nominal	0.10 - 125 A
1A nominal	0.02 - 25 A
Time Dial	ANSI: 0.5 - 10.00 IEC: 0.05 - 1.00 IEEE/US: 0.1 - 10
Definite time	0.05 - 300.00 sec
Moderately inverse	
Inverse	
Very inverse	
Extremely inverse	
Long time inverse	
Short time inverse	
Inverse + maximum time	
Very inverse + maximum time	
Extremely inverse + maximum time	
User defined	

Under- and Overvoltage Elements

Pick-up range	20.00 - 300.00 V
Time delay	0.00 - 300.00 sec

Frequency Elements

Pick-up range	40.00 - 70.00 Hz
Undervoltage inhibit	20 - 150 V
Rate of change	0.5 - 10.00 Hz/s

Synchronism Check Elements

Voltage difference	2 - 30%
Phase angle	5 - 80 deg
Slip frequency	0.005 - 2.00 Hz
Time delay	0.05 - 300.00 s

Recloser

No of shots	1 - 3
Dead-time	0.05 - 300 s
Reset time	0.05 - 300 s

Specifications

Pilot Communications Specifications

Audio Tone Interface

The GARD 8000 System can be supplied with two or four FSK audio tone transceivers. All transceivers are bi-directional and can be programmed for any operating frequency or bandwidth between 300 and 4,000 Hz. Channel one can be set to operate as a modem channel. This channel provides a communication link to the remote terminal for remote interrogation, setting changes or system testing from the local terminal.

Displayed Level Accuracy

The levels displayed on the front panel and through remote access will be within 1 dB of the actual values.

Operate Time

Audio Tone Units (average trip times, Dual Tone System):

±	30.	Hz	Shift:	26.47 ms
±	42.5	Hz	Shift:	20.57 ms
±	60.	Hz	Shift:	14.78 ms
±	75.	Hz	Shift:	12.65 ms
±	120.	Hz	Shift:	11.05 ms
±	150.	Hz	Shift:	10.12 ms
±	240.	Hz	Shift:	9.22 ms

Audio Interface Configurations

Single Two-Wire Terminals
Dual Two-Wire Terminals
Single Four-Wire Terminals
Dual Four-Wire Terminals

Recommended Channel Frequencies

Range: 300 Hz to 4000 Hz
Resolution: 1Hz

Transmit Level

Adjustable from -40 dBm +10 dBm in 0.25 dB steps

Receiver Sensitivity

Minimum Input Level: -40 dBm
Maximum Input Level: 0 dBm

Receiver Dynamic Range (referenced to center point)

-17 dB to + 11 dB

Adjacent Channel Rejection

40 dB

60-Hz Rejection

A received tone at -30 dBm will not be affected by a 50 Hz or 60 Hz signal as great as 40 Vrms with optional 50/60 Hz blocking filter.

Amplitude Stability

The Transmit level will vary by no more than ± 1 dB.

Spurious Output

All harmonics and spurious outputs are at least 40 dB lower than the carrier.

Transmitter Stability

The transmitter frequency is stable within 0.02 percent over the full range of temperature and input power variations.

Trip Boost

Amplitude: Adjustable from zero to +12 dB in 1 dB steps
Duration: Adjustable from zero to 30 seconds in 0.5ms steps

Input and Output Impedance

600 Ohms

Digital Interfaces

The GARD 8000 Digital Teleprotection functionality is provided on the main controller module at no additional cost. Up to 32 functions of digital protection are available for use over a maximum of 4 digital channels. Each of the 4 channels can be set to transmit 4 commands, 8 commands, or 7 commands to emulate a RFL 9745 Digital Teleprotection Channel.

Operate Time

3 ms maximum in the most secure mode

Digital Interface Options

T1/E1; 1.544 Mbps/2.048 Mbps for direct connection to a SONET/SDH multiplexer
RS-449; 56/64 kbps - 768 kbps for connection to a CSU/DSU or a T1 multiplexer
X.21, V.35; 64 - 768 kbps
G.703; 64 kbps
Fiber, 64 - 768 kbps

Wavelength & Emitter Type	Fiber Type	Connector Type	System Gain	Typical Distance
ANSI C37.94	Multimode	ST	25 dB	1 km/0.6 miles
1300nm LED	Singlemode	ST	19 dB	27 km/17 miles
1300nm Laser	Singlemode	ST	36 dB	59 km/37 miles
1550nm Laser	Singlemode	ST	30 dB	90 km/56 miles

Specifications subject to change without notice

General Specifications

Single or Redundant Power Supply

24V	24 Vdc only Range 19-29 Vdc
48/125V	120 Vac Range 38 - 150 Vdc or 96 - 132 Vac
250V	220/250 Vdc or 220 Vac Range 200 - 300 Vdc or 200 - 240 Vac
Burden	Maximum 100 W with fully populated 6U chassis

Terminal Connections

Rear Screw Terminals

Inputs and Outputs

The GARD 8000 System can be configured with up to 20 input and output modules on the rear part of the chassis. Outputs are jumper selectable Form A or Form B, and in addition each input and output has an inverter and a timer associated with it that has settings for both pick-up (debounce) delay and drop-out (pulse-stretch) delay.

Optically Isolated Inputs

Quantity: Six per module
Jumper selectable Input Voltage: 24/48/125/250 Vdc

Rating	No operation	Operates	Max Input Voltage	
	24	<14	>19	36
	48	<28	>37	68
	125	<70	>94	150
	250	<140	>189	300

Input Current: Minimum 1.5 mA
Minimum Pulse Width: 0.03 ms, additional debounce time set with logic timer settings

Solid-State Outputs

Quantity: Six per module
Output Current: Maximum 1 A continuous, 2 A for one minute, or 10 A for 100 msec
Open-Circuit Voltage: 300 Vdc maximum
Pick-up Time: 0 msec

Relay Outputs

Quantity: Six per module
Relay Pick-up Time: 4 msec
Output Current Rating: 6 A continuous
Surge: 30 A for 200 msec

Alarm Relays

Quantity: Two
Contacts: SPDT (Form C)
Rating: 100 mA 300 Vdc resistive load

Temperature
Operating: -20° C to + 75° C (-4 F to 165 F)
Storage: -40° C to +85° C (-40° F to +185° F)

Relative Humidity

Up to 95 percent at +40° C (+104° F), non-condensing

System Ports

Front: Electrical TCP/IP (RJ45)
RS-232
Rear: Electrical (RJ45) or optical TCP/IP
RS-232
RS-485
Optional network port(s): Modbus
DNP 3.0

Time-Code Input

BNC connector for IRIG-B unmodulated (logic-level) or modulated (10 V peak-peak, maximum)

BNC connector for 1- PPS (pulse per second) reference input (logic-level)

Optional GPS receiver (with external antenna). With GPS option installed the system outputs logic-level IRIG-B and 1-PPS signals

RFI Susceptibility

ANSI PC37.90.2 (35 Volts/Meter)
IEC 255-22-3 (RFI Class III)

Interface Dielectric Strength

All contact inputs, solid-state outputs, power supply inputs and relay outputs meet the following specifications:

ANSI C37.90-1989 (Dielectric)
ANSI C37.90.1-2002 (SWC and Fast Transient)
EN 60255-5 (1500 Vrms Breakdown Voltage and Impulse Withstand)
IEN 60255-22-1 (SWC Class III)
EN 60255-22-2 (ESD Class III)
EN 60255-22-4 (Fast-Transient Class III)
EN 60834-1

Warranty

RFL's standard warranty for all GARD 8000 Systems is **10 years** from date of shipment for replacement or repair of any part which fails during normal operation or service.

Specifications subject to change without notice

Examples of GARD 8000 System Configurations

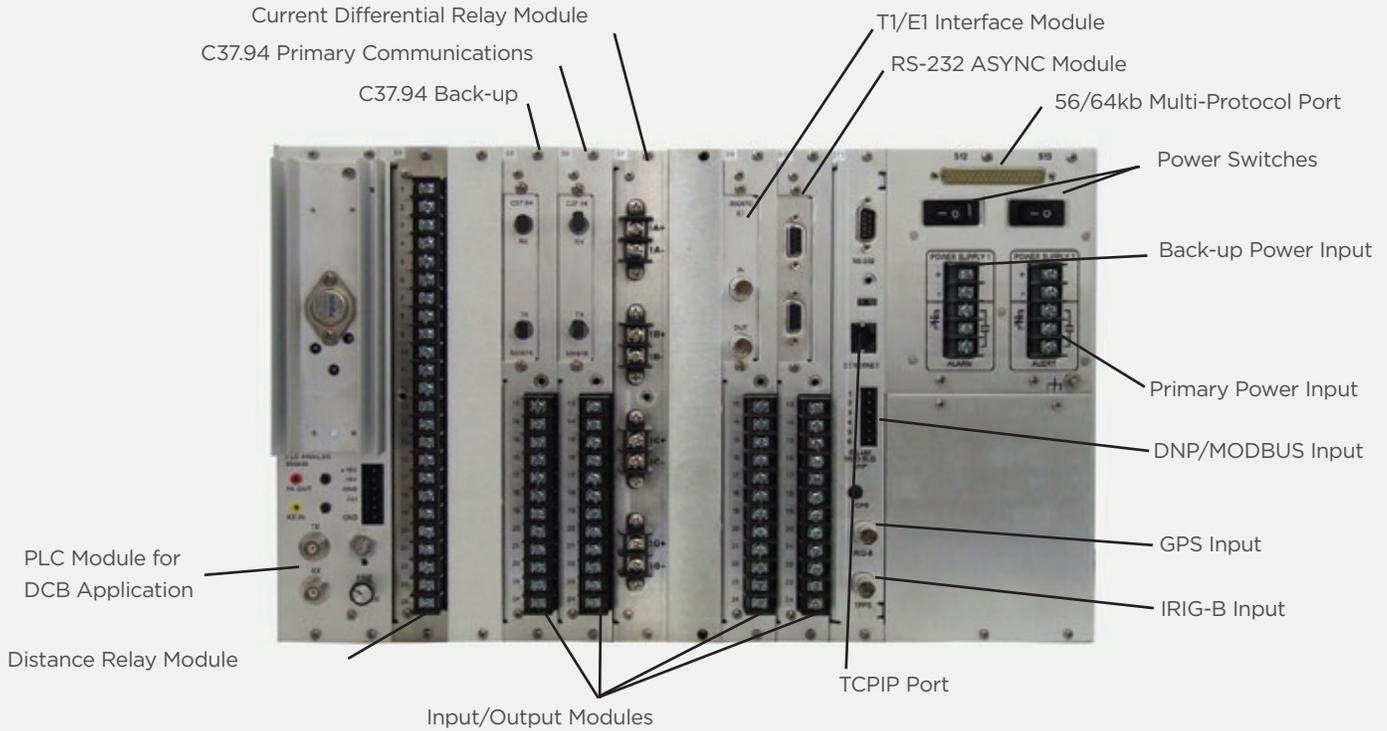


Figure 14. Rear View 6U GARD 8000 with Distance Module with Powerline Carrier Interface and Current Differential Relay with Primary and Back-Up Communications

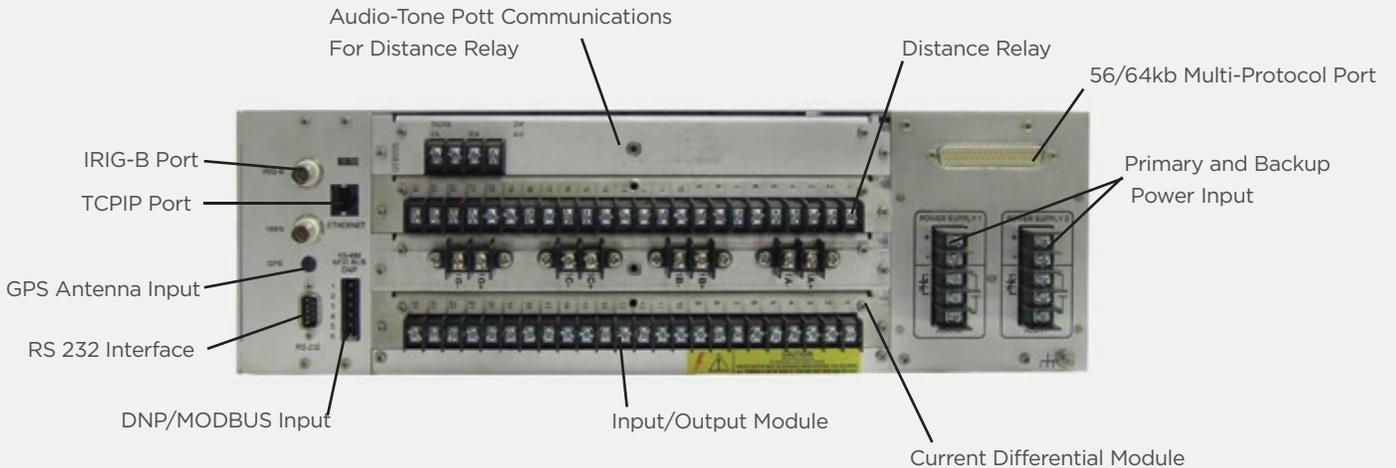


Figure 15. Rear View 3U GARD 8000 with Current Differential Module with Digital Communications and a Distance Module with Audio-Tone Communications

Dimensions

GARD 8000 Single Function PLC 3U System Dimensions



Figure 11. Rack or Cabinet Mounting (3U)

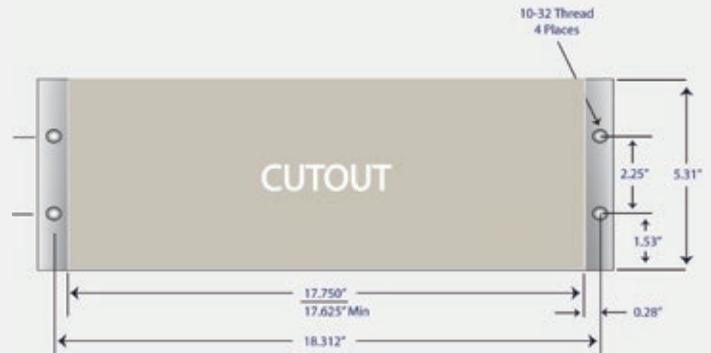


Figure 12. Panel Mounting (3U)

6U System Dimensions



Figure 13. Rack or cabinet Mounting (6U)

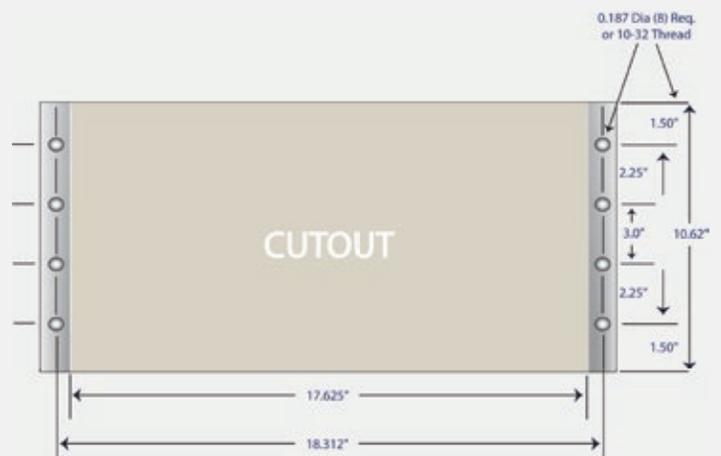


Figure 14. Panel Mounting (6U)

Notes



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RFL GARD 21RL