
RFL
SOLUTIONS FOR AN EVOLVING WORLD
HUBBELL

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.

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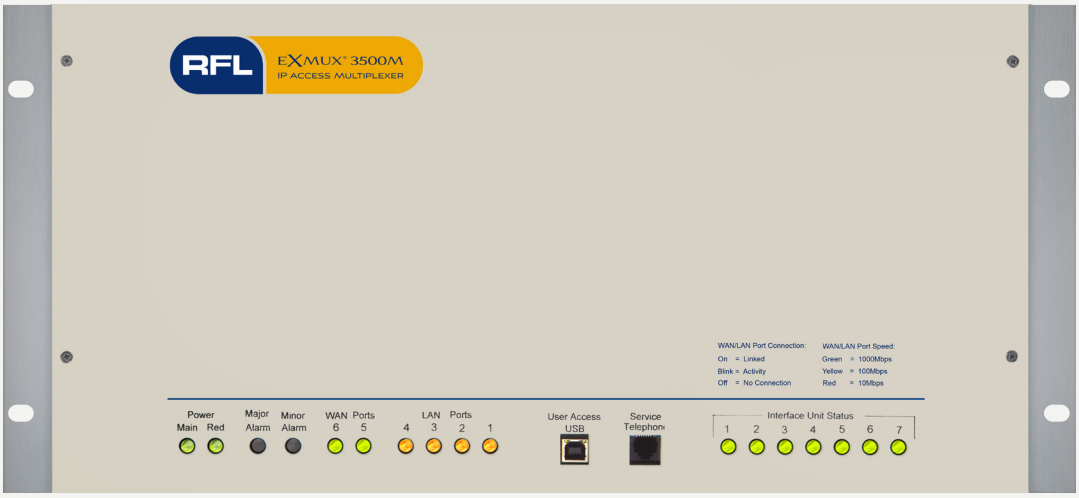
SOLUTIONS FOR AN EVOLVING WORLD

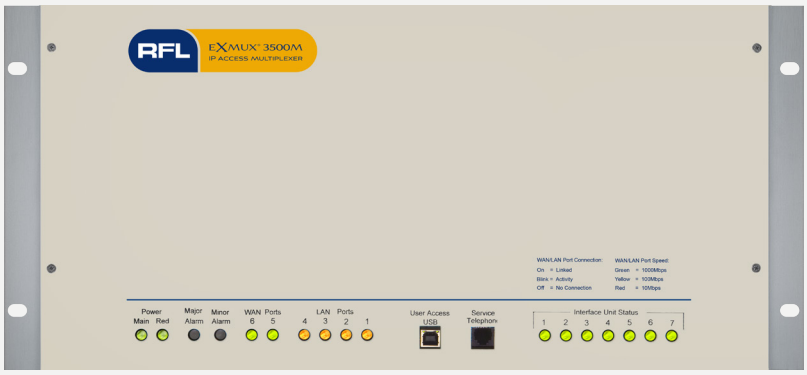
EXMUX® 3500

IP ACCESS MULTIPLEXER



HUBBELL®

eXmux® 3500



System Description

The RFL eXmux 3500 is a substation-hardened IP Access Multiplexer engineered for mission critical infrastructures to transport voice, serial, relaying protection, SCADA, video and Ethernet data communications over Ethernet/IP or MPLS networks, providing the flexibility of backward compatibility with legacy devices and forward compatibility with Ethernet devices on the same communications platform. Designed into the eXmux 3500 is a distinctive “Hitless Switching” feature with zero-data-loss path recovery technology and a Digital Access Cross-Connect (DACS) function for cross-connecting DS0s between T1/E1 circuits and/or eXmux 3500 interface unit. The product is designed for harsh applications and is available in two chassis configurations; a mission-critical model that offers module hot-swap capabilities for all functional cards and a economical compact model for applications where module hot swap capability is not required.

Key Features & Benefits

Chassis Configurations / Hot Swap & Compact:

For Mission Critical applications the eXmux 3500 is available with a Hot Swap Module option where all modules of the eXmux 3500 are field replaceable with the unit powered. All interfaces units, power supplies, and switch can be replaced in the field in seconds. The Hot Swap model is a 5RU high 19″ rack mount chassis while the compact model is a 3RU high 19″ rack mount chassis.

Legacy Interfaces:

Accommodates up to 7 different DS0 or T1/E1 legacy interface units; plus a standard T1/E1 interface and a 2-wire telephone service channel.

Advanced VNMS with DS0 Grooming:

An advanced Visual Network Management Software for effortless configurations, port mapping, maintenance and remote firmware upgrade that includes an Integrated Digital Access Cross-Connect System (DACS), allowing individual DS0 circuits from any legacy T1/E1 system to be connected to any DS0 circuits within the eXmux 3500 network or to another TDM network.

Interface Units (IU):

Supports legacy IUs such as: RS-232, RS-485, Serial Server, RS-422/530, V.35, X.21, G.703, C37.94, Teleprotection, 2W & 4W E&M, 2W FXO, 2W FXS and T1/E1.

Teleprotection System:

An integrated end-to-end teleprotection function that provides 4 bi-directional transfer trips commands in addition to 2 controlling inputs logic and 2 outputs for alarming & status. It is mid-span compatible with the IMUX 2000 T1/E1 multiplexer MTS Teleprotection System.

Value:

A lower cost solution than SONET/SDH or even T1/E1; Along with a simple and more efficient network that reduces maintenance cost and increases user productivity.

Cyber Security:

SNMPv3 for Authentication and Encryption along with an embedded User Access Management System and other cyber security features meeting NERC requirements.

Real Time Critical Applications:

Designed for real-time critical data applications such as SCADA/RTU, Relaying and Teleprotection with minimum latency.

Hitless Switching:

A field proven path redundancy feature with zero-data-loss, making it ideal for critical infrastructure and protective relaying applications.

Key Features & Benefits (continued)

Resilient & Dependable:

Enhanced reliability by offering optional redundant power supplies and path redundancy using MSTP (Multiple Spanning Tree Protocol) or RSTP (Rapid Spanning Tree Protocol) technology.

Bandwidth:

Backbone communications is at a Gigabit Ethernet (GigE) speed, equivalent to about twice the speed of a SONET/SDH OC-12/STM-4.

Compliance:

Designed for harsh environment with Immunity from SWC, ESD & RFI; convection cooling with operating temperature: -30 C to +65 C.

IEEE P1613; IEC61850-3; ANSI C37.90.2; ANSI C37.90.3

Technology

Uses TDM over IP technology that allows point-to-point legacy equipment to communicate over an IP network that includes an Integrated Layer 2 Managed Ethernet Switch including two GigE Uplink (WAN) Ports and four fast Ethernet (LAN) ports.

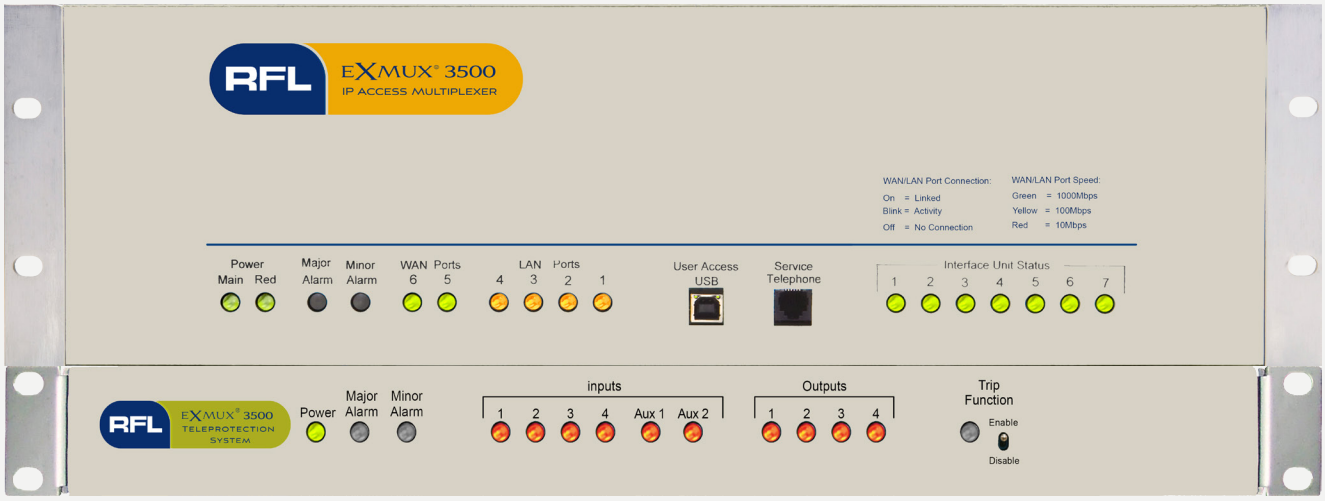
System Description (continued)

Converging two important traffic types into one infrastructure provides the benefit of connecting traditional Voice, Video, Serial data, and relaying protection circuits over Ethernet networks taking advantage of the simplicity and efficiency of IP routing and Ethernet switching. This proven concept offers a cost-effective and feature-rich solution that bridges the gap between the TDM legacy and the modern IP world, achieving the best of both.

The eXmux 3500 comes with an advanced Graphical Visual Network Management Software (VNMS) for Operations, Administration, Maintenance and Provisioning (OAM&P). The VNMS is intuitive and user-friendly, making configuration, interface port mapping and diagnostics effortless. VNMS communications uses the latest SNMPv3 for authentication and encryption along with cyber security features meeting NERC-CIP requirements.

The eXmux 3500 can support any network topology such as Linear, Star, Rings and Mesh. When configured in a ring topology, or, when an alternate path exists, each interface port can be individually configured for “Redundancy”, allowing the device to transmit the data to both WAN ports simultaneously. If a path failure occurs, data continues to reach its destination with no interruptions. The average port interface latency (back-to-back channel delay) is less than 10 milliseconds (ms). When the eXmux 3500 is setup for optimal configuration, latency can be less than 5ms. The low latency capability and the unique “Hitless Switching” mechanism allow critical real-time applications such as SCADA,Teleprotection and Relaying over an IP network just as they are done today on TDM networks.

The eXmux 3500 uses TDM over IP technology and an intergraded Layer 2 Managed Switch, which allows the unit to support Legacy Interfaces such as T1/E1, RS-232, RS 485, Serial Server, RS-530/422, V.35, X.21, G.703, C37.94, Teleprotection and various Voice interfaces, along with native IP solutions. A two-wire telephone service channel is incorporated to provide in-band voice communication to any eXmux 3500 connected to the network, creating the classic feel of a legacy communications device.



eXmux 3500 with Modular Teleprotection System (TPS)

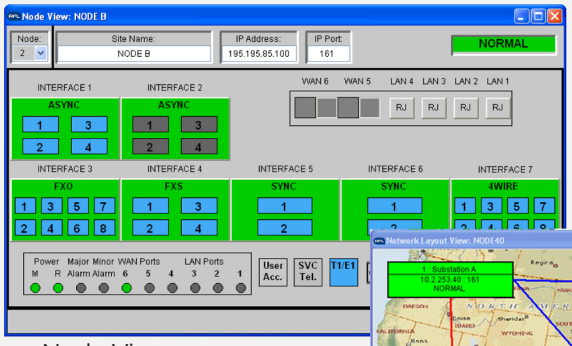
eXMUX® 3500 Visual Network Management Software

The eXmux 3500 IP Access Multiplexer comes with an advanced Graphical User Interface (GUI) Network Management Software for Operations, Administration, Maintenance and Provisioning (OAM&P). The intuitive and user friendly eXmux 3500 VNMS is designed to allow the user to manage their eXmux 3500 network, making configuration, port mapping, network monitoring and diagnostics simple and easy.

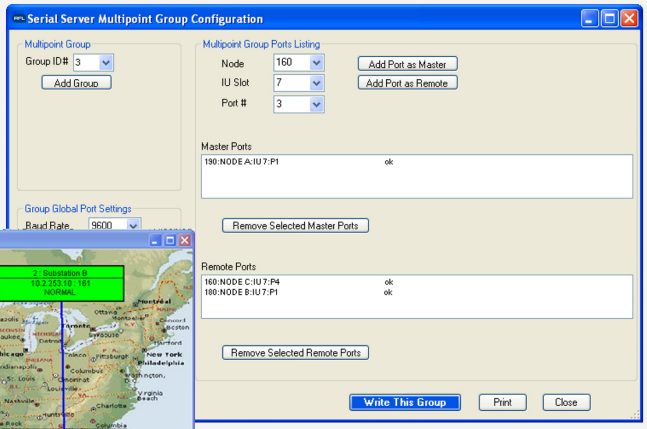
eXmux 3500 Visual Network Management Software Feature Summary:

The VNMS communicates using the latest SNMPv3 for authentication and encryptionalong with cyber security features meeting NERC requirements. The Network view provides the user an overall view of the network and the status of each node in the network and is further enhanced by allowing the user to graphically represent the physical interconnection of each node in the network. The Node view displays a virtual physical view of the unit as configured with real-time status information. Programming details of each module are easily accessible by a simple double click on the module.

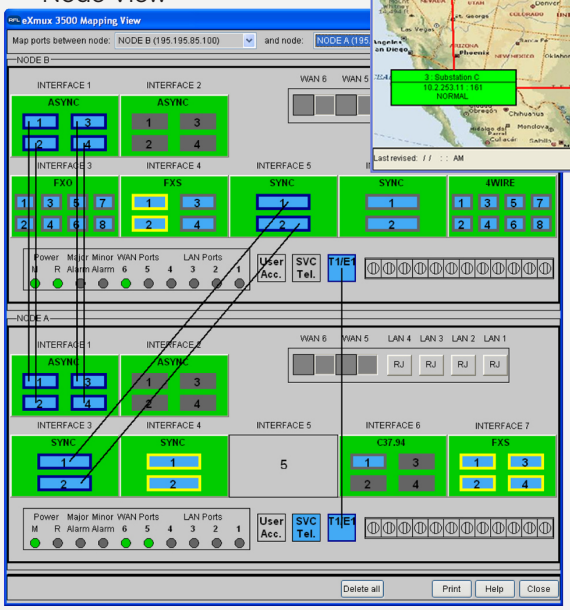
The uniquely designed Port Mapping interface allows the user to easily map any port on an eXmux 3500 to any other eXmux 3500 on the network by a simple point and click ("Map this Port") function. The dynamic Current Active Alarm view gives the user specific information as to which node is in alarm, the type of alarm, the source and the description of the alarm so that diagnostic can be straightforward and quick. The "Tooltip" function provides the user "On-demand" information on any setting, status and alarm from any screen without the need for a manual or cumbersome Help function.



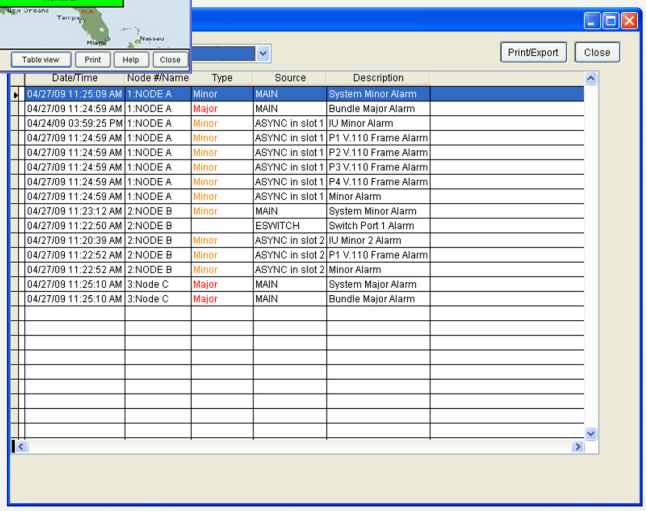
Node View



Serial Server Multipoint

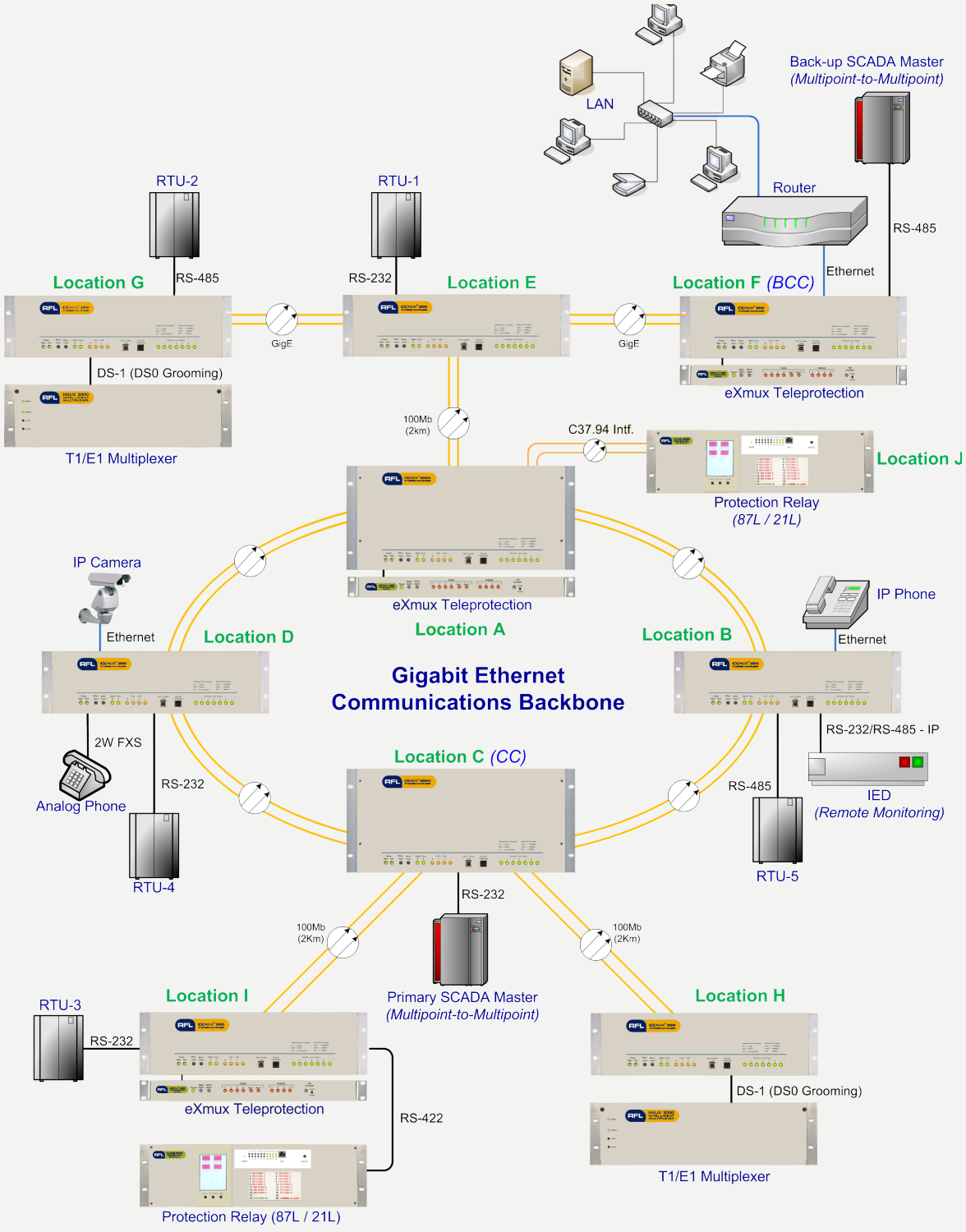


Mapping View



Current Active Alarm View

Network Diagram Example



The above example is a typical communications network using the eXmux 3500 configured with GigE Fiber Interface for the communication backbone and 100Mb FX on the linear and star setups. The communications network is able to transport both existing legacy devices with RS-422, RS-232, RS-485, 2W-FXS, specific DS0's from the DS-1 & C37.94 interfaces, Teleprotection commands and IP devices using the eXmux 3500 common IP platform.

Technical Specifications

Interface Units (IU)

4 Port Synchronous Interface
Protocol supported: RS-422/RS-530, V.35, X.21
Signal Interconnection: DCE / DTE
Control line: RTS and CTS
Connector: DB-25 Female
Slot(s) occupied: 2
Data Rates: 56Kbps, Nx64Kbps (N=1 to 31)
Loopback: Local and Remote

4 Port RS-485 Interface
Protocol supported: RS-485
Operating mode: 2 or 4 Wire
Connector: Compression terminal blocks
Slot(s) occupied: 1
Data Rates: 600bps to 38.4Kbps
Loopback: Local and Remote

4 Port Serial Server Interface
Protocol supported: Raw socket mode, SSH,
Telnet, DNP3-Serial to DNP3-IP
Application: Point-to-point, PC Client, Multipoint-to-multipoint
Operating Mode: RS-232 or RS-485 4-Wire
Connector: DB-9 Female
Slot(s) occupied: 1
Data Rates: 300bps to 115Kbps
Loopback: Local and Remote

4 Port G.703 Co-directional Synchronous Interface
Signal Interconnection: DCE / DTE
Connector: DB-15 Female
Slot(s) occupied: 2
Data Rate: 64Kbps
Loopback: Local and Remote

4 Port C37.94 Synchronous Relaying Interface
Connector: ST
Slot(s) occupied: 1
Data Rates: Nx64Kbps (N=1 to 12)
Conforms to ANSI C37.94
Loopback: Local and Remote

8 Port Asynchronous Interface
Protocol supported: RS-232, V.24
Control line: RTS and DTR
Connector: DB-9 Female
Slot(s) occupied: 2
Data Rates: 600bps to 38.4Kbps
Loopback: Local and Remote

8 Port 4-Wire & 4 Port 2-Wire E&M Audio Interface
Coding: PCM
Signaling: Type I, II, III & V
Connector: RJ-45
Slot(s) occupied: 1
Conforms to AT&T Publication 43801
Loopback: Local and Remote

8 Port 2-Wire FXO Interface
Coding: PCM
Signaling: Loop start
Connector: RJ-11
Slot(s) occupied: 1
Conforms to AT&T Publication 43801

4 Port 2-Wire FXS Interface
Coding: PCM
Signaling: Loop start
REN per Port: 4
Connector: RJ-11
Slot(s) occupied: 1
Conforms to AT&T Publication 43801

T1/E1 Interfaces

Built-in single T1/E1:
Framer type: Electrical T1 or E1
Framer mode: Pass-thru or DS0 grooming
T1 framer: Conforms to ANSI T1.102-1993, AT&T 62411 & 43801
E1 framer: Conforms to ITU G.703, G.823 & G.704
Connector: RJ-48C
Loopback: Local and Remote

Single Port T1/E1 Interface:
Framer type: Electrical T1 or E1
Framer mode: Pass-thru or DS0 grooming
T1 Mode: Conforms to ANSI T1.102-1993, AT&T 62411 & 43801
E1 Mode: Conforms to ITU G.703, G.823 & G.704
Connector: RJ-48C and DB-15
Loopback: Local and Remote

Digital Teleprotection System

2 Port eXmux TPS Interface Unit:
Signal Interconnection: RS-485
Interface Connector: DB-9 Female
Slot(s) occupied: 1
Data Rate: Two independent 64Kbps channel
Records: 1500 SOE records
SOE synchronization: NTP/SNTP/IEEE 1588
Loopback: Local and Remote
Compatibility: IMUX 2000 MTS

eXmux TPS I/O Box:
Interface Connector: DB-9 Male
Inputs: 4 Optically isolated (voltages: 24V, 48V,
125V or 250V), 2 auxiliary controlling inputs
Outputs: 4 Solid state or Relay
Terminal Block: Compression or Screw type
Status: Inputs, Outputs, Power, and alarms
Alarms: Minor and Major alarm and form C contacts
Trip Function Disable Switch

Technical Specifications Continued

Layer 2 Managed Efthernet Switch

WAN Ports
Number of Ports: 2
Copper Ports: 10/100/1000 Base-TX
Fiber SFP Ports: 100 Base-FX or 1000 Base-FX Fiber Connector: LC

Dual Fiber
100 Base-FX distance options: 2km (2.4mi), 10km (6.21mi), 40km (24.8mi), 80km (49.7mi)
1000 Base-FX distance options: 550m (0.34mi), 10km (6.21mi), 40km (24.8mi), 80km (49.7mi), 120km (74.5 mi)

Single Fiber:
1000 Base-FX BWDM 10km (6.21mi) TX1310/RX1490
1000 Base-FX BWDM 10km (6.21mi) TX1490/RX1310
1000 Base-FX BWDM 120km (74.5mi) TX1490/RX1550
1000 Base-FX BWDM 120km (74.5mi) TX1550/RX1490

LAN Ports
Number of Ports: 4
Copper Ports: 10/100 Base-TX
Fiber Ports: 100 Base-FX
Fiber Fiber Connectors: ST or SC
Fiber Distance: 2km & 30km

Features
VLAN, QoS, CoS, ToS/DS, SNMPv3, IGMP Snooping & querying, Port mirroring, Broadcast & multicast storm protection, Full duplex w/ flow control, 32Gbps throughput for max speed on all ports, Supports RSTP and MSTP

Standards
All IEEE 802.3 compliant devices are supported

Power Supply
19-32 VDC
38-150 VDC / 88-130 VAC

Mechanical

Standard
19" Rack Mount (3RU)
H: 5.25"(144mm) W: 19"(483mm) D: 11"(279mm)
Status LEDs (front and rear for either front mount or rear/wall mount)

Hot Swap
19" Rack Mount (5RU)
H: 8.75" (222mm) W: 19: (483mm) D: 11" (279mm)
Status LEDs (front and rear for either front mount or rear/wall mount)

User Interface / Service Channel
USB Port User Access for IP address setup
LAN/WAN port for Visual NMS GUI
2-Wire Telephone Service Channel

Environmental
Convection cooling (No Fans)
Operating temperature: -30 C to +65 C (-22 F to +149 F)
ANSI/IEC SWC, ESD, RFI compliant
IEEE1613, IEC61850-3 compliant
200-300 VDC
200-275 VAC

Environmental & Safety Compliance

System and Chassis
EN 60950: 2002 Safety of information technology equipment
EN 60825-2: 2004 Safety of laser products — Part 2
EN 55022: 1998 Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
EN 55024: 1998 Information technology equipment – Immunity characteristics - Limits and methods of measurement IEC 61850-3 Environmental standard
EN 61000-4-2 (8/15 KV ESD) (front of chassis)
EN 61000-4-3 / EN 61000-6-4 – Radiated RFI immunity.
EN 61000-4-6 / EN 61000-6-2 – Conducted RFI immunity
ANSI C37.90.2 – EMI Withstand
ANSI C37.90.3 – (ESD Withstand, front of chassis)
IEEE P1613 – (Environmental, ESD, RFI, Shock & Vibration)

Power Supply and Alarm contacts
EN 61000-4-4 / ANSI P1613 / ANSI C37.90.1 (4 KV EFT)
EN 61000-4-5 (Surge withstand)
EN 60255-5 / ANSI P1613 (5 KV Impulse)
EN 60255-5 / ANSI P1613 (2.8 KV High Pot)
EN 60255-22-1 (Damped Oscillatory Disturbance)
ANSI C37.90.1 / ANSI P1613 (Oscillatory)
IEC 60834-1 (Power supply disturbance tests)

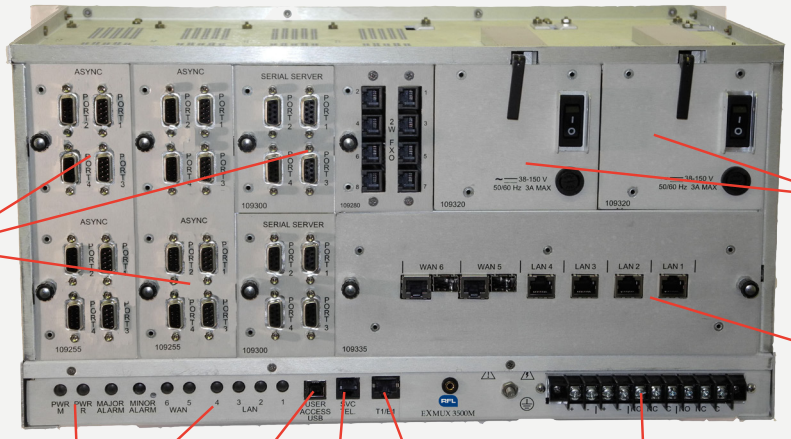
Synchronous Data Ports
All Common Mode Using Capacitive Clamp and Shielded Cable
EN 61000-4-4 / ANSI P1613 / ANSI C37.90.1 (4 KV EFT)
EN 60255-22-1 (2.5 KV, 1 MHz Damped Oscillatory)
ANSI C37.90.1 / ANSI P1613 – (2.5 KV Oscillatory)

Four Wire Audio Ports, T1/E1 Ports
EN 61000-4-2 / ANSI C37.90.3 / ANSI P1613 (8/15 KV ESD)
EN 60255-5 / EN 60834-1 / ANSI P1613 (0.72 KV High Pot, common mode)

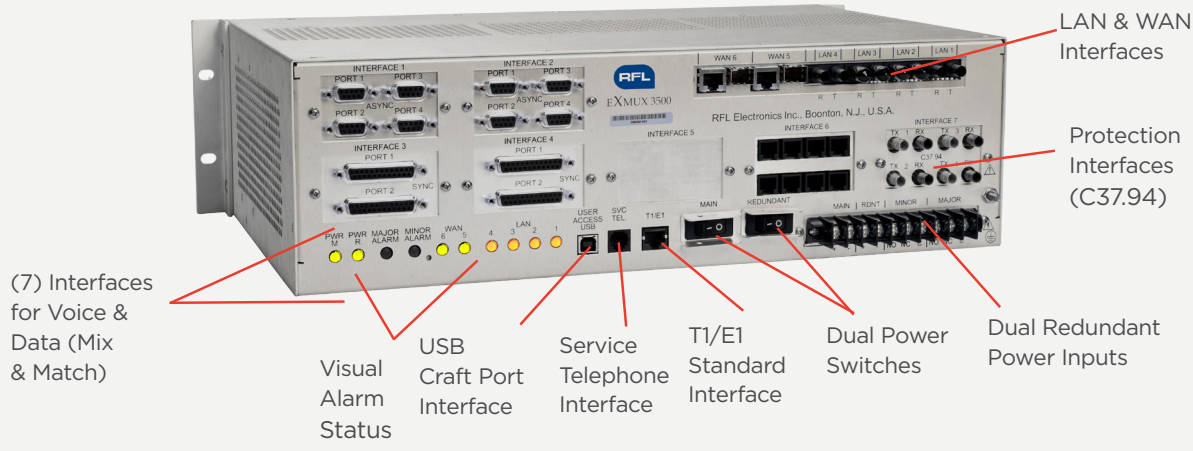
VF Ports and Asynchronus Ports
EN 61000-4-2 / ANSI C37.90.3 / ANSI P1613 (8/15 KV ESD)

User Interface Ports
EN 61000-4-2 / ANSI C37.90.3 / ANSI P1613 (8/15 KV ESD)

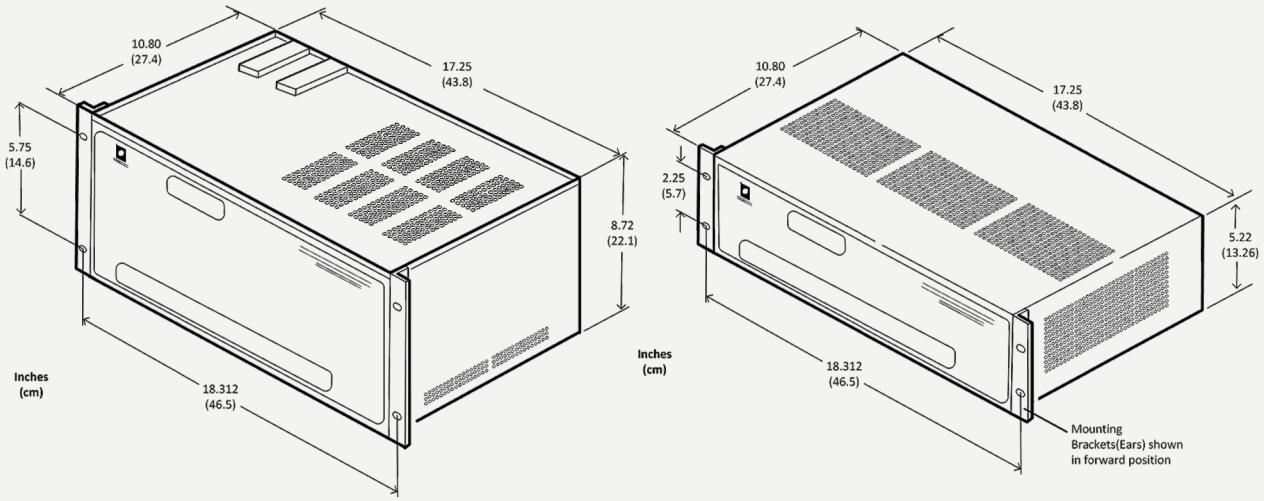
eXMUX® 3500M Chassis Interface Overview



eXmux 3500 Chassis Interface Overview



Mounting Information



RFL EXMUX 3500/3500M - IP Access Multiplexer

Ordering Information

RFL Smart Number Description (fill in blanks):	EX	CM	MP	RP	L	W5	W6	S3 (D)	S4	S1 (D)	S2	S5 (D)	S6	S7
CHASSIS & MOTHER BOARD STYLE														
Non-Modular		M												
Modular Hot-Pluggable		H												
MAIN POWER SUPPLY														
24 VDC w/Terminal Block			1											
38-150VDC / 110VAC w/Terminal Block			2											
200-300VDC w/Terminal Block			3											
24 VDC w/Compression Block			4											
38-150VDC / 110VAC w/Compression Block			5											
200-300VDC w/Compression Block			6											
220VAC w/Terminal Block			7											
220VAC w/Compression Block			8											
REDUNDANT POWER SUPPLY OPTION														
None				0										
24 VDC				1										
38-150VDC / 110VAC				2										
200-300VDC				3										
220VAC				4										
ETHERNET SWITCH WITH LAN PORTS (1 -4)														
4-RJ-45 10/100 Base TX					1									
4-2km MM Optical 100 Base FX w/ST					2									
4-2km MM Optical 100 Base FX w/SC					3									
2-RJ-45 10/100 BaseTX and 2-2km MM Optical 100 Base FX w/ ST					4									
2-RJ-45 10/100 BaseTX and 2-2km MM Optical 100 Base FX w/ SC					5									
2-RJ-45 10/100 BaseTX and 2-30km SM Optical 100 Base FX w/ ST					6									
2-RJ-45 10/100 BaseTX and 2-30km SM Optical 100 Base FX w/ SC					7									
4-30km SM Optical 100 Base FX w/ST					8									
4-30km SM Optical 100 Base FX w/SC					9									
ETHERNET SWITCH WAN PORT 5 & Port 6 Option														
Electrical RJ-45 10/100/1000 Base TX						A								
One[1] SFP - 100Base-FX 1310nm 2km/1.2mi MM LC Connector						B								
One[1] SFP - 100Base-LX 1310nm 10km/6.2mi SM LC Connector						C								
One[1] SFP - 100Base-FX 1310nm 40km/24.9mi SM LC Connector						D								
One[1] SFP - 100Base-ZX 1550nm 80km/49.7mi SM LC Connector						E								
One[1] SFP - 1000Base-SX 850nm 550m/1800ft MM LC Connector						F								
One[1] SFP - 1000Base-LX 1310nm 10km/6.2mi SM LC Connector						G								
One[1] SFP - 1000Base-FX 1310nm 40km/24.9mi SM LC Connector						H								
One[1] SFP - 1000Base-ZX 1550nm 80km/49.7mi SM LC Connector						J								
One[1] SFP - 1000Base-ZX 1550nm 120km/74.5mi SM LC Connector						K								
One[1] Single Fiber SFP - 1000Base-DX TX1310/RX1550nm 10km/6.2mi SM Simplex LC Connector						L								
One[1] Single Fiber SFP - 1000Base-DX TX1550/RX1310nm 10km/6.2mi SM Simplex LC Connector						M								
One[1] Single Fiber SFP - 1000Base-DX TX1490/RX1550nm 120km/74.5mi SM Simplex LC Connector						N								
One[1] Single Fiber SFP - 1000Base-DX TX1550/RX1490nm 120km/74.5mi SM Simplex LC Connector						P								

DS0 INTERFACE UNIT (IU) OPTIONS **SLOT 1 - 7 DOUBLE AND SINGLE POSITIONS**	**SLOT(S)**		
4-Port Multi-Protocol Sync IU (RS-422/530, X.35, X.21)	D	(See note 1 below)	A 1
4-Port G.703 Sync. IU	D	(See note 1 below)	B 1
8-Port Async. RS-232 IU	D	(See note 1 below)	C 1
4-Port C37.94 Sync. IU	S		D
8-Port 4-Wire Audio E&M IU	S		E
8-Port 2-Wire FXO IU	S		F
4-Port 2-Wire FXS IU	S	(See note 2 below)	G
4-Port RS-485 IU	S		J
1-Port T1/E1 IU	S	(See note 3 below)	K
4-Port RS-232/485 Serial Server IU	S		L
4-Port 2-Wire Audio E&M IU	S		M
2-Port TPS IU with One[1] SS I/O Box	S		N
2-Port TPS IU with One[1] RLY I/O Box	S		P
2-Port TPS IU with Two[2] SS I/O Box	S		Q
2-Port TPS IU two Two[2] RLY I/O Box	S		R
2-Port TPS IU with One[1] SS I/O Box and One[1] RLY I/O Box	S		S
None	S		Z

CM = Chassis & Motherboard Style
MP = Main Power
RP = Redundant Power
L = LAN
WX = WAN Port X (where x= 5 or 6)
SX = Slot X (where X=1-7)
D = Can fit double slot moodule (3500 Only: Double slot IUs can only start in S1, S3 or S5)

Note 1: If A, B or C is selected for S1, S2, must be 1
If A, B or C is selected for S3, S4, must be 1
If A, B or C is selected for S5, S6, must be 1
Note 2: Only a maximum of two[2] FXS IU is allowed per chassis

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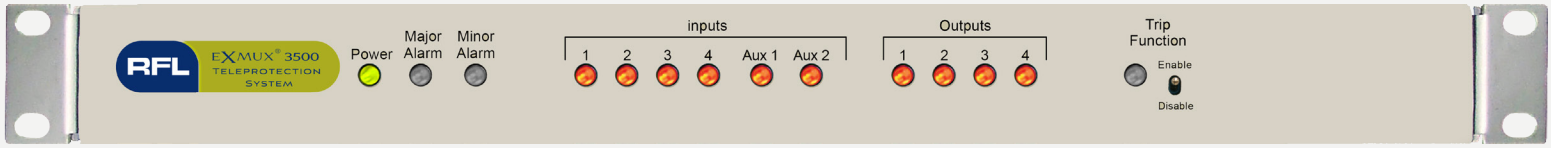
eXmux® 3500

Teleprotection System



The eXmux 3500 Teleprotection System provides an integrated end-to-end teleprotection function in the eXmux 3500 IP Access Multiplexer. The teleprotection system comprises of an eXmux TPS Interface Unit and a 1 RU TPS I/O Box, providing a teleprotection channel over Ethernet/IP or MPLS network using TDM over IP. It is mid-span compatible with the IMUX 2000 T1/E1 multiplexer MTS Teleprotection system.

The eXmux 3500 Teleprotection system provides 4 bidirectional transfer trip commands point-to-point between two peer units or between one unit and an IMUX 2000 MTS unit. The system allows the transport of two independent 4 function inputs/outputs; in addition to 2 controlling inputs logic and 2 outputs for alarming & status for each TPS I/O unit.

Key Features & Benefits

Transfer Trip over Ethernet/IP/MPLS
Provides Teleprotection channel over an Ethernet/IP or MPLS network

Programmable Logic
Supports a number of programmable logic functions including auxiliary controlling inputs

Communication Interface
Two independent 64kb/s DS0 using TDM over IP technology with future option to include Serial to IP with encryption

Inputs/Outputs
4 Optically isolated inputs with 2 auxiliary controlling inputs logic and 4 outputs with solid state and relay options

Sequence of Events (SOE)
Maintains 1500 SOE records, each time stamped with 1 ms accuracy and synchronized via NTP/ SNTP or IEEE 1588 network timing signals

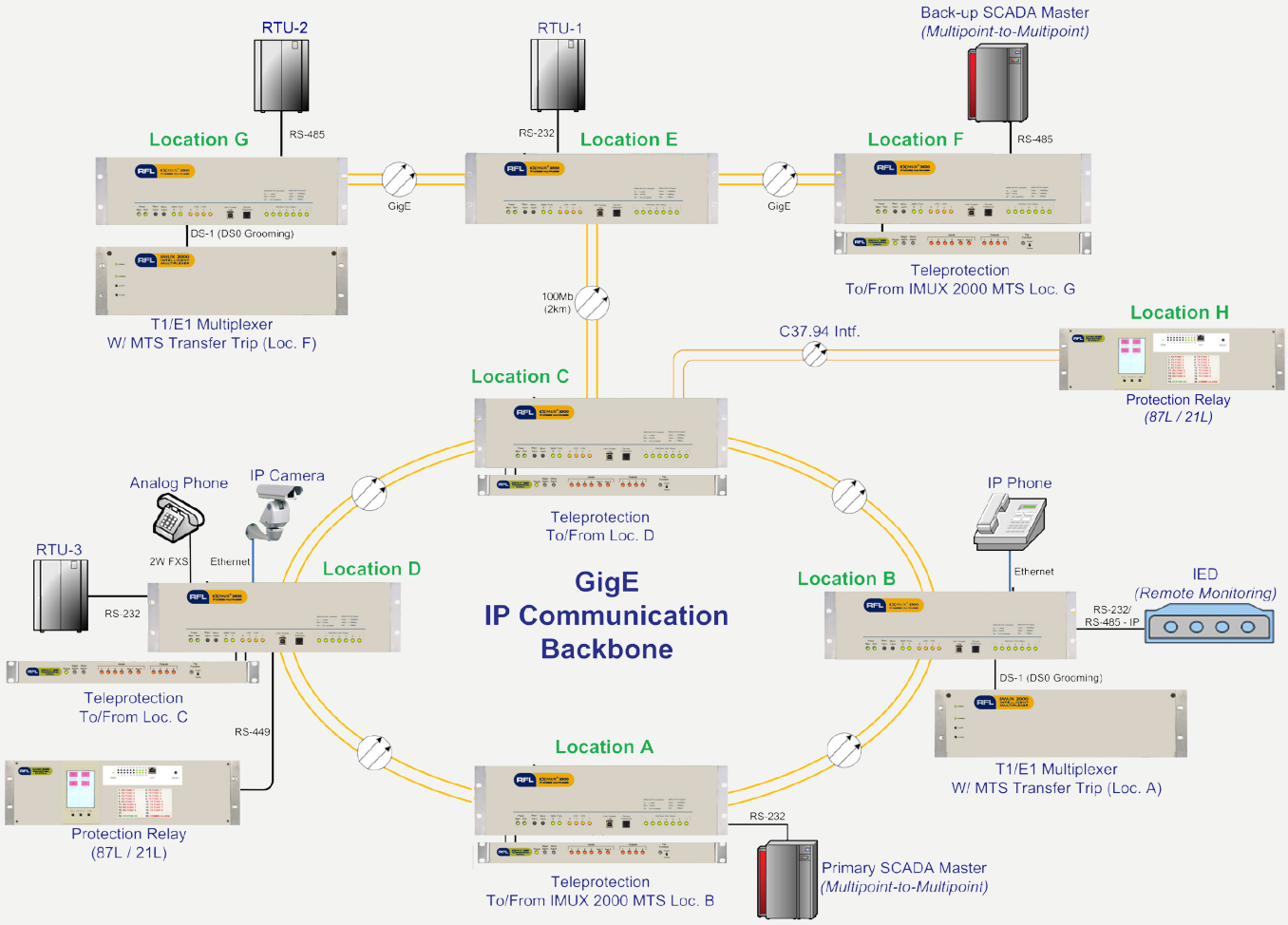
IMUX 2000 MTS Compatibility
Mid-span compatibility with IMUX 2000 T1/E1 multiplexer MTS Teleprotection module for ease of migration to IP

Hitless Teleprotection Channel
Teleprotection channel packets are sent simultaneously both ways around the ring for a zero-data-loss path recovery, providing high dependability/availability using TDM over IP

User Friendly Interface
User interface via the slickest eXmux 3500 Visual Network Management Software for an effortless user friendly experience and easy system management

Point-to-Multipoint Functionality*
Future capability to include point-to-multipoint communications providing integrated multipoint Teleprotection functionality between multiple substations (*Future)

eXMUX® 3500 TPS Application



Technical Specifications

Programmable Logic

- Input / Output Inversion
- Input activation delay (de-bounce)
- Output activation delay (pre-trip)
- Output release delay (trip hold)
- Output hold in event of comms loss
- Directional Comparison blocking mode
- Unblocking
- Trip Input /Output Disable
- Input Or-ing & And-ing

Remote Access and Control

- eXmux 3500 VNMS

Inputs/Outputs

- Optically Isolated Inputs
- Input Voltage 24V, 48V, 125V, 250V
- Solid State Outputs
- Relay Outputs
- Compression or Screw Block Terminal

Status Indicators

- Inputs, Outputs, and Communications / Alarm Status LEDs
- Minor & Major Alarm LED and Form C Contacts

Sequence of Events (SOE)

- Records: 1500 SOE Records
- Synchronization: NTP/SNTP/IEEE 1588

Communications

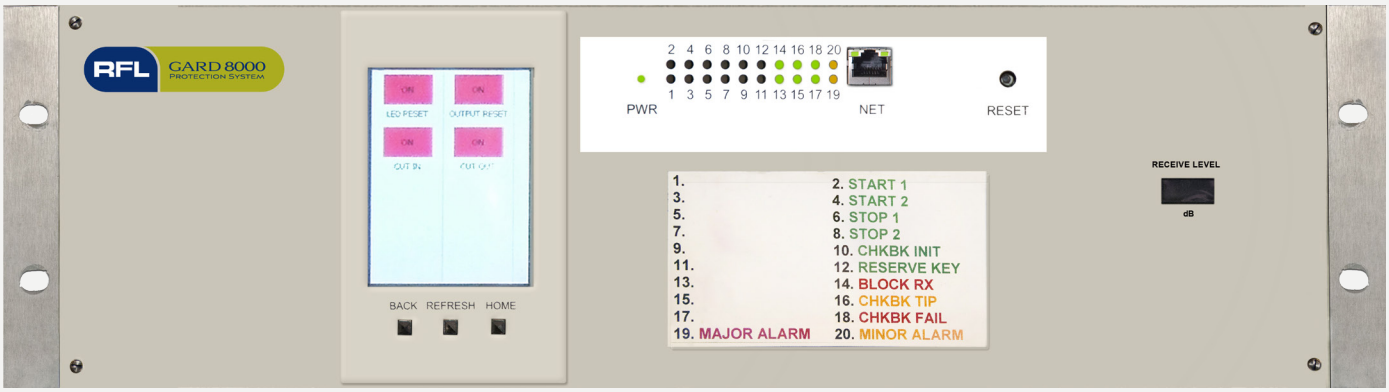
- TDM over IP: Two independent Single 64Kb/s DS0
- Serial to IP with Encryption* (*Future option)
- Compatible with IMUX 2000 MTS Transfer Trip Module (TDM over IP mode only)
- Ping Pong Round Trip Delay measurement
- Trip Function Disable Switch

BR_10_075_E

SOLUTIONS FOR AN EVOLVING WORLD

RFL GARD 8000

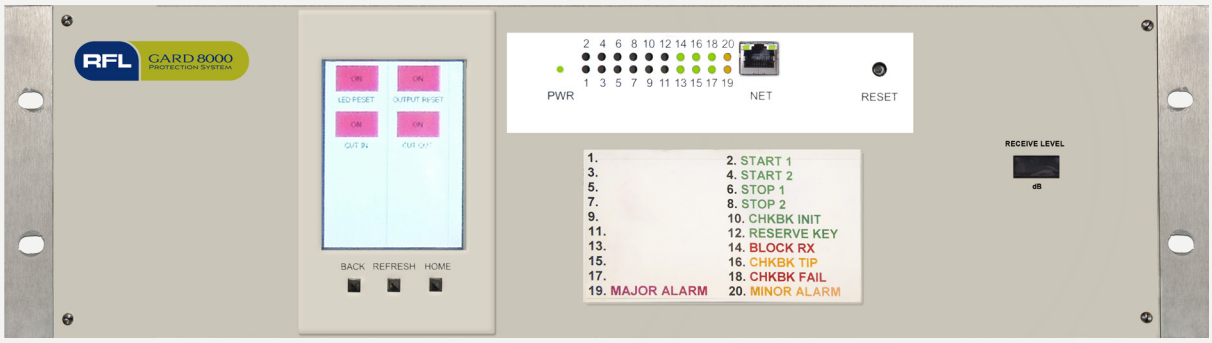
Programmable Single Function PLC



HUBBELL

GARD 8000

Programmable Single Function PLC



System Features

Remote access via Ethernet, RS485, RS232

Easy to program via integrated HTML Web Pages

Optional integrated 4-zone distance protective relay

Supports IEC 61850

User defined logic and alarms for your specific applications

Straight forward web browser user interface for setting and diagnostics; no proprietary application program required

Optional built-in GPS receiver provides accurate time tags

DNP3, Level 2 compliant

Full system redundancy option available

Additional plug-in protection modules such as audio-tone teleprotection and distance relay modules can be used with the GARD 8000 Single Function PLC System

Supports NERC/FERC security standards

Single Function PLC Features

Single or dual PLC systems in one chassis available

One product for all ON/OFF and FSK PLC applications

Up to four ON/OFF or FSK can be supplied in one chassis

Internal CLI meter available

One filter

Built-in skewed hybrid

Automatic setup for commissioning

Integrated Reflected Power Meter

Full system redundancy option

10W, 50W, and 100W Power Options

Built-in Check-back with remote initiate capabilities standard

Complies to latest ANSI C93.5-1997 Single Function PLC Standard

Complete address and Check-back testing

10 Year Warranty

GARD 8000 SFPLC

System Description

The GARD 8000 Single Function PLC channel is a product that can be programmed as Frequency-Shift Keyed (FSK) power line carrier system or as an amplitude-modulated ON/OFF powerline carrier transmitter/receiver terminal.

The unit is designed for pilot protection relaying applications, requiring high-speed reliable communications. The GARD 8000 PLC can be programmed for On/Off type directional comparison blocking (DCB), or Frequency Shift, type direct transfer trip, (DTT) Unblocking (DCU), or either single, or dual phase comparison applications.

The extensive sequence of events and diagnostic features provide information for the GARD 8000 and integrated PLC modules.The chassis is available in both a 3U version which can support one PLC system, or a 6U version which can support up to four PLC systems.

In the smaller 3U version, a PLC system and a plug-in 4-Zone distance relay module is supported eliminating the need for a conventional PLC and distance relay. The 6U version can support two PLC systems and two distance relays with full redundancy to simplify applications even further.

The unit is available with front panel direct reading (in dB) digital meter to indicate signal strength. Each unit also comes with an external carrier level indicator output for use with external measuring devices such as a panel meter or an analog RTU input.

Other GARD 8000 function modules such as an analog teleprotection module and current differential relay module can also be used in the chassis if desired. Redundant controller and power supplies are available as options.

On/Off Carrier Operation

Description

On/Off Powerline Carrier is normally used in a "Blocking" type protection application. In this application the transmitter is normally off, and is turned on by a protective device. The blocking signal is sent to a remote station, via the transmission line, to prevent undesirable tripping for circuits that are not affected by the system fault. The Blocking signal needs to be sent, and received with a minimum of delay to prevent tripping out healthy circuits, and causing unnecessary system disturbances. On/Off Powerline Carrier applications, are almost always bi-directional, and send, and receive the same RF frequency at both terminals.

Transmitter

Frequency programmable: Frequency programmable from 30 to 392 kHz in 125 Hz increments, without hardware changes. Frequencies from 392 to 500 KHz utilize a high frequency output filter.

Output Power: Programmable for 1 watt, 3 watt, or 10 watt levels. Output power is displayed on optional front PDA and is remotely accessible. The unit is available with 50W and 100W options in external 3RU chassis.

Output Impedance: 50 Ohms standard
75 Ohms available

Frequency Stability: +/- 10 Hz

External Keying Inputs: (4) Carrier Start, Stop, Reserve Signal Key, and Check Back Test Initiate. All inputs programmable active high or low to operate at the following nominal voltage levels: 24 Vdc, 48 Vdc, 125 Vdc, 250 Vdc. Active inputs are recorded in SOE files and their status displayed on the optional front PDA.

Receiver

Frequency programmable: Programmable from 30 to 500 kHz in 125 Hz increments, without hardware changes.

Receiver Level: On command, the receiver sensitivity will self adjust to the incoming signal strength. The receiver gain will then be fixed.

Receiver Input Impedance: Terminated mode, 50 or 75 Ohm Unterminated mode, > 30 K-Ohm.

Dynamic Range: >40dB

Receiver Bandwidth, Channel Spacing and Channel Delay Times: Receiver bandwidth is user selectable from the following table, without hardware changes. The channel times are inclusive of GARD 8000 System.

Receiver Outputs: The receiver can be provided with the following standard outputs; or programmed for specific applications:

Nominal Bandwidth	*Total Channel Delay Time*	*Channel Spacing*
500 Hz	5 ms	1 kHz
1000 Hz	3 ms	2 kHz
1500 Hz	1.5 ms	3 kHz

(4) Block received
(1) Transmitter Fail / Hardware Alarm
(1) Checkback fail alarm
(1) Checkback test in progress
Guard output status
Checkback initiate status
High percent reflected power alarm
Logic alarm

Automatic Checkback Operation: The PLC system is supplied with an internal automatic carrier checkback program. The checkback code structure, and programming is compatible with the existing RFL 9785, and previous Model 6785P series checkback systems. The checkback can also be manually initiated from either end.

This system consists of two modes, normal and hard carrier. In normal mode, a code is on-off modulated onto the powerline and a response code is returned at full or reduced power by the receiving station. In hard carrier, instead of a response code, the receiving station responds by turning on its carrier at full or reduced power for a programmed period of time.

FSK Carrier Operation

Description

Frequency shift power line carrier is normally used in a "Unblocking" or "Permissive" type protection application. In this application the transmitter is continuously sending a "Guard" signal, via the transmission line to the remote terminal. Reception of the guard signal provides both continuous channel, and equipment monitoring. The receipt of a valid guard signal prevents high speed tripping at the remote terminal. The transmitter is keyed to the Unblock or Trip frequency by a protective device. The trip signal is sent to a remote station, via the transmission line, to enable tripping for circuits that are affected by the system fault. The tripping signal needs to be sent, and received with a minimum of delay to "permit" high speed tripping of transmission line circuit breakers to limit equipment damage, and minimize any system disturbances. These permissive trip type applications are usually bi-directional, and send, and receive different guard, and trip frequencies between terminals.

Transmitter

Frequency programmable: Frequency programmable for either 2F, or 3F operation, from 30 to 352 kHz in 125 Hz increments, without hardware changes frequency from 392 to 500 KHz utilize a high frequency output filter. Output frequency settings will be available on optional front mounted PDA.

Frequency Shift : Standard frequency shifts of +/- 100 Hz +/- 250 Hz, and +/- 500 Hz are available. Three – frequency operations are capable of providing 250 Hz shift from the center (Guard) frequency for permissive relaying protection channels, and 100 Hz shift from the center frequency (Guard) for direct transfer trip (breaker failure) applications.

Output Power: User programmable for the following power output levels:

1W guard /1W trip
1W guard /10W trip
3W guard /10W trip
10W guard /10W trip
Optional 50W guard /50W trip available
Optional 100W guard /100W trip available

Output Impedance: 50 Ohms standard
75 Ohms available

Frequency Stability: +/- 10 Hz

Receiver

Frequency programmable: Programmable from 30 to 500 kHz. in 125 Hz increments, without hardware changes.

Receiver Level: The receiver sensitivity self adjusts to the incoming signal strength. The actual signal level is available for display on the optional front mounted PDA, remotely via TCP/IP or RS-232 interface or on a local laptop, The level can be selectively displayed in either dBm, (+/- 20 dB range), or mv.

Receiver Sensitivity: Minimum = 5 mVrms,
Maximum = >25 Vrms

Receiver Input Impedance: Terminated mode, 50 or 75 Ohm Unterminated mode, > 30 K-Ohm.

Dynamic Range: >40dB

Receiver Bandwidth, Channel Spacing and Channel Delay Times: Receiver bandwidth is user selectable from the following table, without hardware changes. The channel times are inclusive of GARD 8000 System

Nominal Bandwidth	*Frequency Shift*	*Total Channel Delay Time*	*Unidirectional Channel Spacing*	*Bidirectional Channel Spacing*
200 Hz	+/- 100 Hz	13 ms	500 Hz	1000 Hz
500 Hz	+/- 250 Hz	8 ms	1250 Hz	2500 Hz
1000 Hz	+/- 500 Hz	6 ms	2500 Hz	5000 Hz

No Test Equipment Needed

Transmit and Receive Levels Measured

The Transmit and Receive Levels are measured and can be accessed remotely. If the receive level drops below a preset value an alarm will activate.

Reflected Power Measured

The power reflected due to mismatch of the power line coupling equipment is measured every second and available when requested. A threshold can be entered by the user, beyond which an alarm condition is generated.

Trans Hybrid Loss Measured

The trans-hybrid attenuation value is also available to the system. The amount of the transmitter leaking back into the receiver will be measured. This attenuation includes the affect of any receive filter. This feature eliminates the need for frequency selective voltmeters to perform routine carrier maintenance testing.

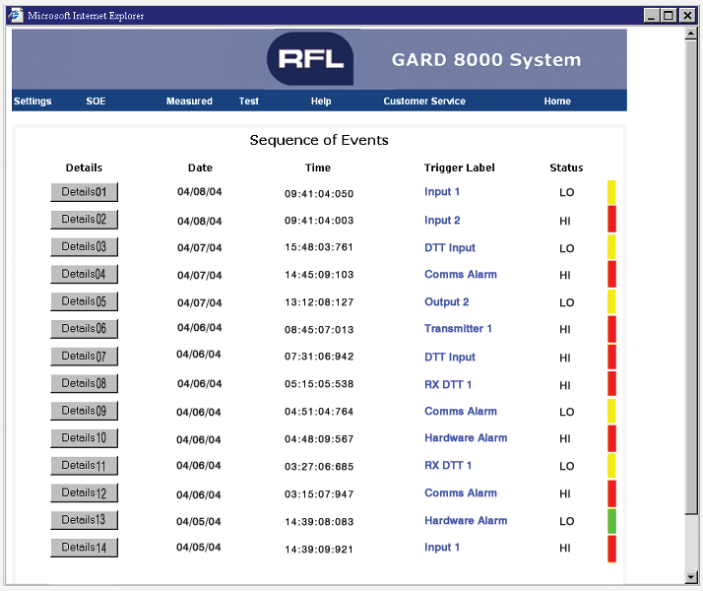
Diagnostics and Testing

Diagnostic information is available and easily accessible with the GARD 8000 Single Function PLC unit. RFL's diagnostic package takes the guesswork out of power system fault analysis and evaluating communications system performance during the fault-clearing process. The GARD 8000 Single Function PLC provides the following standard features:

Two ethernet TCP/IP ports and two RS-232 ports for local and remote access
600 Sequence-of-events records
Remote access to transmit/receive and reflected power levels
Internal real-time system clock
Optional built-in GPS receiver
IRIG-B Clock sync input
Current status of all system parameters
Diagnostic information about the remote end
Checkback testing either locally or remotely initiated
Automatic checkback

Sequence of Events

Figure 1 shows the Sequence of Events directory, listing the record number, date, time, trigger label, status and color indicator.



Details	Date	Time	Trigger Label	Status
Details01	04/08/04	09:41:04:050	Input 1	LO
Details02	04/08/04	09:41:04:003	Input 2	HI
Details03	04/07/04	15:48:03:761	DTT Input	LO
Details04	04/07/04	14:45:09:103	Comms Alarm	HI
Details05	04/07/04	13:12:08:127	Output 2	LO
Details06	04/06/04	08:45:07:013	Transmitter 1	HI
Details07	04/06/04	07:31:06:942	DTT Input	HI
Details08	04/06/04	05:15:05:538	RX DTT 1	HI
Details09	04/06/04	04:51:04:764	Comms Alarm	LO
Details10	04/06/04	04:48:09:567	Hardware Alarm	HI
Details11	04/06/04	03:27:06:685	RX DTT 1	LO
Details12	04/06/04	03:15:07:947	Comms Alarm	HI
Details13	04/05/04	14:39:08:083	Hardware Alarm	LO
Details14	04/05/04	14:39:09:921	Input 1	HI

Figure 1. Sequence of Events Log

Programmability

Logic functions can be changed or fine-tuned remotely through the GARD 8000 Single Function PLC unit's TCPIP or RS-232 ports.

User Programmable Logic Functions

Change timer values, logic states and logic functions without ever removing a module or opening the chassis.

User Programmable Inputs and Outputs

The smaller 3U version of the GARD 8000 when configured with the single Function PLC module has two I/O slots available. Each I/O can accept communications or up to two discrete input / output modules. All logic mapping to the inputs, outputs and communications is fully programmable to meet specific customer requirements.

Create your own alarm conditions

The GARD 8000 Single Function PLC unit can be programmed to any alarm configuration desired using the outputs on the I/O modules.

Programming

The GARD 8000 Single Function PLC unit is programmed to use a standard web browser (e.g. MicroSoft Internet Explorer™ on a PC. All programming levels available over the RS-232 or TCP/IP interface are password-protected.

Every GARD 8000 Single Function PLC unit is supplied pre-programmed with either default operating logic or custom logic. It should be noted that it is standard practice for RFL to provide system programming with every unit at no charge.

Real Time Clock

IRIG-B

The GARD 8000 Single Function PLC unit accepts the IRIG-B Standard Time Code on a 1kHz modulated or unmodulated carrier. Nominal signal levels are 3.3 volts peak-to-peak (3 0.5v) for a logic "1" and 1 volt peak-to-peak (3 0.2v) for a logic "0". The IRIG-B input presents a 3.7k ohm impedance and is transformer isolated. An optional integrated GPS receiver is available.

Resolution 1 ms

Accuracy
Free Running: Within 1 minute per month
Under IRIG-B Control 31msecs

Reset
Manual or by IRIG-B code

Carrier Level Indicator

Display Front panel 3 1/2 direct reading (in dB)

Range 310 dB

External Meter Output 0-5 V, 0-1 mA, 0-100 mA

Technical Specifications

Real Time Clock

IRIG-B

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Resolution 1 ms

Accuracy

Free Running: Within 1 minute per month
Under IRIG-B Control 31msecs

Reset

Manual or by IRIG-B code

Remote Access

Events Storage

The Sequence of Events Recorder on the main controller module can store up to 600 events. After this limit is reached, older events are overwritten. The Events Log keeps a running tally of the number of times each function, input, output and alarm is active along with the time and date the event occurred. Up to 1,000,000 counts can be stored for each item.

Ethernet TCP/IP Port

Two ethernet TCP/IP ports, located on the front and rear of the chassis, for remote interrogation.

Isolation

The GARD 8000 Single Function PLC unit's RS-232 port is isolated from circuit common and chassis ground to a surge withstand level of 500 Vdc.

RS-232 Interrogation Ports

The GARD 8000 Single Function PLC unit provides one RS-232 Port located on the rear of the chassis. The RS-232 port is configured as a DTE interface.

Data Rates

300 bps, 1200 bps, 2400 bps, 9600 bps or 19.2 Kbps.

Communication Parameters:

Number of Data Bits: Eight
Number of Stop Bits: One
Parity: None
Flow Control: XON/XOFF

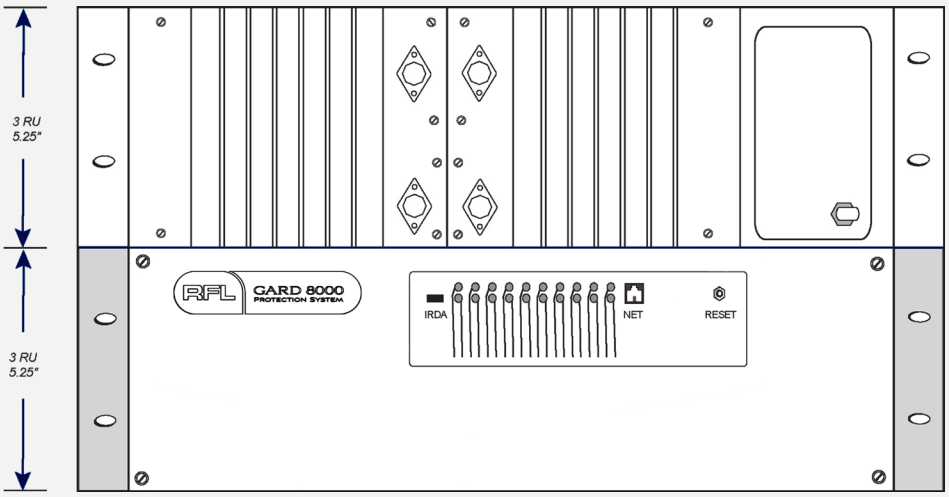


Figure 2. GARD 8000 50 Watt Configuration

The GARD 8000 Single Function PLC can be configured for either 50 or 100 Watt RF power outputs. The RFL model 9508 RF power amplifier is rated for 50 Watt PEP and is the standard amplifier used for single sideband applications. Two amplifiers are required for 100 Watt applications. A 6U GARD 8000 can also be configured with 50 and 100 Watt applications.

General Specifications

Displayed Level Accuracy

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

Pre-Trip Timer

Adjustable in 0.5 ms steps

Trip Hold Timer

Adjustable in 0.5 ms steps

Command Extend Timer

Adjustable in 0.5 ms steps

Non-Volatile Storage

All parameters relating to system operation are stored in electric erasable non-volatile RAM.

Specifications are subject to change without notice

General Specifications Continued

RFI Susceptibility
ANSI C37.90.2 (35 Volts/Meter)
EN 60255-22-3 (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)
EN 60255-22-1 (SWC Class III)
EN 60255-22-2 (ESD Class III)
EN 60255-22-4 (Fast-Transient Class III)
EN 60834-1

Input Power Requirements (EN 60834-1)

24V	Rated	Vdc
	Range	19-29 Vdc
	Burden	<100W
48/125V	Rated	48/125 Vdc or 120 Vac
	Range	38-150 Vdc or 96-132 Vac
	Burden	<100W
250V	Rated	250 Vdc or 220 Vac
	Range	200-300 Vdc or 200-240 Vac
	Burden	<100W

Power Supply
A single or redundant power supply can be provided depending on the reliability of the application. For example a DTT application for a higher voltage level line may demand the dependability of a redundant power supply. When a redundant supply is used, only one supply carries the load. The GARD 8000 Power Supply is provided with Form C alarm contacts for power supply failure and system failure alarm.

Temperature
Operating: -20° C to +75° C (-4° F to + 167° 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

Warranty Statement
RFL's standard warranty for the Single Function PLC unit is 10 years from date of delivery for replacement or repair of any part which fails during normal operation or service.

Ordering Information
Contact RFL or use GARD 8000 configurator available on RFL website (www.rflelect.com).

Front Panel LEDs

Two rows of ten multi-colored LEDs provide basic event information. The LED operation is fully configurable and labels can be changed to suit the application. Custom configuration and labeling can be factory-made by RFL without extra charge. Any field modifications required are simply made by use of the browser interface.

Front Panel Display

An optional touch screen display (TSD) is available for metering, targets and settings. The TSD provides a color screen that will automatically orientate itself for horizontal or verticle mounting. User programmable buttons are provided for unique customer requirements. For things such as breaker control or cut-in/cut-out switches.

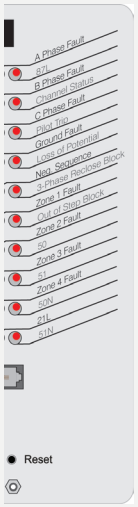


Figure 3. GARD 8000 Front Panel LEDs (6U)

The GARD 8000 front panel has two infrared ports when the PDA is supplied permanently mounted on the front. One communicates with the front PDA and the other is available for any external PDA the user may carry. Communication may be established with any Palm OS PDA via its browser application.

Figure 4. GARD 8000 3U Front Panel

Specifications are subject to change without notice

Web Browser UI

Protection system reliability may be compromised by increased complexity of protection devices. While these protection devices offer added flexibility they also increase the risk for errors. Complicated settings, configurations and interconnections all combine to having an undesirable effect on protection system security and dependability. The GARD 8000 System is designed with ease-of-use in mind. While high functionality and great detail is provided, it is not necessary to make field configurations, if not desired. The Web Browser User Interface makes interaction with the device highly intuitive and handling greatly simplified.

All interaction with the GARD 8000 System is made by the use of a standard web browser. The web pages reside in the device; no special application software is required on the PC.

A PC is connected to the front Ethernet TCP/IP port with a standard connector. Alternatively, the front (or rear) RS-232 port can be used but will not provide the same “lightning-fast” response, as the ethernet port.

Web browser technology provides a much higher level of ease-of-use as compared to the conventional “menu-driven” operation. It is fast and simple to view device status, access diagnostic and test functions and to change settings. Emulating the operations of a standard web site, navigation is intuitive and eliminates the need to study written instructions. If needed, the instruction manual, that also resides in the device, is simply accessed by the HELP function.

For off-line preparation of settings and configuration files, a small application program “emulating” a GARD 8000 System can reside on the PC or local server. Archiving and documentation of settings and configuration is made simple as these are stored in standard text files.

Up to 8 setting groups are available. A group does not only contain settings but all configuration, output and input mapping and labels as well. Input contacts and/or HMI commands can be used for group switching.

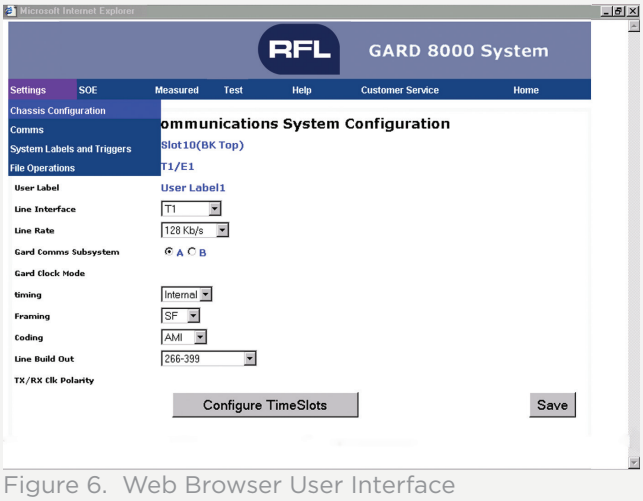


Figure 6. Web Browser User Interface

Input and Output Modules

The GARD 8000 System is configured with a selectable number of input and output modules on the rear part of the chassis. Each communication interface contains 1 input module with 6 opto-isolated inputs or 1 output module.

Solid-state outputs, relay outputs and additional inputs are mounted in sets of 6, with 2 sets on each board occupying 1 slot. The following combinations are available. Ten rear slots are available in the 6U version and 4 rear slots are available in the 3U version:
1 communication interface/6 inputs
1 communication interface/6 outputs
6 inputs/6 inputs
6 inputs/6 relay outputs
6 inputs/6 solid state outputs
6 solid state outputs/6 solid state outputs
6 solid state outputs/6 relay outputs
6 relay outputs/6 relay outputs
4 latching relay outputs/4 Form-C contacts

All output contacts are Form A (NO) or Form B (NC) jumper selectable. A simple setting for an inverter logic gate will provide inversion for each input and output. Each input and output has a timer associated with it that has settings for both pick-up delay (input debounce, output security) and drop-out delay (pulse-stretch).

* With the exception of the latching relay module which is Form-C only.

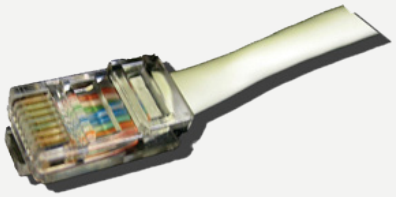


Figure 7. Ethernet Connector

Optically Isolated Inputs

Quantity: 6 per module

Input Voltage Jumper Selectable: 24/48/125/250 Vdc
Operation Range:

24 Volts:	19 to 36 Vdc, Nominal Input
48 Volts:	37 to 68 Vdc
125 Volts:	94 to 150 Vdc
250 Volts:	189 to 300 Vdc

Input Current: 1.5 mA minimum

Minimum Pulse Width:
0.03 ms, additional debounce time set in the logic

Solid-State Outputs

Quantity: 6 per module
Output Current:
Maximum 1 A continuous, 2 A for 1 minute, or 10 A for 100 msec
Open-Circuit Voltage: 300 Vdc maximum
Pick-up Time: 0 msec

Relay Output

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

Alarm Relays

Quantity: 2
Contacts: SPDT (Form C)
Output Current: 100 mA 300 Vdc resistive load

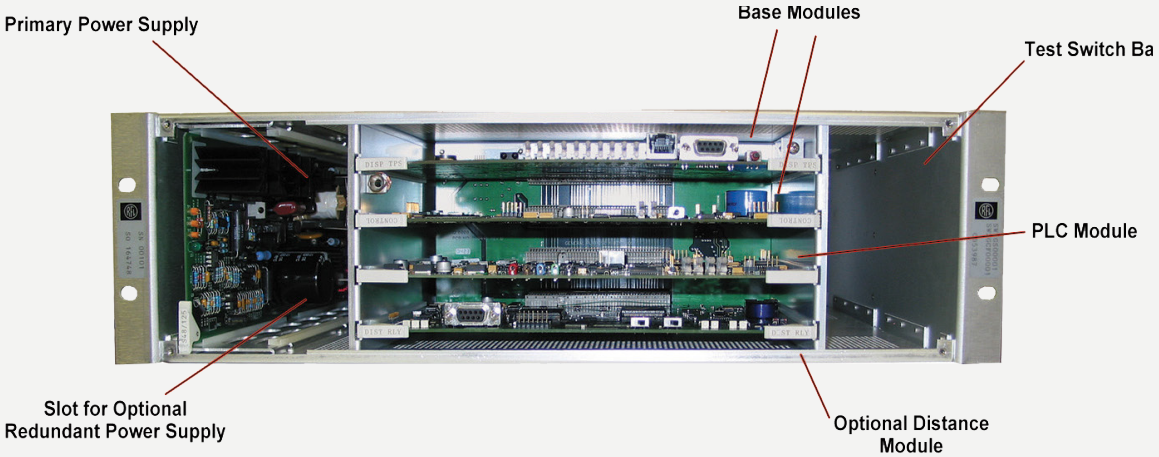


Figure 8. Front View 3U GARD 8000 with panel removed

Examples of GARD 8000 System Configurations

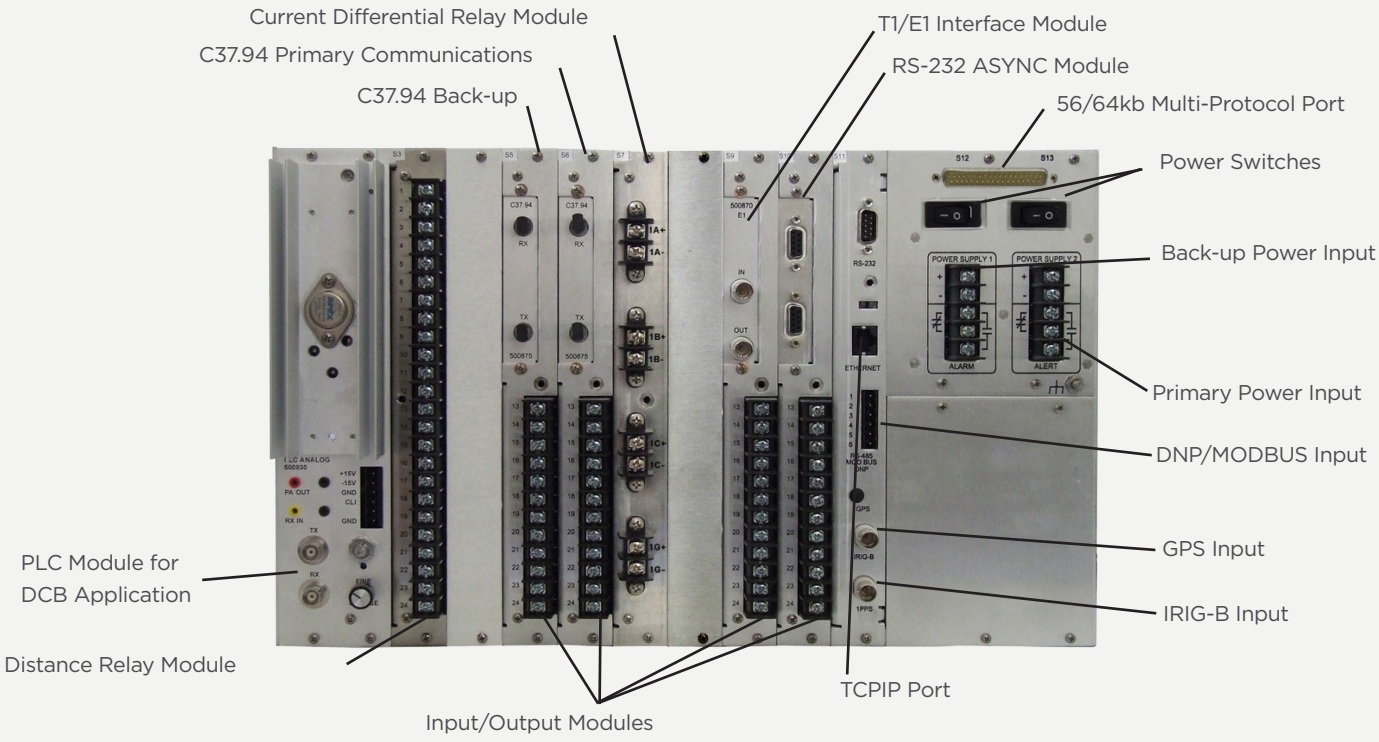


Figure 9. Rear View 6U GARD 8000 with Distance Module with Powerline Carrier Interface and Current Differential Relay with Primary and Back-Up Communications

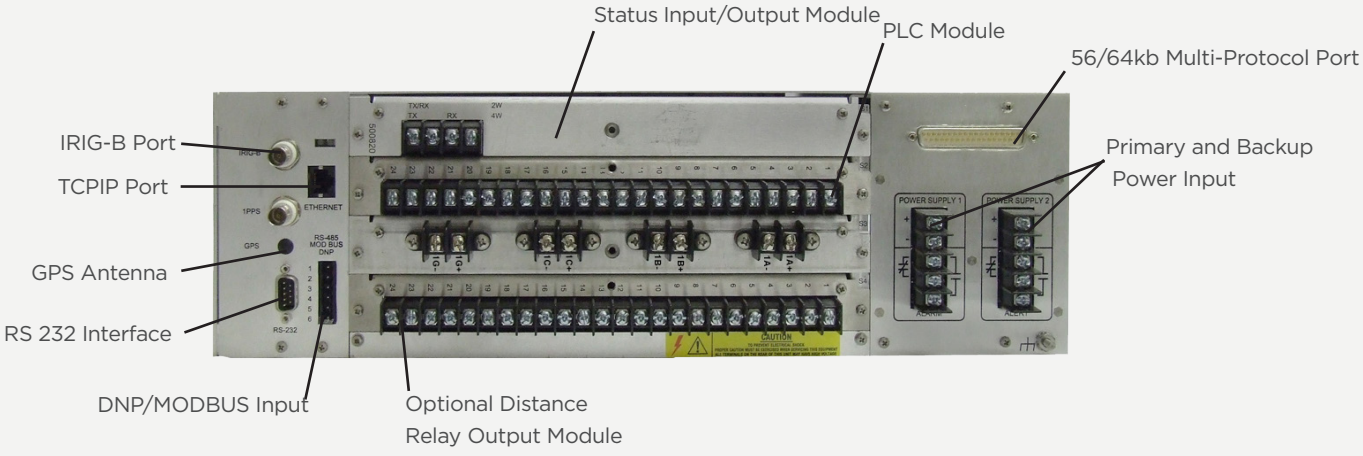


Figure 10. Rear View 3U GARD 8000 with PLC Module, Distance Relay, and Input/Output Module

Dimensions

GARD 8000
Single Function PLC
3U System Dimensions

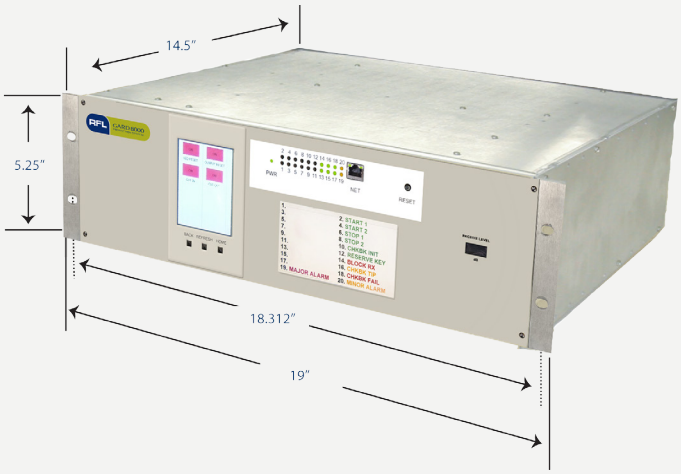


Figure 11. Rack or Cabinet Mounting (3U)

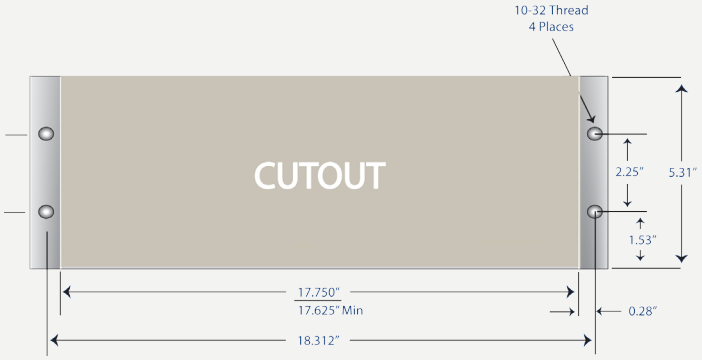


Figure 12. Panel Mounting (3U)

6U System Dimensions

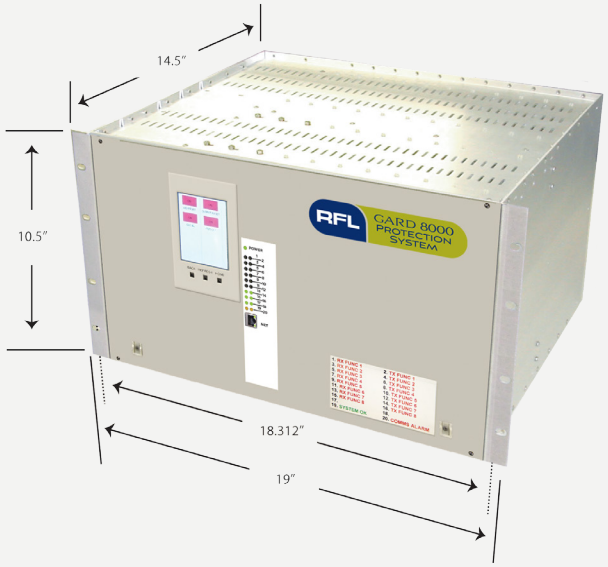


Figure 13. Rack or cabinet Mounting (6U)

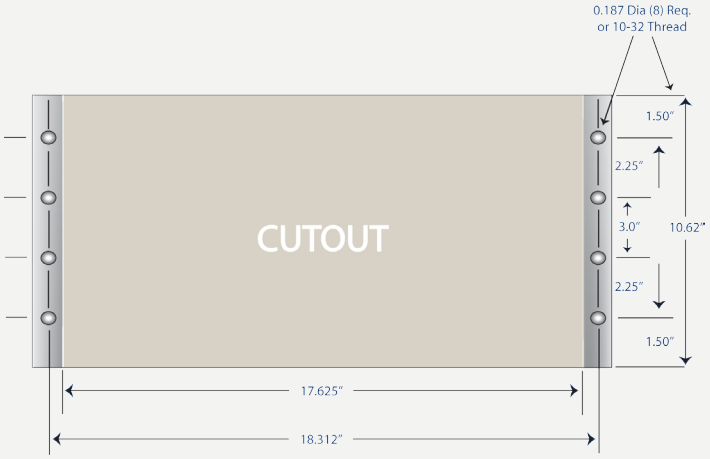
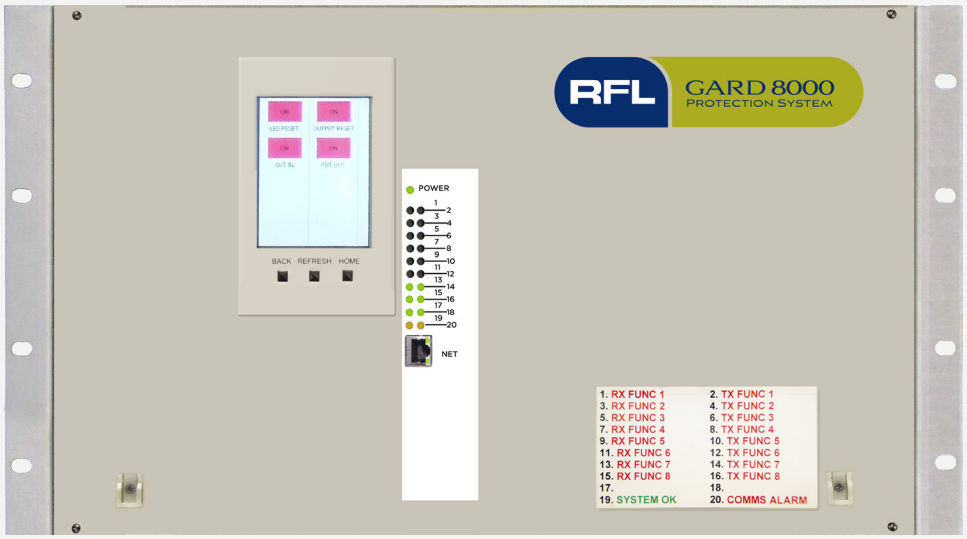


Figure 14. Panel Mounting (6U)

SOLUTIONS FOR AN EVOLVING WORLD

RFL GARD 8000

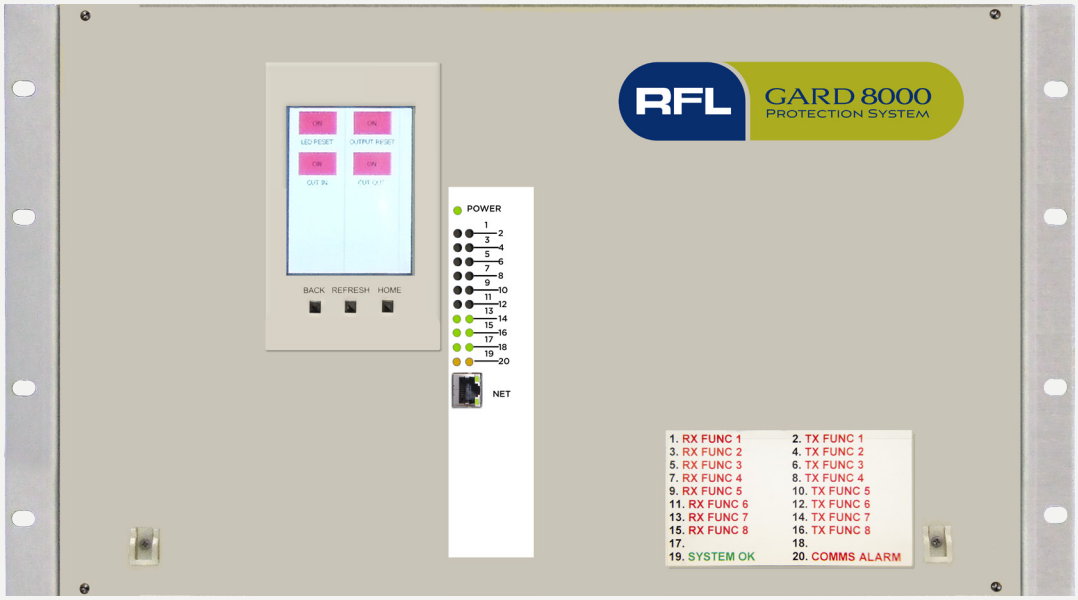
Protective Relay & Communications System



HUBBELL

GARD 8000

Protective Relay & Communications System



System Features

One product for all your teleprotection and line protection needs

Proven, high-speed, secure and reliable synchronous communications

Use as a stand-alone Teleprotection Channel, Current Differential Protection, Distance Protection, Power Line Carrier, or combine them in one device

Selectable redundancy for power supply, main processor, functional modules and communication interfaces

Customized programmable logic for your specific application saves commissioning time and eliminates complex configuration

Straight-forward web browser user interface for settings and diagnostics; no proprietary application program required

Optional, built-in GPS receiver provides accurate time tags, independently from any station clock

Supports NERC/FERC security standards

Efficient use of your communications channel; up to 12 x 64 kbps per communication interface

Metering, Telemetry and Status Modules for RAS (Remedial Action Scheme) Wide Area Protection

A wide range of communication interfaces to choose from:

- T1/E1
- RS-449, 56 -768 kbps
- X.21, 64-768 kbps
- V.35, 64-768 kbps
- G.703, co-directional, 64 kbps
- ANSI C37.94 fiber
- Fiber, multi-mode or single-mode; up to 100 km
- Audio Tone, 2 wire or 4 wire
- Power Line Carrier; ON/OFF or FSK selectable

GARD 8000 supports DNP3 Level 2 with point mapping

Supports IEC 61850

10 Year Warranty

System Specifications

System Description

The GARD 8000 Global Architecture Relaying Device is a revolutionary product platform that provides the user with a fully programmable system that can be used for all teleprotection and line protection needs.

The system uses fully programmable logic and settings that can be uploaded or downloaded using the built-in TCP/IP (electrical or optical) or RS-232 interface. Communicating with the system is done with a PC using a Web Browser. The GARD 8000 has a built-in web server that contains all of the user settings, no special or proprietary software is required to access the product. A most unique feature is that the user manual and customer system and application drawings are stored in the GARD 8000 in Adobe pdf format and are easily accessible from the GARD 8000 web browser.

The GARD 8000 is available in a 3U chassis (5.25") which can support up to two additional teleprotection or protective relay function modules, or a 6U chassis (10.50") which
can support up to eight teleprotection or protective relay function modules. Redundant controller and power supplies are available as options for applications where ultra reliable systems are required.

Protection System

Proper performance of the Protection System requires a functioning communication link and teleprotection device. While protective relays are commonly duplicated for increased redundancy, this is not always the case for the communications channel. Limited availability of external communication links, or the cost of adding a second channel compromises power system protection redundancy.

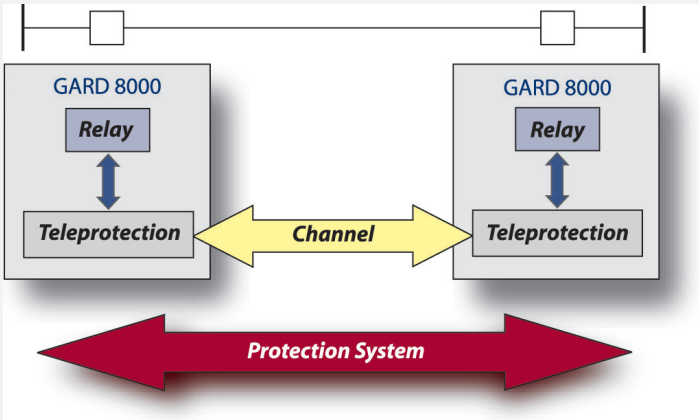


Figure 1. Protection System

System protection redundancy can be improved by the GARD 8000 System. Not only can additional channels easily be made available but the built-in hardware redundancy will provide a higher degree of dependability than two separate protection systems. In addition, external relay-to-teleprotection wiring is eliminated, minimizing the risk of faulty connections or interference affecting the protection system.

Hardware Redundancy

The telecommunications industry has very stringent requirements for redundancy. The principle of "no single point of failure" is adopted. With the increased demands on the power system, hardware redundancy in the protection device provides an added level of insurance. The GARD 8000 can be equipped with redundant power supplies, redundant main processors, redundant input/outputs, redundant functional modules and redundant communication interfaces providing an unequaled safe-guard against equipment failures.

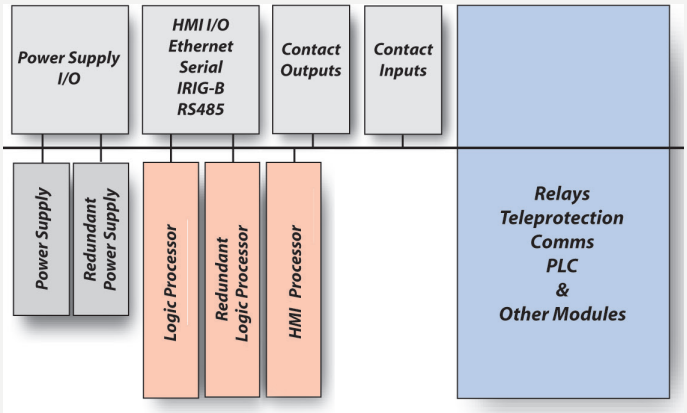


Figure 2. Hardware Redundancy

Economical Use of Your Communication Link

With the exponential growth of data communications, the use of a dedicated fiber for a single channel, low-speed data, might no longer be justified. The GARD 8000 system uses the communication channel efficiently and can provide up to 768 kbps on one link (twelve 64 kbps channels).

The GARD 8000 System offers interfaces for dedicated fiber and direct connection to T1/E1 or SONET/SDH muliplexers.

For applications where no digital channels are available, the audio tone interfaces can be used for 2-wire or 4-wire FSK communications. In addition, GARD 8000 can be equipped with an integral Power Line Carrier, selectable for ON/OFF or FSK operation.

System Specifications (continued)

The GARD 8000 System provides 24 channels, each carrying 64 kbps data. These channels can be assigned to any communications interface and operate redundantly or independently

Functional Redundancy

It has been shown that redundancy is increased by built-in redundant modules, operating in parallel. A typical, coven-tional, protection system would consist of a Main 1 pilot protection scheme and a Main 2 pilot or non-pilot scheme.

The GARD 8000 offers full flexibility to use multiple communication interfaces for Main and Redundant relay protections. Both protections can communicate over both channels or they can use separate channels.

You may also achieve redundancy by using one interface with multiple channels when digital media is available, or use one digital communications interface for more data demanding protections such as current differential and a second, independent, analog channel for distance pilot and/or transfer trip functions.

Optimize Existing Fiber Applications

Dedicated fiber links can be routed via the GARD 8000 System making up to twelve 64 kbps channels available on the existing optical fiber. These channels can be used for proven, secure and dependable transfer trip as well as high speed pilot communications, current differential and/or distance protections.
No change to the existing scheme is required.

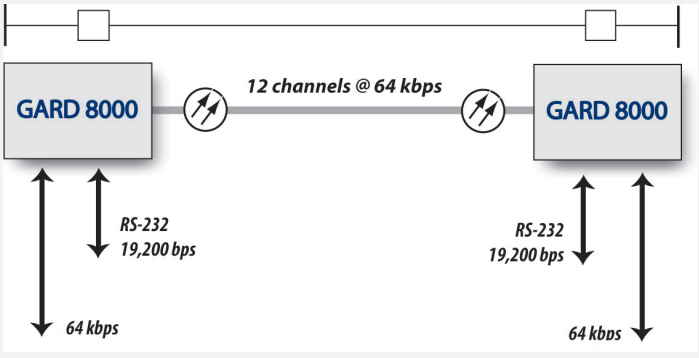


Figure 3. Dedicated Fiber Application

A protection relay using low-speed RS-232 communication or current differential relays using 64 kbps will still have the use of a functionally dedicated point-to-point connection.

Multiplexer Pass-Through Channel

The GARD 8000 has 24 built in communications channels (12 in each of the two subsystems) that can be used for Teleprotection and other Protection applications. These communications channels can also be used with external devices that require a communications or pilot channel to operate. This allows the GARD 8000 Teleprotection channel to also be used as a substation multiplexer that other protective relays can be interfaced with.

The GARD 8000 can be configured with 56/64kb channels with RS-449, G.703, V.35, X.21 and C37.94 fiber optic interfaces. The unit can also be configured with a dual RS-232 communi-cations channel for slow speed devices. Figure 4 shows a RFL 9300 current differential relay and a relay with RS-232 port relay communicating over a GARD 8000 Teleprotection channel configured with two relaying communication interfaces.

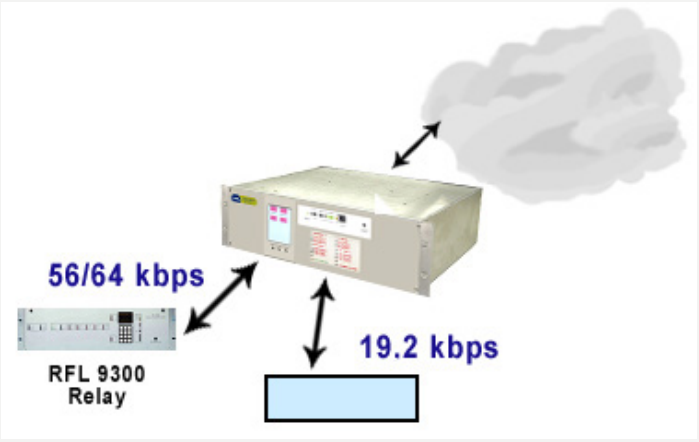


Figure 4. GARD 8000 Used as Multiplexer

The GARD 8000 System can pass the data from one channel on one communications interface directly to another channel on another communications interface. The maximum through-delay for this operation is less than 0.25 ms. Data communication remains synchronous during the pass-through process and can be used for current differential relay channels and teleprotection channels as well as other relaying channels.

System Specifications (continued)

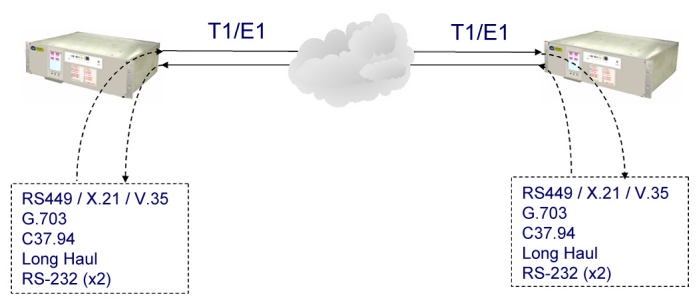


Figure 5. Pass-through functionality

Any GARD 8000 with T1/E1 interface also provides Drop and Insert capability. As illustrated in Figure 6, data can be passed by an external device in station A' to A, or to B'. In the same way data is passed from station B' to B or A'. This functionality, borrowed from multiplexer technology, provides substantial cost savings in applications where a full-blown multiplexer would not be fully utilized.

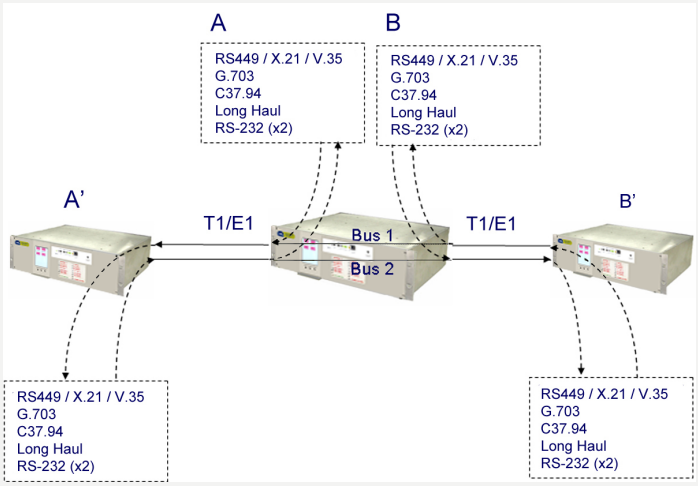


Figure 6. T1/E1 Drop and Insert Capability

Architecture

The GARD 8000 system can be equipped with up to eight functional modules in the 6U chassis and three in the 3U chassis.

- Full featured teleprotection channel
- High speed current differential line protection, charge comparison
- High speed pilot or stepped distance protection
- ON/OFF and FSK Power Line Carrier
- Breaker module for dual breaker applications
- Metering and Telemetry Modules
- Remedial action schemes

All modules independently provide full functionality and can be freely combined to suit your application.

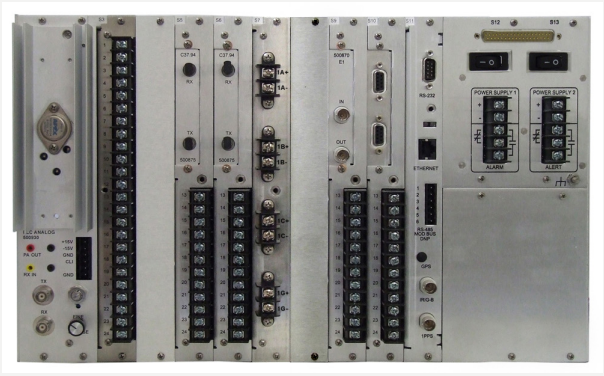


Figure 7. 6U Rear View (Distance configuration)

A Truly Modular System

The GARD 8000 is a modular system and functional modules can be added at any time as needed. This facilitates gradual refurbishment. For instance, the teleprotection channel device can be replaced with GARD 8000 using existing relays for pilot protection. At some later time a protection module can be added to replace or complement the existing relays. Or, communications modules can be added as more external channels become available.

The functional modules are truly individual devices. They all need access to the power supply and the HMI/main processor modules but there is no direct communication between functional modules. This makes it easy to change the functionality of the GARD 8000 as required without having to change the entire system.

Any of the functional modules can be removed at any time (even without powering off the system) without affecting the other functional modules.

A functional module can be located anywhere within a chassis, with the exception of the 3 fixed slots required for the HMI/main processor boards. In this way, a system can contain any combination of functions, with selectable redundancy.

Input and output boards are also freely selectable, and an additional board is easily installed in the field if extra contacts are required.

The modular flexibility extends to the communications modules that may be selected to operate independently or redundantly.

Figure 8. 3U Rear View (Distance configuration)

System Specifications (continued)

User Interface

Protection system reliability may be compromised by increased complexity of protection devices. While these protection devices offer added flexibility they also increase the risk for errors. Complicated settings, configurations and interconnections all combine to having an undesirable effect on protection system security and dependability.

The GARD 8000 System is designed with ease-of-use in mind. While high functionality and great detail is provided, it is not necessary to make field configurations, if not desired. The web browser User Interface makes interaction with the device highly intuitive and handling greatly simplified.

Front Panel LEDs

Two rows of ten multi-colored LEDs provides basic event information. The LED operation is fully configurable and labels can be changed to suit the application. Custom configuration and labeling can be factory-made by RFL without extra charge. Any field modifications required are simply made by use of the browser interface.

Front Panel Display

An optional touch screen display (TSD) is available for metering, targets and settings. The TSD provides a color screen that will automatically orientate itself for horizontal or verticle mounting. User programmable buttons are provided for unique customer requirements. For things such as breaker control or cut-in/cut-out switches.

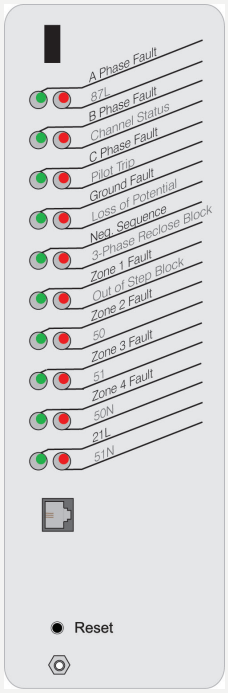


Figure 9. GARD 8000 Front Panel LEDs (6U)

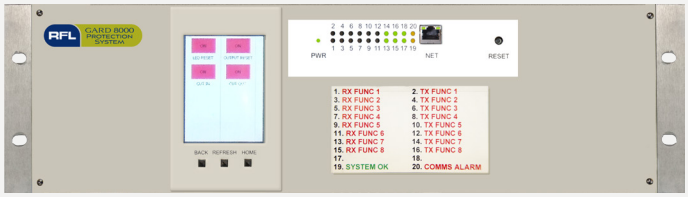


Figure 10. GARD 8000 3U Front Panel

Web Browser User Interface

All interaction with the GARD 8000 System is made by the use of a standard web browser. The web server reside in the device; no special application software is required on the PC.

A PC is connected to the front TCP/IP port with a standard RJ45 connector. Alternatively, the rear RS-232 port can be used but will not provide the same “lightning-fast” response.

Web browser technology provides a much higher level of ease-of-use as compared to the conventional “menu-driven” operation. It is fast and simple to view device status, access diagnostic and test functions and to change settings. With the same operations as a standard web site, navigation is intuitive and eliminates the need to study written instructions. If needed, the instruction manual, that also resides in the device, is simply accessed by the HELP function.

For off-line preparation of settings and configuration files, a small application program “emulating” a GARD 8000 System can reside on the PC or local server. Archiving and documentation of settings and configuration is made simple as these are stored in standard text files.

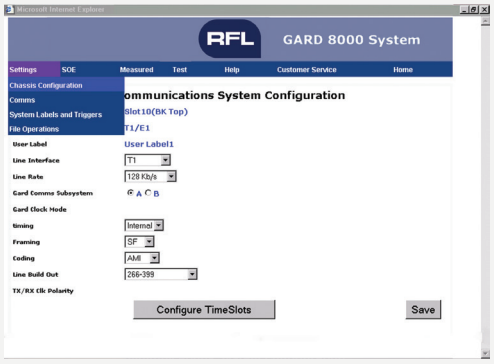


Figure 11. Web Browser User Interface

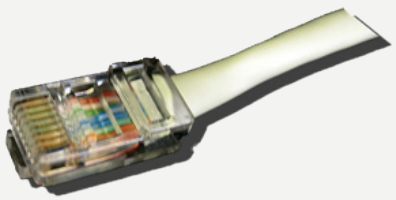


Figure 12. Ethernet Connector

Input and Output Modules

The GARD 8000 System is configured with a selectable number of input and output modules on the rear part of the chassis.

Each communication interface comes with 1 input module with 6 opto-isolated inputs or 1 output module with 6 outputs. Additional solid-state outputs, relay outputs and inputs are mounted in sets of 6, with 2 sets on each board occupying 1 slot. The following combinations are available for mounting in the up to 10 rear slots (6U) or 4 rear slots (3U):

- 1 communication interface/6 inputs
- 1 communication interface/6 outputs
- 6 inputs/6 inputs
- 6 inputs/6 relay outputs
- 6 inputs/6 solid state outputs
- 6 solid state outputs/6 solid state outputs
- 6 solid state outputs/6 relay outputs
- 6 relay outputs/6 relay outputs
- 4 latching relay outputs/4 form C contacts

All relay output contacts are Form A (NO) or Form B (NC) jumper selectable. *With the exception of the latching relays module which is form-C only.

The GARD 8000 Power Supply is provided with Form C alarm contacts for power supply failure and system failure alarm.

Optically Isolated Inputs

Quantity: 6 per module
Input Voltage Jumper Selectable: 24/48/125/250 Vdc
Operation Range:
24 Volts: 19 to 36 Vdc
48 Volts: 37 to 68 Vdc
125 Volts: 94 to 150 Vdc
250 Volts: 189 to 300 Vdc
Input Current: 1.5 mA minimum
Minimum Pulse Width: 0.03 ms, additional debounce time set in the logic

Solid-State Outputs

Quantity: 6 per module
Output Current: Maximum 1 A continuous, 2 A for 1 minute, or 10 A for 100 msec
Open-Circuit Voltage: 300 Vdc maximum
Pick-up Time: 0 msec

Relay Output

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

Alarm Relays

Quantity: 2
Contacts: SPDT (Form C)
Output Current: 100 mA 300 Vdc resistive load

Terminal Connections

Screw terminals for ring lugs with wire up to AWG #10.

GPS Module

Accurate time stamping is essential for evaluation of protection system operations, especially following a major system disturbance.

The substation may be equipped with a GPS central clock that can be connected to the GARD 8000 IRIG-B port. When a central clock is not available the GARD 8000 can have its own, built-in GPS receiver. This module is supplied with a small antenna to be mounted outside to receive the GPS signal.

When the GARD 8000 is equipped with the internal GPS receiver, the IRIG-B port can be used to supply IRIG-B to other devices. This enables not only the GARD 8000 System to keep accurate time tags but other protective devices also have access to a dc-powered, substation hardened, time source that is independent from any centralized GPS system.

Figure 13. GPS Antenna

Protection

Teleprotection System

Based on the RFL 9745 teleprotection channel, the GARD 8000 Teleprotection System carries relaying communications to the next level.

The Teleprotection System is emulating RFL 9745's flexible, customized programmable logic, but provides a higher degree of ease-of-use. Selection of pre-programmed schemes for blocking, unblocking, permissive, and transfer trip operations is simply done by a setting.

The GARD 8000 System is customized to provide the number of channels, type and number of channel interfaces, inputs and outputs and redundancy to meet your application needs. Features include:

- Pre-configured permissive, blocking, unblocking and transfer trip scemes
- 8 to 32 commands per digital interface
- Operating time is 5 ms for digital channel and from 9 ms for analog channel
- 2 or 4 commands per analog channel interface
- Redundant (hot/standby) operation with digital/analog or digital/digital channel interfaces
- Optional 16 point bi-directional status & teleprotection

For applications where a high number of status points need to be transferred, a 96 bit version of the Teleprote tion system module is available. This version allows 96 functions to be transported in one 64 kbps channel slot.

Distance Protection

The distance protection module in the GARD 8000 System has 4 measuring zones, each configurable to forward or reverse operation.

The distance protection can operate as stepped distance with instantaneous operation from Zone 1 with Zone 2 and Zone 3 time-delayed. It can alternatively be applied in a pilot scheme, selectable to permissive, unblocking or blocking.

It may use the same communications channel interface as the current differential relay and/or teleprotection system, or a separate communications interface. Features include:

- 4 Zones, all reversible
- Phase-phase and phase-ground mho
- Selectable quadrilateral characteristic
- POTT, DCUB or DCB pilot schemes
- High-set and inverse time overcurrent elements
- Breaker failure protection
- Reclosing and sync check
- Under- and overvoltage elements
- Frequency elements
- Accurate Fault Locator
- Digital fault records directly in COMTRADE format
- Optional single pole trip logic

The Distance Protection module in the GARD 8000 System can provide back-up for the current differential protection, in case of channel failure. It can also operate in parallel with the current differential providing an independent different measuring principle. Or, it can be used as a stand-alone non-pilot or pilot distance protection.

Current Differential Protection

A current differential protection module can be integrated in the GARD 8000 System. Using one 64 kbps channel, the current differential relay can use the same communication link as the teleprotection system module, or it can have its separate channel interface. Duplicating the highly successful RFL 9300 measuring principle with its high speed operation, the GARD 8000 current differential protection provides added flexibility and enhanced functionality:

- Extended fault recording and oscillography with larger dynamic range and more digital signals
- Fault records directly in COMTRADE allows evaluation by use of any standard reader
- While still extremely simple to set, extended setting ranges are made available for increased system fault current coordination
- Transient block logic for added security at external fault clearing with ct errors
- Adjusts for different ct ratios by setting
- High speed trip; Ð cycle minimum, 1 cycle typical
- Is completely unaffected by channel delay errors up to +/- 4 ms, as may be caused by asymmetric transmit and receive channels
- Two- or three-terminal versions
- Hot/stand-by redundant channel operation
- Optional single pole trip logic
- Dual breaker version

Protection (continued)

Dual Breaker Applications

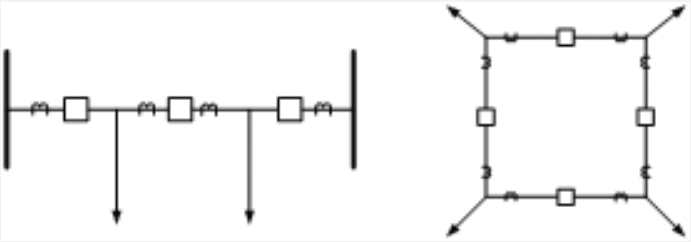


Figure 14. Breaker and a half and Ring Bus Application

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 current transformers.

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 sync check, overcurrent, voltage and frequency elements.

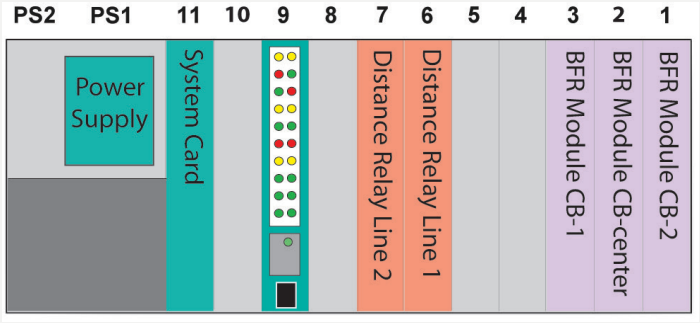


Figure 15. GARD 8000 Distance Protection for a Breaker and a half application

The GARD 8000 System logic makes it easy to combine the protection modules as required by the application. No external interconnection wiring is required as all coordination is performed in the system logic.

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.

Power Line Carrier

The Power Line Carrier (PLC) module in the GARD 8000 System implements the functionality of the RFL 9785 ON/OFF PLC and the RFL 9780 FSK PLC, all in one device. FSK or ON/OFF operation is selectable and the DSP based transmitter and receiver allows full frequency programmability in the range 30 to 500 kHz.

The setting options include:

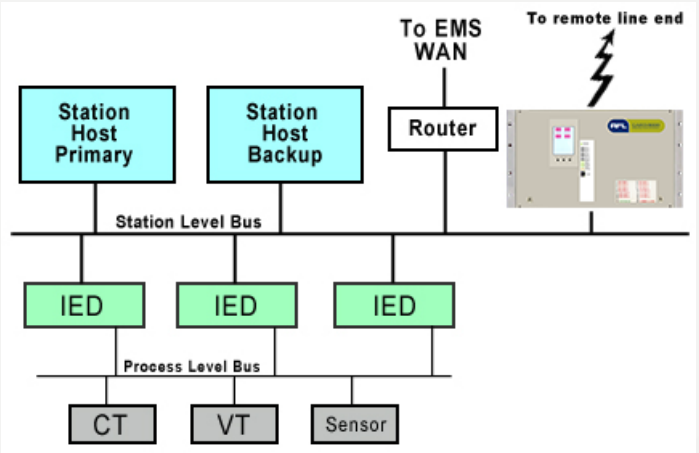
- Selectable FSK or ON/OFF operation
- Transmit frequency 30 to 500 kHz
- Programmable receive bandwidth and frequency shift
- Adjustable logic timers
- Unblock, blocking, permissive, transfer trip or phase comparison applications

Power Line Carrier features include:

- Channel monitoring
- Built-in check-back function; set for periodic check and/or remotely activated
- Extensive Sequence of Event Reporting
- Local or remote interrogation
- Built-in reflected power measurement

Ethernet Tripping Module (IEC 61850 compliant)

The GARD 8000 System can be provided with an Ethernet Tripping Module. IEC 61850 substation automation provides a LAN (Local Area Network) in the substation where trip messages are passed between the devices via GOOSE messages on a TCP/IP network.



Protection (continued)

The GOOSE is routed to perform trip functions of circuit breakers but a shortcoming with the network is that there is no easy means to transfer a GOOSE message to a remote location if the Ethernet network does not encompass the two substations. The GARD 8000 Ethernet tripping module solves this dilemma, by retrieving GOOSE messages from the LAN and transporting them over any of its communica-tion interfaces. The communication interface can be of any type supported by GARD 8000; digital, fiber, audio-tone and/or PLC.

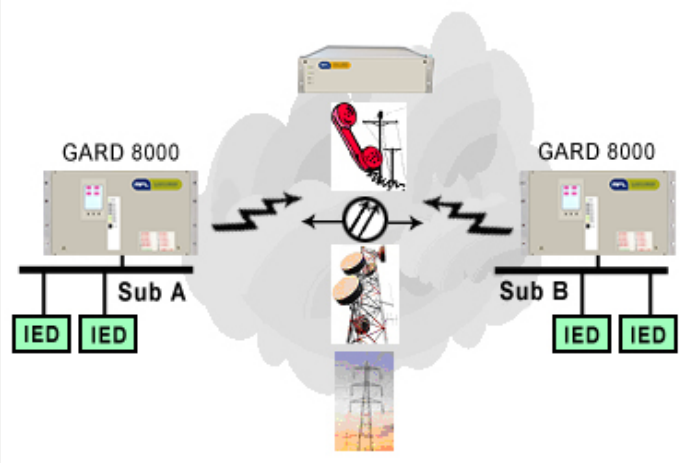


Figure 17. GARD 8000 teleprotection between two IEC 61850 substations

The GARD 8000 provides the link between two IEC 61850 substations over any communication media. The sending GARD 8000 retrieves GOOSE messages from the substation LAN, puts it on a communication link to a remote GARD 8000, that puts it on its substation LAN.

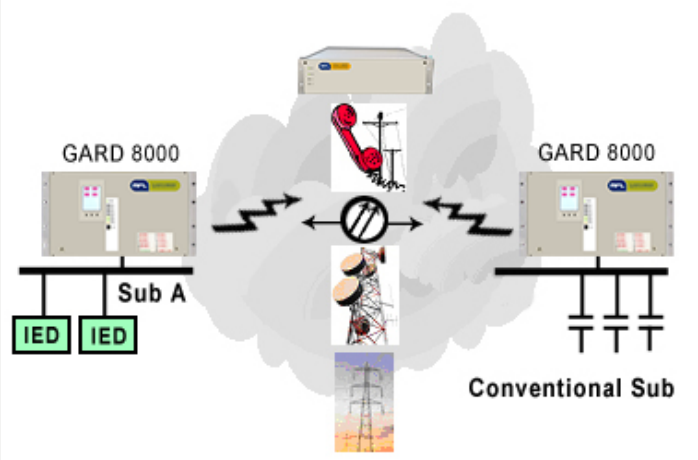
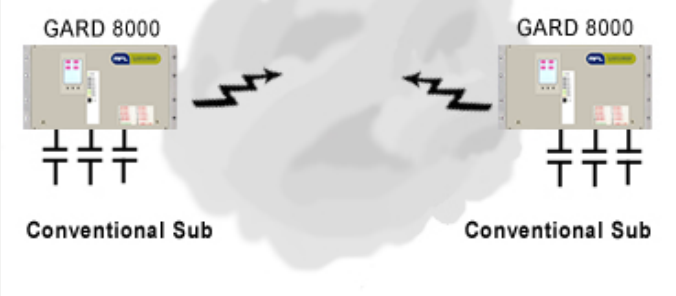


Figure 18. GARD 8000 Teleprotection between an IEC 61850 substation and a conventional substation

Generally, a new IEC 61850 substation needs to interact with a conventional substation at remote line ends. In this case, the GARD 8000 retrieves GOOSE messages for transfer trip or pilot relaying operations from the IEC 61850 substation LAN, transports them over any communication link and the remote, receiving GARD 8000 performs normal teleprotection operations such as tripping of breakers and pilot relaying signaling.

In addition, in case pilot relaying and teleprotection need to be performed over an Ethernet network between two conventional substations, a GARD 8000 at each line end can send GOOSE messages over the network for intertripping.



High Capacity Status Transfer Module

The GARD 8000 standard Teleprotection System supports up to eight high-speed functions in one 64 kbps channel. For telemetry applications, there is often a need to transport a higher number of status points, but transmission time is less critical than for teleprotection signaling. To complement the teleprotection systems, a high capacity status module is available. This module supports up to 96 status bits over a 64 kbps channel. End-to-end delay is 7-12 ms, depending on the security count used.

The high capacity status transfer module can be added as an optional front mounted module, or be supplied instead of the standard teleprotection system on the Base TPS/Display board.

Examples of GARD 8000 System Configurations

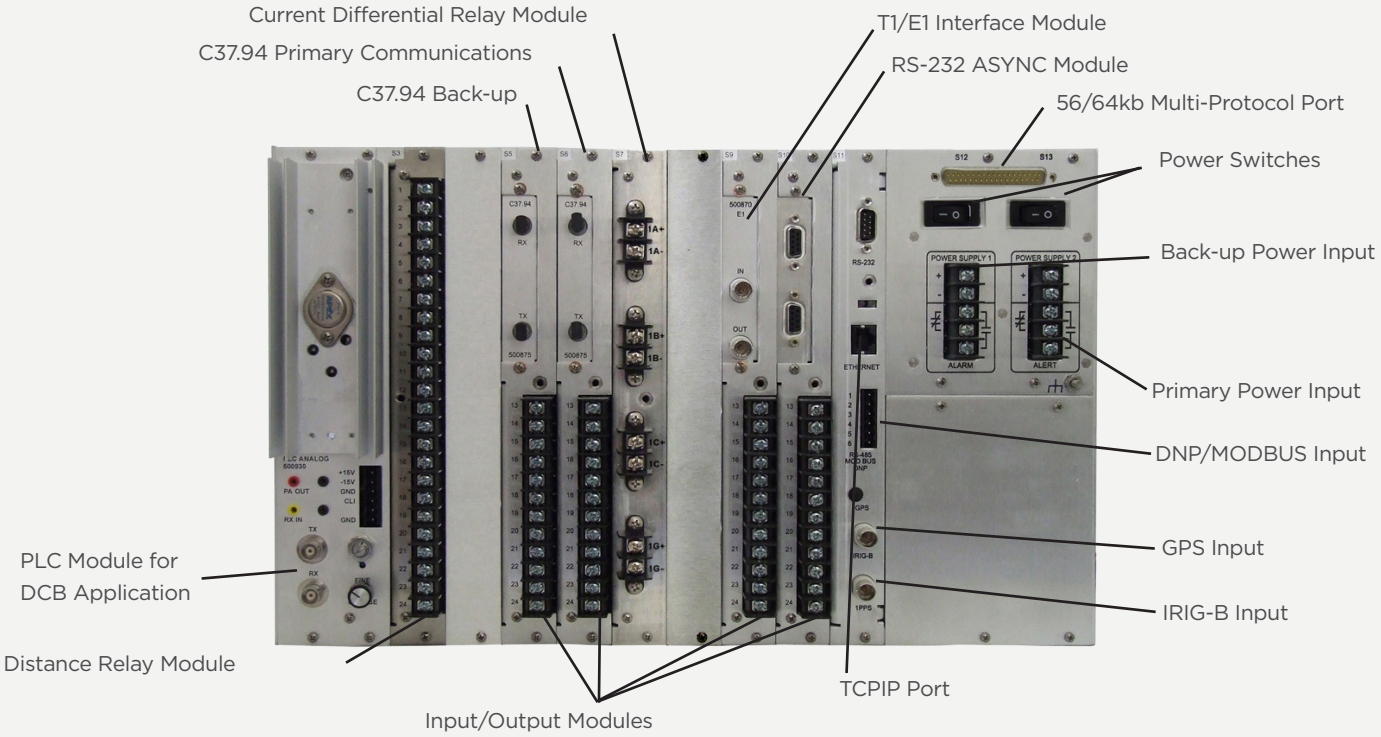


Figure 9. Rear View 6U GARD 8000 with Distance Module with Powerline Carrier Interface and Current Differential Relay with Primary and Back-Up Communications

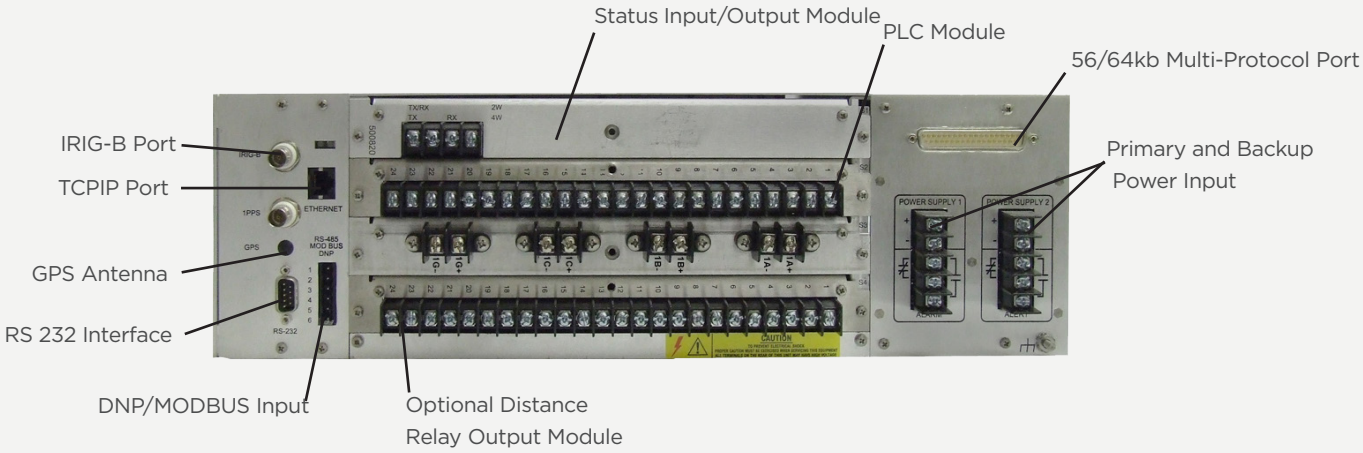


Figure 10. Rear View 3U GARD 8000 with PLC Module, Distance Relay, and Input/Output Module

Dimensions

GARD 8000
Single Function PLC
3U System Dimensions

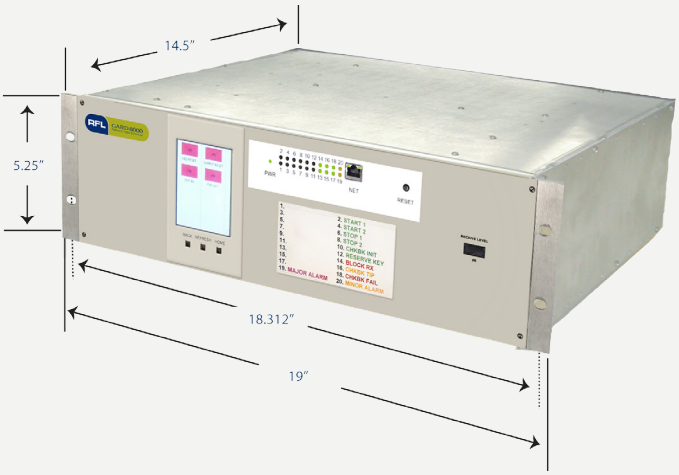


Figure 11. Rack or Cabinet Mounting (3U)

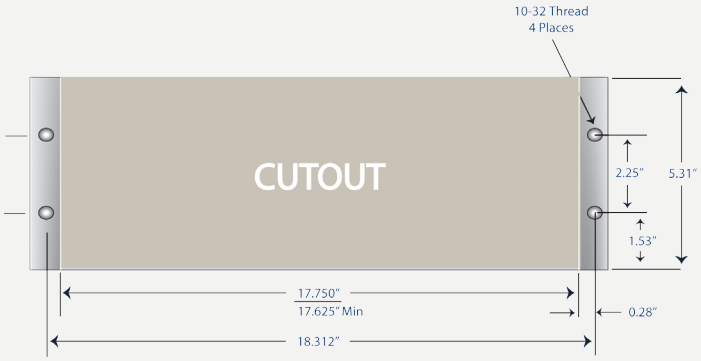


Figure 12. Panel Mounting (3U)

6U System Dimensions

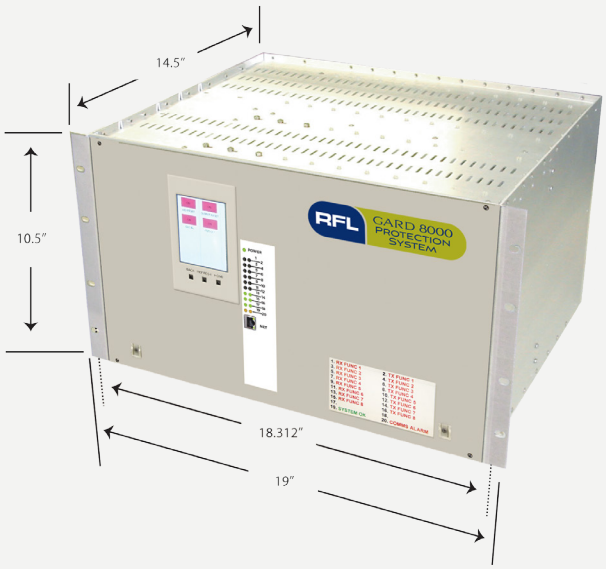


Figure 13. Rack or cabinet Mounting (6U)

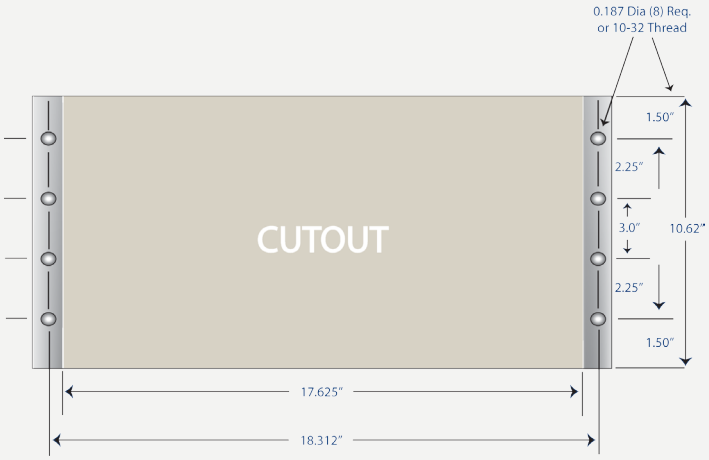
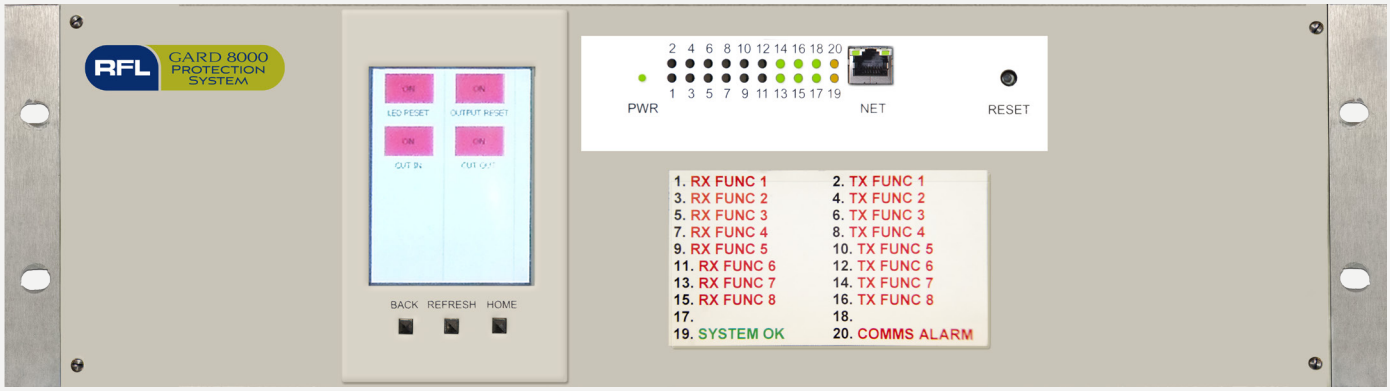


Figure 14. Panel Mounting (6U)

SOLUTIONS FOR AN EVOLVING WORLD

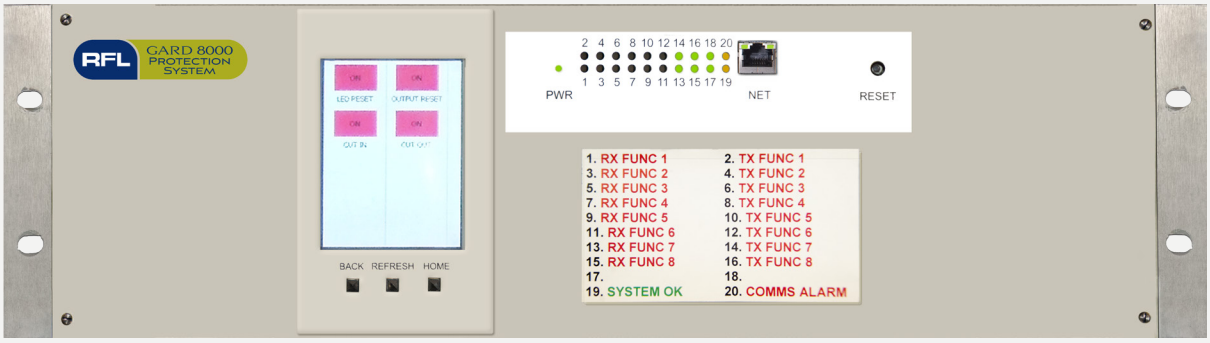
RFL GARD 8000

Teleprotection Channel



GARD 8000

Teleprotection Channel



System Features

One product for all your digital, analog, and IEC 61850 teleprotection needs

User defined logic and alarms for your specific applications

Straight forward web browser user interface for settings and diagnostics; no proprietary application program required

Supports SNTP (Simple Network Time Protocol)

Optional, built-in GPS receiver provides accurate time tags

Complete address and checkback testing

DNP3, Level 2 compliant

SNMPV2 Compliant

IEC-61850 HMI standard

Full system redundancy option available

Optional pass-through 56/64kbs or 19.2kbs Mirrored Bit multiplexer relaying channels

Additional plug-in protection modules such as RFL Distance and Current Differential Relays

Supports NERC/FERC security standards

Teleprotection Features

Digital system comes standard with 32 functions for tripping applications

4 Channels available on Audio Teleprotection Module

16 point bidirectional status & RS-232 data option available for analog TPC systems

Optional IEC-61850 LAN tripping module

System can accommodate multiple teleprotectionschemes in one chassis

Analog and digital systems can be mixed in one chassis

1+1 and other redundant back-up schemes are easily supported

96 bit high capacity 56/64kbps status transfer module option

Complete range of digital and fiber optic interfaces including C37.94

Remote interogation of far end with analog and digital systems

10 Year Warranty

GARD 8000 Teleprotection

System Description

The GARD 8000 Teleprotection channel is a revolutionary product platform that provides the user with a fully programmable system that can be used for Direct Transfer Trip, Permissive Transfer Trip, Blocking, and Unblocking applications. The product is unique in that the same platform is used for analogue, digital, and IEC 61850 LAN tripping applications. The base system is the digital platform that can be used to transmit and receive up to 32 functions in groups of 8. Each block of 8 commands is transmitted over a 56/64kbs data channel, these data channels can be any of the supported digital interfaces. In essence the user is provided a teleprotection channel that has four conventional 8-function teleprotection systems built-in for the price of one.

Based on the RFL 9745 Teleprotection channel, the GARD 8000 Teleprotection system carries relaying communications to the next level. The system uses fully programmable logic and settings that can be uploaded or downloaded using the built-in TCPIP (electrical or optical) or RS-232 interface. Communicating with the system is done with either a laptop PC using Web Browser, or, with the optional built-in color TSD (touch screen device) that communicates with the GARD. The GARD 8000 has a built-in web server that contains all of the user settings. No special or proprietary software is required to access the product. A most unique feature is that the user manual and customer system and application drawings are stored in the GARD 8000 in Adobe pdf format and are easily accessible from the GARD 8000 web browser.

The GARD 8000 is available in a 3U chassis (5.25") which can support up to two additional analog or digital teleprotection function modules, or a 6U chassis (10.50") which can support up to eight analog or digital teleprotection function modules. Other GARD 8000 communications or protection modules can be used in the chassis if desired. Redundant controller and power supplies are available as options for applications where ultra reliable systems are required.

Applications

The GARD 8000 Teleprotection communications interface can be configured for audio, digital, fiber optic, or Ethernet LAN per the IEC 61850 standard. It is well suited for standard and non-standard pilot protection schemes such as:

- Permissive Transfer Trip
- Direct Transfer Trip
- Blocking and Unblocking
- Remedial Action schemes (96 status bits over a 56/64 kbps channel)
- Transfer trip plus bi-directional status
- Transfer trip with slow speed RS-232 data

The GARD 8000 can have up to twelve communications interfaces which allow the product to be used over all communications media available. The following digital interfaces are available for the GARD 8000.

- RS-449/X.21/V.35 (DB37 connector), this multi-protocol interface is standard with all systems (Analog and Digital)
- G.703 (DB15 connector)
- T1/E1 (DB15 connector)
- E1 (BNC connector 50/75 Ohm
- C37.94 short haul fiber, 820nm and 1300 nm LED (ST connector), provides up to 12 channels for teleprotection functions
- 1300nm LED SM/MM (ST connector)
- 1300nm LASER SM (ST connector)
- 1550nm LASER SM (ST connector)
- IEC 61850 TCPIP interface

A GARD 8000 can be configured with many functional teleprotection modules, each with their own communications interfaces, an example of this is shown in Figure 1. These communication channels can be configured for primary and back-up communications channels. For example 8 digital teleprotection commands from Functional Module #1 can be transmitted over communications interface A via direct fiber optic link, and another 8 digital teleprotection commands from Functional Module #2 can be transmitted over communications interface B via a digital microwave. This configuration capability also allows a user to consolidate the number of teleprotection boxes used for an application. A primary and a back-up scheme can be configured with one GARD 8000, each of the protection schemes can be configured with back-up communications channels and also redundant power supplies and processors. This configuration will have a higher overall MTBF than two separate conventional protection channels and will cost less.

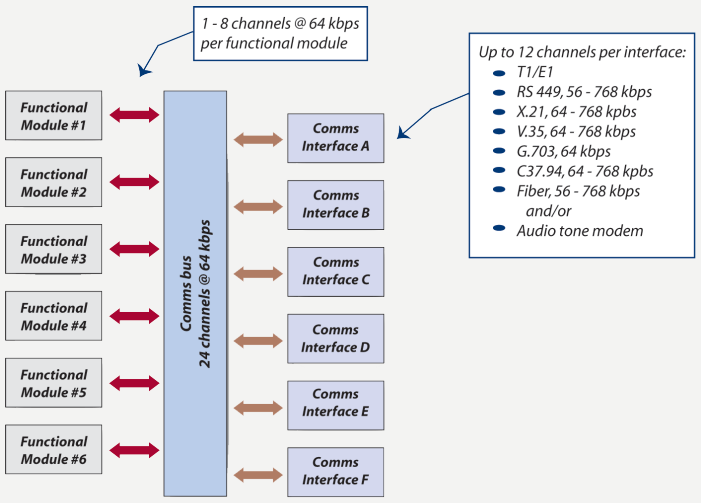


Figure 1. System Architecture

Diagnostics and Testing

Diagnostic information is available and easily accessible with the GARD 8000 Teleprotection unit. RFL's diagnostic package takes the guesswork out of power system fault analysis and evaluating comm nications system performance during the fault-clearing process. The GARD 8000 Teleprotection provides the following standard features:

- Two TCPIP ports (electrical or fiber)
- One RS-232 port for local or remote access
- 600 Sequence-of-events records
- Internal real-time system clock
- IRIG-B Clock sync input
- Current status of all system parameters
- Diagnostic information about the remote end
- Checkback testing either locally or remotely initiated
- Automatic checkback and addressing
- Channel propagation delay measured and reported

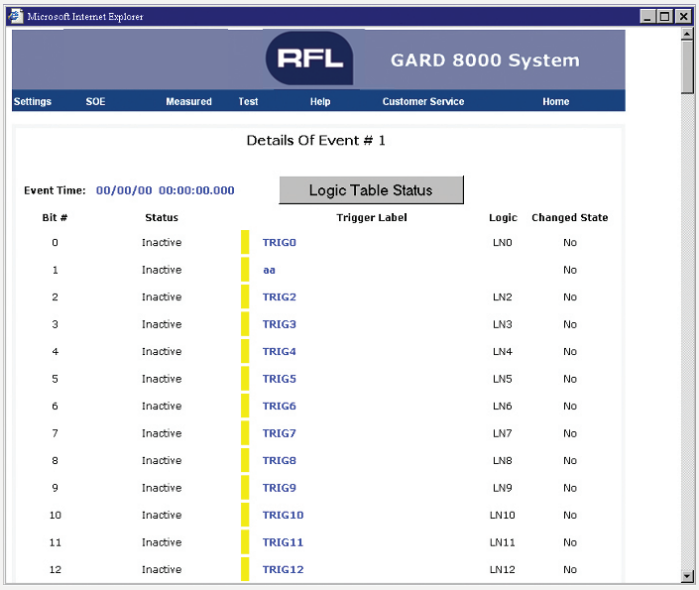


Figure 3. System of Events Details

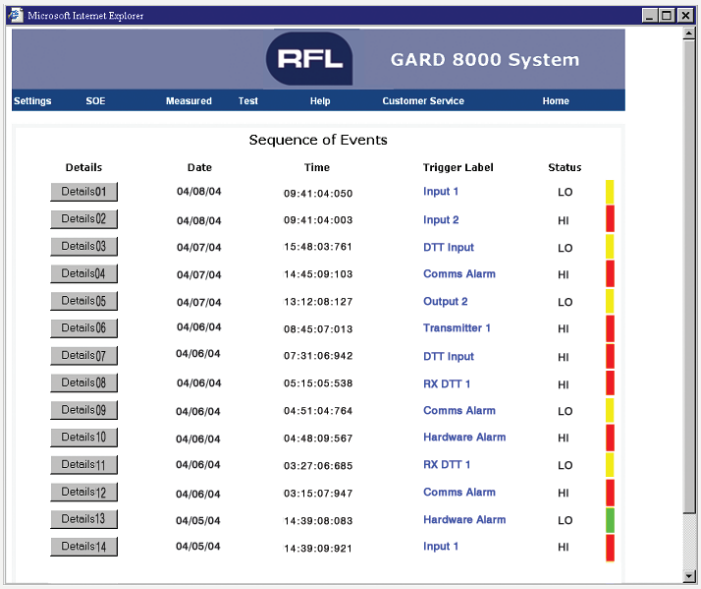


Figure 2. Sequence of Events Log

Sequence of Events

Figure 2 shows the Sequence of Events directory, listing the record number, date, time, trigger label, status and color indicator. Figure 3 shows the details from event record #1.

Programmability

Logic functions can be changed or fine-tuned remotely through the GARD 8000 Teleprotection unit's TCPIP or RS-232 port.

User Programmable Logic Functions

Change timer values, logic states and logic functions without ever removing a module or opening the chassis.

User Programmable Inputs and Outputs

The 3-rack GARD 8000 System unit has 8 I/O slots in the back to house a number of communications or discrete I/O modules. All logic mapping to the inputs, outputs and communications is fully programmable to meet specific customer requirements.

Create your own alarm conditions

The GARD 8000 Teleprotection unit can be programmed to any alarm configuration desired using the outputs on the I/O modules.

Every GARD 8000 Teleprotection unit is supplied pre-programmed with either default operating logic or custom logic. It should be noted that it is standard practice for RFL to provide system programming with every unit at no charge. Figure 4 shows the parameter settings for Channel 4 of the audio-tone version.

System Specifications

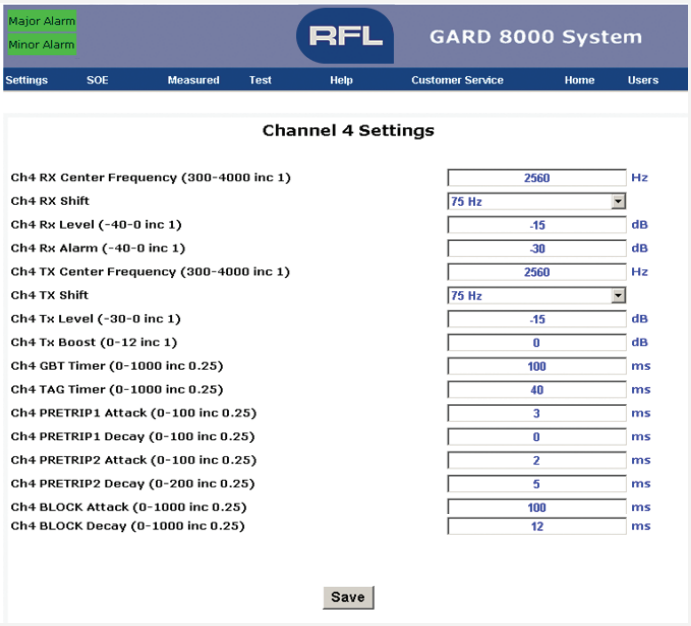


Figure 4. Channel Parameter Settings

Audio Teleprotection

The GARD 8000 audio tone teleprotection module provides four FSK transmitters/receivers. All transceivers are bidirectional 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.

Channel one can also be configured to be used for bi-directional status, up to 16 points are supported. The channel can also be used to transmit RS-232 data at rates up to 300bps. When status or data is enabled, the remote interogation feature can not be used.

Audio Interface Configurations
Single Two-Wire Terminals
Single Four-Wire Terminals

Recommended Channel Frequencies
Range: 300 Hz to 4000 Hz
Resolution: 1Hz

Transmit Level
Adjustable from -30 dBm +0 dBm in 1dB 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 31 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 .25ms steps.

Input and Output Impedance
600 Ohms

16 Point Bidirectional Status
Requires use of modem channel
Bandwidth 300Hz (3 150 Hz)
Transmit time: 110ms (one way)

RS-232 Data Channel
Requires use of modem channel
Bandwidth 300Hz (3 150 Hz)
Data rate: 300bps
RS-232: Software handshaking, TX, RX data

Digital Teleprotection

Each Digital TPS Engine can transfer up to 32 functions. These functions are broken down into 4 different function blocks. Each can be configured independently, and sent over the communications bus to the communications interface of choice.

Figure 5. shows a GARD 8000 with the four standard fun-ction blocks configured with three different communications interfaces.

Technical Specifications

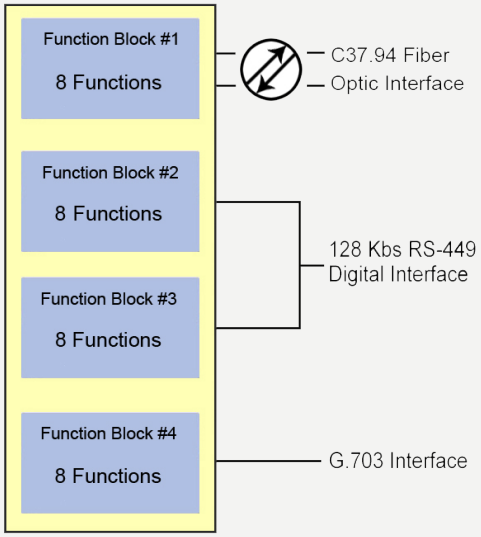


Figure 5. GARD 8000 System Diagram

Fiber Optic Communications

Fiber Optic Communications Interfaces and System Gains are as follows:

Wavelength & Emitter Type	Fiber Type	Connector Type	Output Level	Receiver Sensitivity	System Gain
1300nm LED	Singlemode	ST	-17 dBm	-39 dBm	21 dB
1300nm Laser	Singlemode	ST	0 dBm	-39 dBm	39 dB
1550nm Laser	Singlemode	ST	-3 dBm	-39 dBm	36 dB
C37.94	MM	ST	-19dBm	-32 dBm	13 dB
C37.94	SM	ST	-21.5Bm	-32 dBm	10.5 dB

* @ 25 C

Real Time Clock

IRIG-B

The GARD 8000 Teleprotection unit accepts the IRIG-B Standard Time Code on a 1kHz modulated or unmodulated carrier. Nominal signal levels are 3.3 volts peak-to-peak (3 0.5v) for a logic "1" and 1 volt peak-to-peak (3 0.2v) for a logic "0". The IRIG-B input presents a 3.7k ohm impedance and is transformer isolated.

Resolution

1 ms

Accuracy

Free Running: Within 1 minute per month
Under IRIG-B Control 31ms

Reset

Manual or by IRIG-B code

SNTP - Simple Network Timing Protocol

The GARD 8000 comes with standard support for SNTP. Settings are accessed via the web browser.

General Specifications

Events Storage

The Sequence of Events Recorder on the main controller module can store up to 600 events.

TCPIP Port

Two TCPIP ports, one on the front, one on the back.

RS-232 Interrogation Ports

The GARD 8000 Teleprotection unit provides one RS-232 Ports, located on the rear of the chassis. The rear RS-232 port is configured as a DTE Interface.
Number of Stop Bits: One
Parity: None
Flow Control: XON/XOFF

Isolation

The GARD 8000 Teleprotection unit's RS-232 ports (front and rear panel) are isolated from circuit common and chassis ground to a surge withstand level of 500 Vdc.

Input Power Requirements (EN 60834-1)

24 V	Rated	24 Vdc
	Range	19-29 Vdc
	Burden	<100W
48/125V	Rated	48/125 Vdc or 120 Vac
	Range	38-150 Vdc or 96-132 Vac
	Burden	<100W
250V	Rated	250 Vdc or 220 Vac
	Range	200-300 Vdc or 200-240 Va
	Burden	<100W

Power Supply

A single or redundant power supply can be provided depending on the reliability of the application. For example a DTT application for a higher voltage level line may demand the dependability of a redundant power supply. Note: The GARD 8000 Power Supply I/O provides two Form C alarm contacts for major and minor alarms.

Operate Time

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

3 30	Hz	Shift:	26.47 ms
3 42.5	Hz	Shift:	20.57 ms
3 60	Hz	Shift:	14.78 ms
3 75	Hz	Shift:	12.65 ms
3 120	Hz	Shift:	11.05 ms
3 150	Hz	Shift:	10.12 ms
3 240	Hz	Shift:	9.22 ms

Digital and Fiber systems: 3-5 ms depending on mode of operation. "Operate Time" is defined as the time from the receipt of a command input to the response of a solid-state output, less any channel propagation time.

Specifications are subject to change without notice

General Specifications Continued

Pre-Trip Timer
Adjustable in 0.25 ms steps

Trip Hold Timer
Adjustable in 0.25 ms steps

Command Extend Timer
Adjustable in 0.25 ms steps

Non-Volatile Storage
All parameters relating to system operation are stored in erasable non-volatile RAM. All parameters related to event logging are stored in capacitor-backed RAM.

RFI Susceptibility
ANSI PC37.90.2 (35 Volts/Meter)
EN 60255-22-3 (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)
EN 60255-22-1 (SWC Class III)
EN 60255-22-2 (ESD Class III)
EN 60255-22-4 (Fast-Transient Class III)
EN 60834-1

Temperature
Operating: -20° C to +75° C (-4° F to + 167° 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

Warranty Statement
RFL's standard warranty for the GARD 8000 Teleprotection unit is 10 years from date of delivery for replacement or repair of any part which fails during normal operation or service.

User Interface

Protection system reliability may be compromised by increased complexity of protection devices. While these protection devices offer added flexibility they also increase the risk for errors. Complicated settings, configurations and interconnections all combine to having an undesirable effect on protection system security and dependability.

The GARD 8000 System is designed with ease-of-use in mind. While high functionality and great detail is provided, it is not necessary to make field configurations, if not desired. The web browser User Interface makes interaction with the device highly intuitive and handling greatly simplified.

Front Panel LEDs

Two rows of ten multi-colored LEDs provide basic event information. The LED operation is fully configurable and labels can be changed to suit the application. Custom configuration and labeling can be factory-made by RFL without extra charge. Any field modifications required are simply made by use of the browser interface.

Front Panel Display

An optional touch screen display (TSD) is available for metering, targets and settings. The TSD provides a color screen that will automatically orientate itself for horizontal or verticle mounting. User programmable buttons are provided for unique customer requirements. For things such as breaker control or cut-in/cut-out switches.

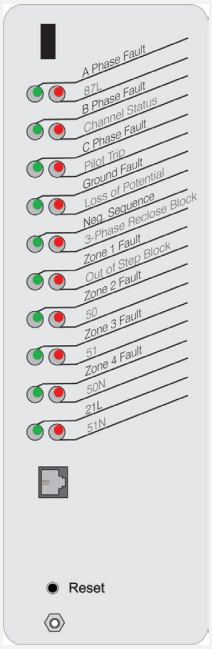


Figure 6. GARD 8000 Front Panel LEDs (6U)

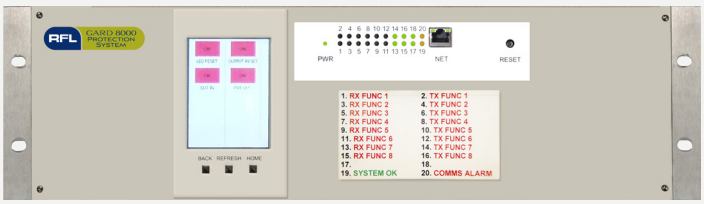


Figure 7. GARD 8000 3U Front Panel

Web Browser User Interface

Web Browser UI

All interaction with the GARD 8000 System is made by the use of a standard web browser. The web pages reside in the device; no special application software is required on the PC.

Web browser technology provides a much higher level of ease-of-use as compared to the conventional "menu-driven" operation. It is fast and simple to view device status, access diagnostic and test functions and to change settings. Emulating the operations of a standard web site, navigation is intuitive and eliminates the need to study written instructions. If preferred, the instruction manual, that also resides in the device, is simply accessed by the HELP function.

For off-line preparation of settings and configuration files, a small application program "emulating" a GARD 8000 System, which is available free of charge, can reside on the PC or local server.

A PC is connected to the front TCP/IP port with a standard connector.

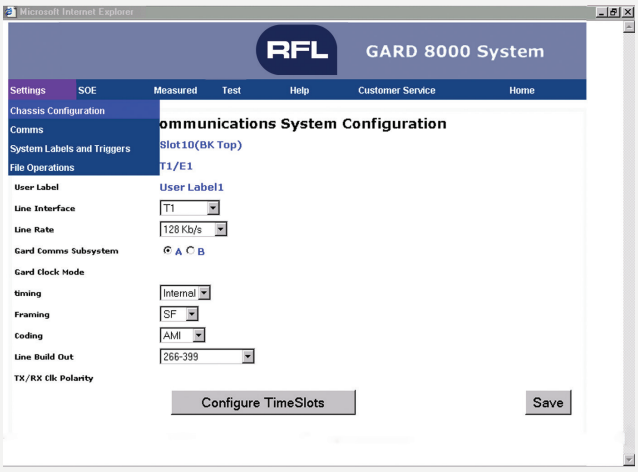


Figure 9. Web Browser User Interface

Figure 10. Ethernet Connector

Input and Output Modules

The GARD 8000 System is configured with a selectable number of input and output modules on the rear part of the chassis.

The following combinations are available for mounting in the up to 10 rear slots (6U) or 4 rear slots (3U):

1 communication interface/6 inputs
1 communication interface/6 outputs
6 inputs/6 inputs
6 inputs/6 relay outputs
6 inputs/6 solid state outputs
6 solid state outputs/6 solid state outputs
6 solid state outputs/6 relay outputs
6 relay outputs/6 relay outputs
4 latching relay outputs/4 form-C contacts

All relay output contacts are Form A (NO) or Form B (NC) jumper selectable. A simple setting for an inverter logic gate provides inversion for each input and output. Each input and output has a timer associated with it that has settings for both pick-up delay (input debounce, output security) and drop-out delay (pulse-stretch).

* With the exception of the latching relay module which is form-C only.

Optically Isolated Inputs

Quantity: 6 per module
Input Voltage Jumper Selectable: 24/48/125/250 Vdc
Operation Range:
24 Volts: 19 to 36 Vdc, Nominal Input
48 Volts: 37 to 68 Vdc
125 Volts: 94 to 150 Vdc
250 Volts: 189 to 300 Vdc
Input Current: 1.5 mA minimum
Minimum Pulse Width:
0.03 ms, additional debounce time set in the logic

Solid-State Outputs

Quantity: 6 per module
Output Current: Maximum 1 A continuous, 2 A for 1 minute, or 10 A for 100 msec
Open-Circuit Voltage: 300 Vdc maximum
Pick-up Time: 0 msec

Relay Output

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

Alarm Relays

Quantity: 2
Contacts: SPDT (Form C)
Output Current: 100 mA 300 Vdc resistive load

Terminal Connections

Screw terminals for ring lugs with wire up to AWG #10.

Native IEC-61850 8

Native IEC-61850

The GARD 8000 complies to the requirements stated in IEC-61850-2 for teleprotection equipment. The HMI functions come standard with the GARD 8000, however, if tripping capability over a LAN is desired, the optional ethernet tripping module is required.

Ethernet Tripping Module (IEC 61850 compliant)

The GARD 8000 System can be provided with an Ethernet Tripping Module. IEC 61850 substation automation provides a LAN (Local Area Network) in the substation where trip messages are passed between the devices via GOOSE messages on a TCP/IP network.

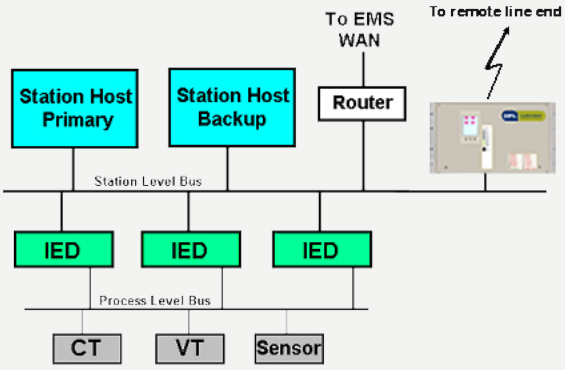


Figure 11. IEC 61850 Substation

The GOOSE message is routed to perform trip functions of circuit breakers, but a shortcoming with the network is that there is no easy means to transfer a GOOSE message to a remote location if the Ethernet network does not encompass the two substations. The GARD 8000 Ethernet trip-ping module solves this dilemma, by retrieving GOOSE messages from the LAN and transporting them over any of its communication interfaces.

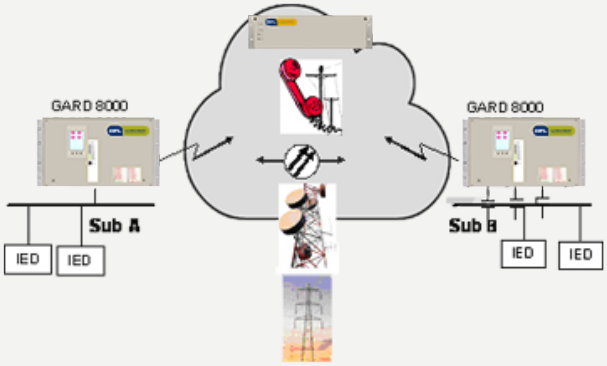


Figure 12. GARD 8000 teleprotection between two IEC 61850 substations

The GARD 8000 provides the link between two IEC 61850 substations over any communication media. The sending GARD 8000 retrieves GOOSE messages from the substation LAN, puts it on a communication link to a remote GARD 8000 that puts it on its substation LAN.

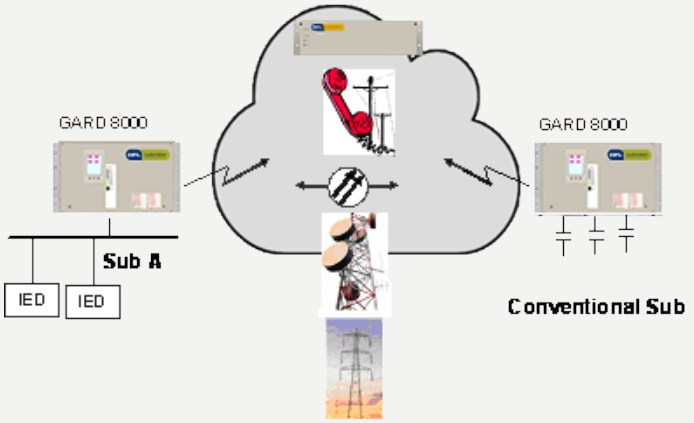


Figure 13. GARD 8000 Teleprotection between an IEC 61850 substation and a conventional substation

Generally, a new IEC 61850 substation needs to interact with a conventional substation at remote line ends. In this case, the GARD 8000 retrieves GOOSE messages for transfer trip or pilot relaying operations from the IEC 61850

substation LAN, transports them over any communication link and the remote, receiving GARD 8000 performs normal teleprotection operations such as tripping of breakers and pilot relaying signaling.

In addition, in case pilot relaying and teleprotection need to be performed over an Ethernet network between two conventional substations, a GARD 8000 at each line end can send GOOSE messages over the network for intertripping.

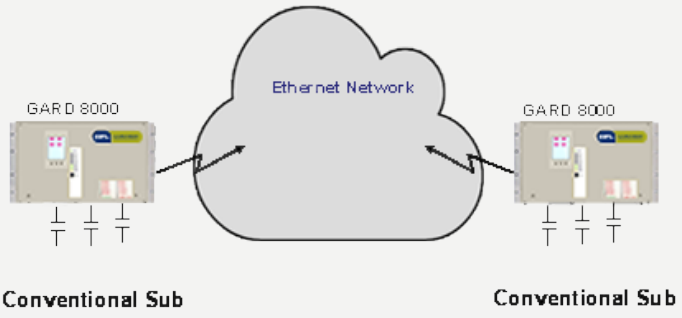


Figure 14. GARD 8000 Teleprotection over an Ethernet Network

Modules and Alarms

High Capacity Status Transfer Module

The GARD 8000 standard Teleprotection System supports up to eight high-speed functions in one 64 kbps channel. For telemetry applications, there is often a need to transport a higher number of status points, but transmission time is less critical than for teleprotection signaling.

To complement the teleprotection systems, a high capacity status module is available. This module supports up to 96 status bits over a 64 kbps channel. End-to-end delay is 7-12 ms, depending on the security count used.

The high capacity status transfer module can be added as an optional front mounted module, or be supplied instead of the standard teleprotection system on the Base TPS/Display board.

Multiplexer Pass-Through Channel

The GARD 8000 has 12 built in communications channels that can be used for Teleprotection and other Protection applications. These communications channels can also be used with external devices that require a communications or pilot channel to operate. This allows the GARD 8000 Teleprotection channel to also be used as a substation multiplexer that other protective relays can be interfaced with.

The GARD 8000 can be configured with 56/64kb channels with RS-449, G.703, and C37.94 fiber optic interfaces. The unit can also be configured with a dual RS-232 communications channel for Mirrored Bit relaying or other slow speed devices. Figure 15 shows a RFL 9300 current differential relay and a Mirrored Bit relay communicating over a GARD 8000 Teleprotection channel configured with two relaying communication interfaces.

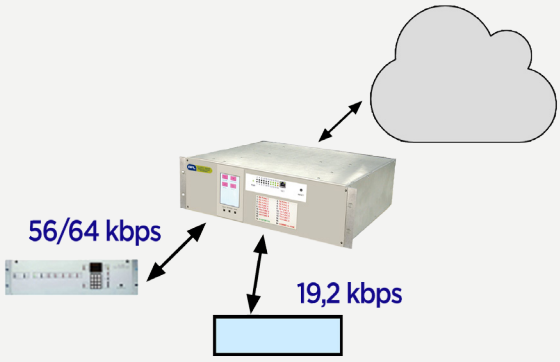


Figure 15. GARD 8000 Used as a Multiplexer

GPS Module

Accurate time stamping is essential for evaluation of protection system operations, especially following a major system disturbance.

The substation may be equipped with a GPS central clock that can be connected to the GARD 8000 IRIG-B port. When a central clock is not available, the GARD 8000 can have its own, built-in GPS receiver.

When the GARD 8000 is equipped with the internal GPS receiver, the IRIG-B port can be used to supply IRIG-B to other devices. This enables not only the GARD 8000 System to keep accurate time tags but other protective devices also have access to a dc-powered, substation hardened, time source that is independent from any centralized GPS system.

Alarm Reporting

The GARD 8000 System Platform provides three types of alarm reporting capabilities:

Programmable Contact Output
Any alarm output that is defined in the system logic can be programmed to a user defined output. You can have as many outputs as needed for alarm requirements. The GARD 8000 alarm configuration page allows the user to program system level Minor or Major alarms. When a Minor or Major alarm is triggered an output will be initialized on the unit.

DNP3
The GARD 8000 can broadcast DNP3 message through the Ethernet port or the integrated RS-485 port to support DNP masters along with solicited or unsolicited messages.

SNMP
The GARD 8000 can generate SNMP V2C traps in the event of an alarm condition. The alarm traps are programmable. The GARD 8000 has HMI Output bits which can be defined by the user to refer anything in the system logic. This includes alarms and trip inputs/outputs. By using the built in web interface, each HMI output can be assigned a text label by the user. If an alarm event occurs a trap will be generated and will include the version number (V2C Notification), the RFL OID and the "timestamp".

Examples of GARD 8000 System Configurations

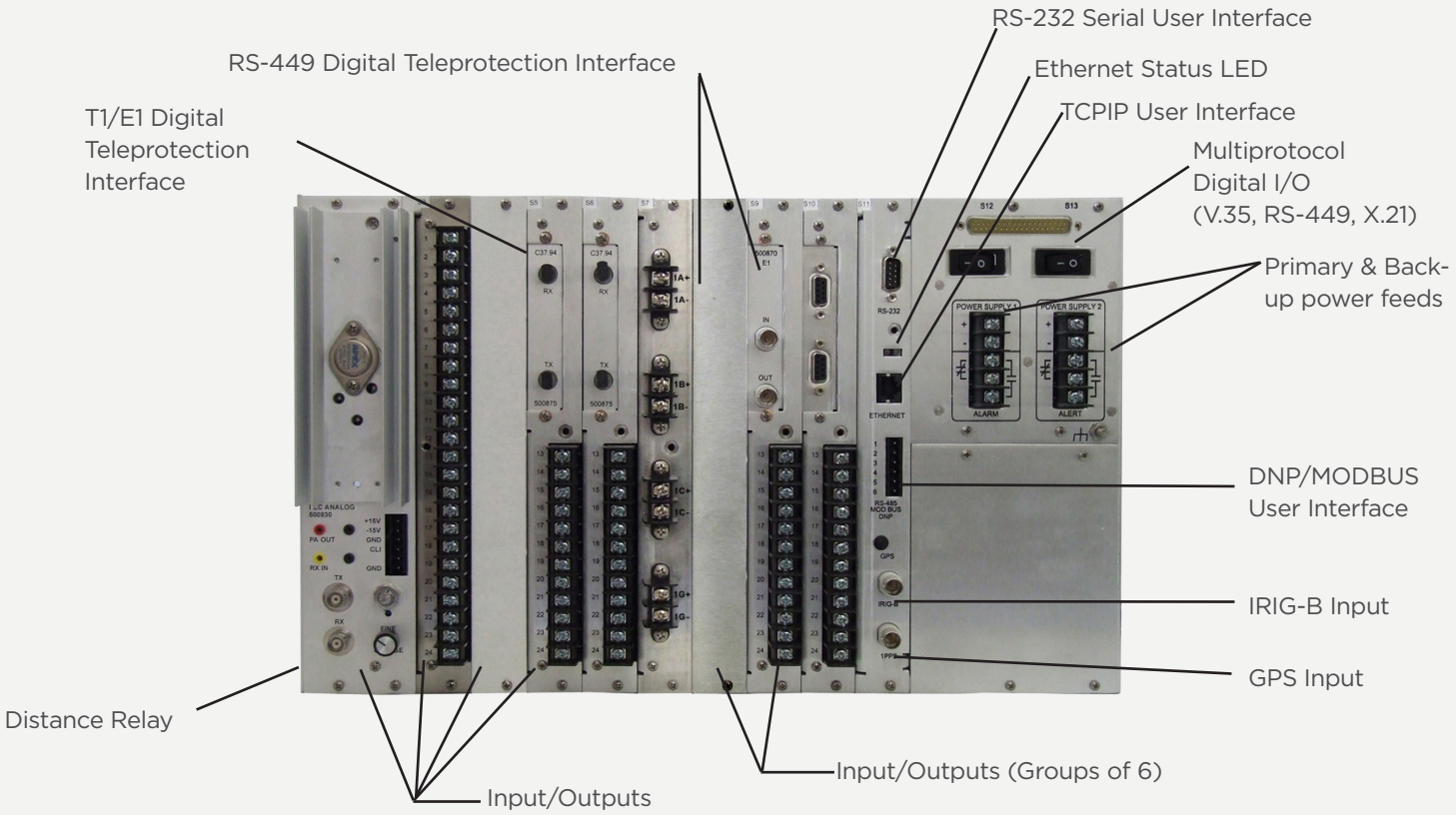


Figure 16. Rear View 6U GARD 8000 Digital Protection System with (4) Digital Interfaces

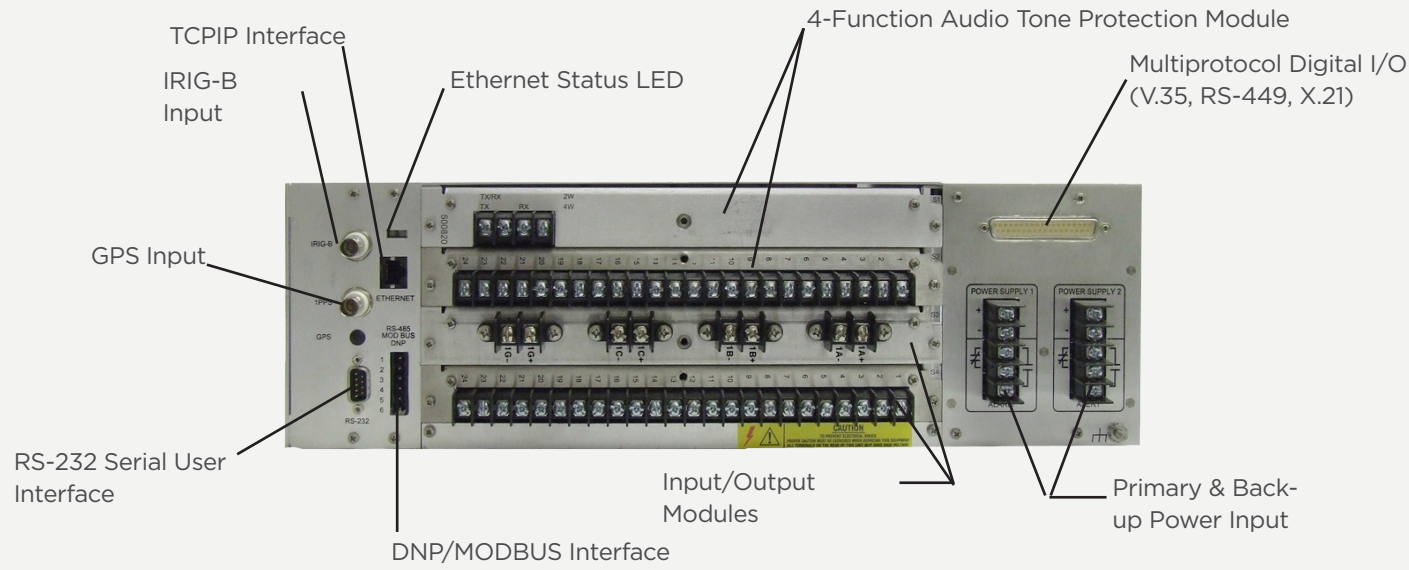


Figure 17. Rear View 3U GARD 8000 Dual Analog Protection System.

Dimensions

GARD 8000
Single Function PLC
3U System Dimensions

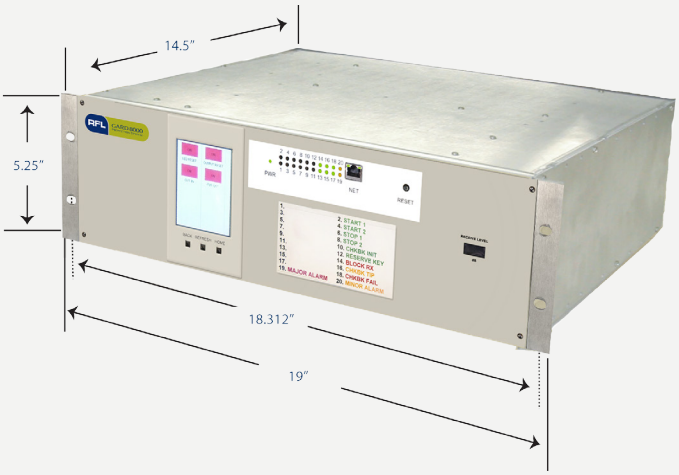


Figure 11. Rack or Cabinet Mounting (3U)

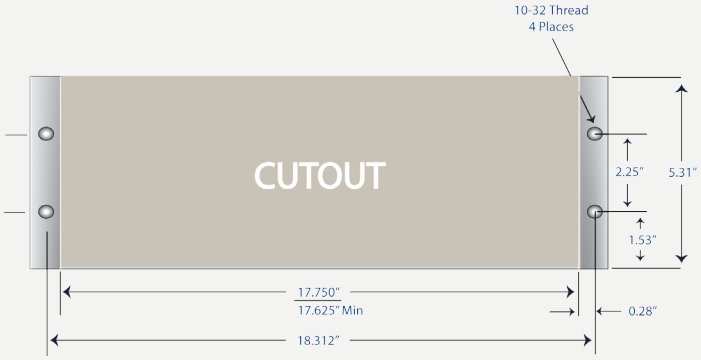


Figure 12. Panel Mounting (3U)

6U System Dimensions

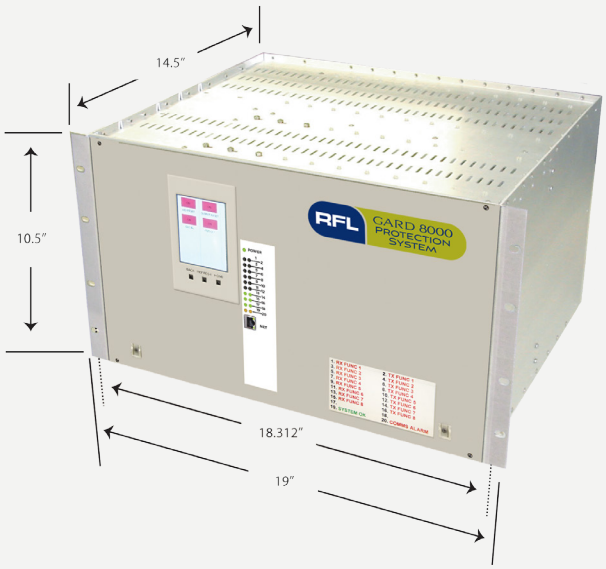


Figure 13. Rack or cabinet Mounting (6U)

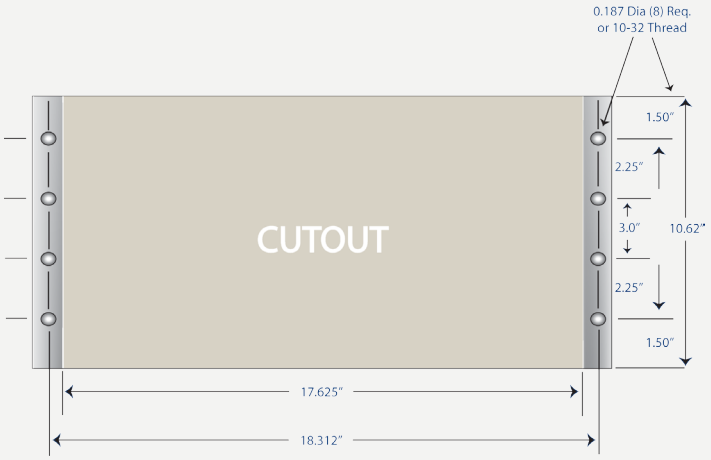


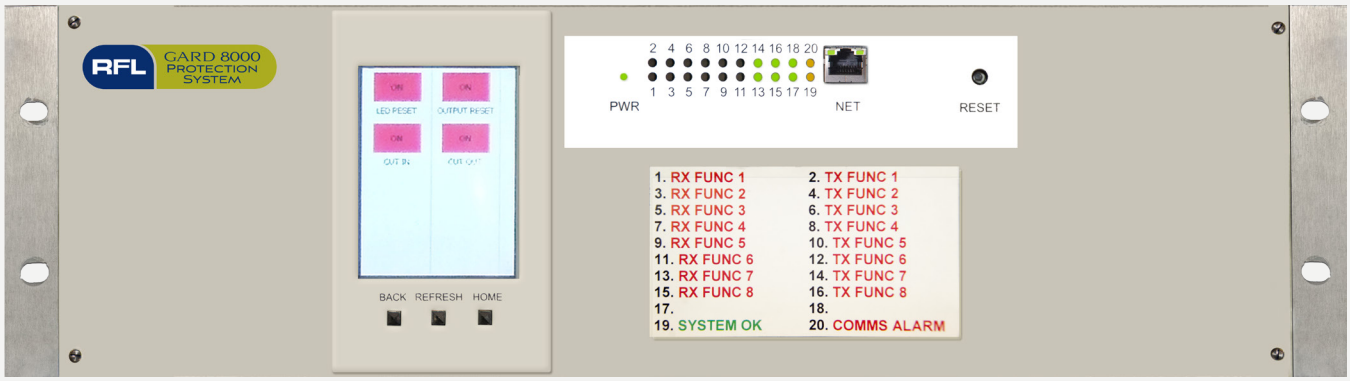
Figure 14. Panel Mounting (6U)

RFL

SOLUTIONS FOR AN EVOLVING WORLD

RFL GARD 21RL

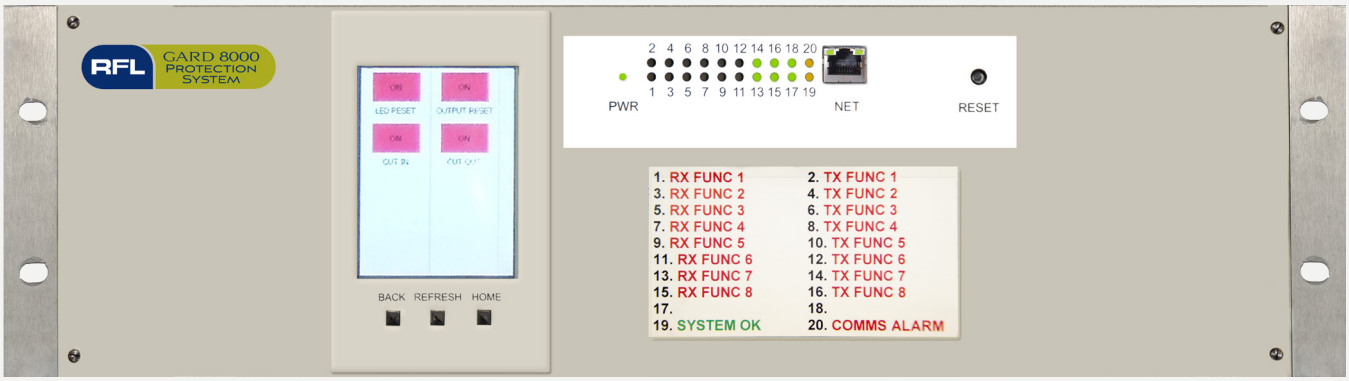
Distance Relay



HUBBELL

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.

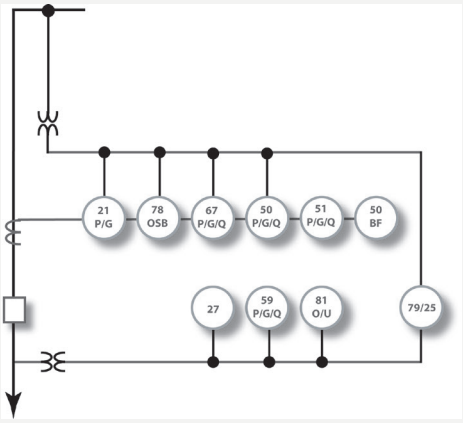


Figure 1. Distance Module Functional Diagram

Protection Features

The Distance Protection in the GARD 8000 System resides on a plug-in module with its own input transfomers 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.

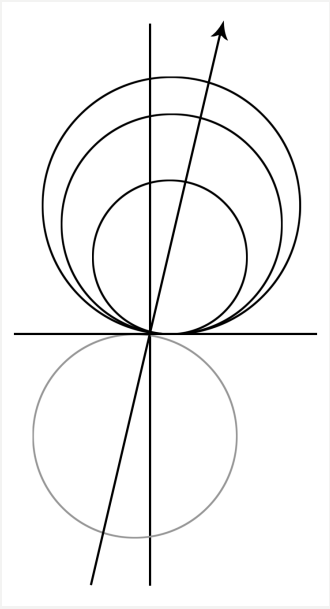


Figure 2. Distance Protection Characteristic

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).

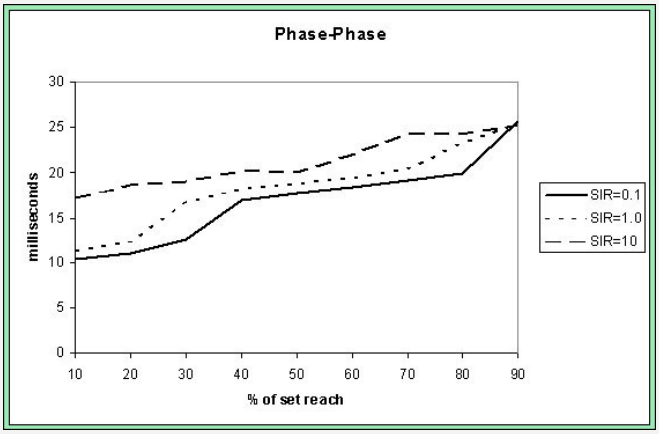


Figure 3. Phase-Phase Fault Operating Times

System Description and features (continued)

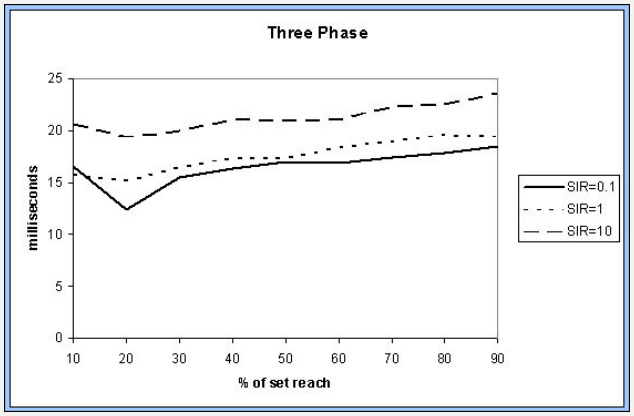


Figure 4. Three Phase Fault Operating Times

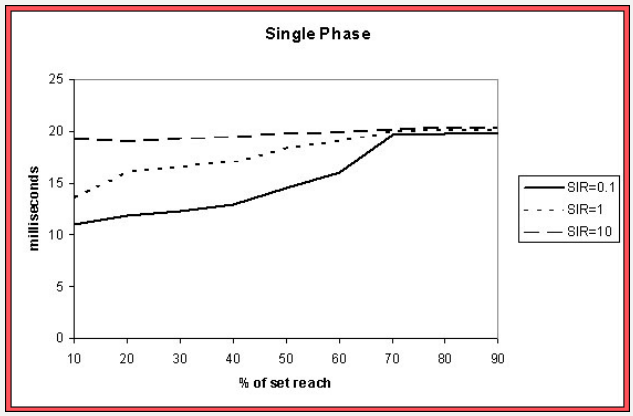


Figure 5. Single Phase to Ground Fault Operating Times

Overcurrent Elements

The GARD 8000 Distance Protection Module includes a large number of overcurrent elements for back-up.

Instantaneous phase, ground and negative sequence elements can be set to provide independent high-speed tripping for closing faults.

Phase, ground and negative sequence time overcurrent elements provide back-up with any of the built-in pre-defined inverse time characteristics. All standard IEC and ANSI curves are available and 'User curves' with other characteristics can be supplied on request.

All current elements can be selected to be torque controlled by directional elements (67). The ground directional element can be set to Zero or Negative Sequence polarizing.

Overcurrent Supervision of Distance Elements

All distance elements are supervised with settable overcurrent elements. Forward-looking and reverse-looking zones have individual current element settings which ensure security when a reverse zone is used as part of a pilot scheme operation.

Phase-phase and phase-ground supervision are individually set. This enables higher sensitivity for ground faults while security is increased for phase-phase and three-phase faults by setting the supervision element above load current.

Overvoltage and Undervoltage Elements

The GARD 8000 Distance protection provides overvoltage and undervoltage elements for each phase. Operation can be
enabled on a single phase or three phase basis. Individual setting thresholds and timers are available for overvoltage and undervoltage operation.

Out-of-Step Blocking

The GARD 8000 Distance Protection has an Out-of-Step Detector that will block operation of any distance zone according to setting. The Out-of-Step Characteristic has settable blinders and timer that enables fine tuning to actual system conditions. The Out-of-Step detector can also be set to perform Out-of-Step tripping, with the selection of trip on the Way Out or Way In.

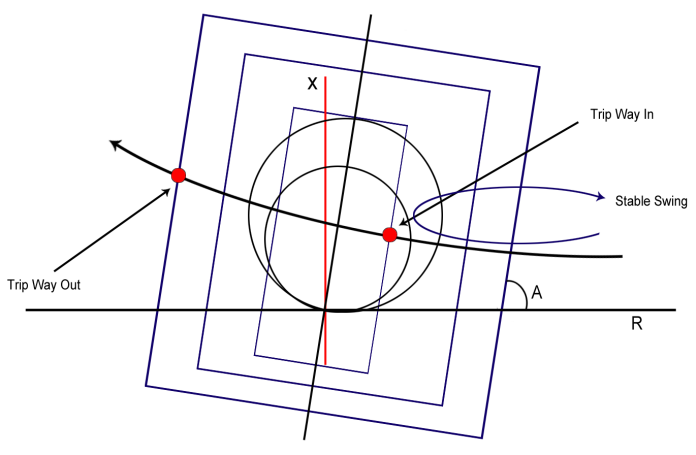


Figure 6. Out-of-Step Detector

Load Encroachment

The GARD 8000 Distance Protection has dynamic mho characteristic which will expand with the source impedance. As it is not possible to control the resistive reach of the dynamic mho, there is a risk that the characteristic will fall into the load impedance on long, heavily loaded lines. To prevent this, a load encroachment characteristic is provided. The characteristic has individual setting for forward and reverse load, which enables fine tuning for the actual application. Generally, maximum forward and reverse load differ and the blocking zones should not be larger than necessary for the application. The load encroachment characteristic provides blocking zones that will prevent an expanding mho characteristic from operation within the set zone.

System Description and features (continued)

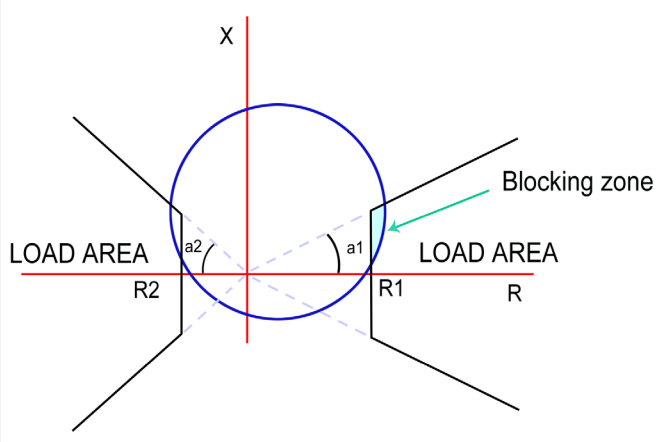


Figure 7. Load Enchroachment Characteristic

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 intiate 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 sync 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 sync 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

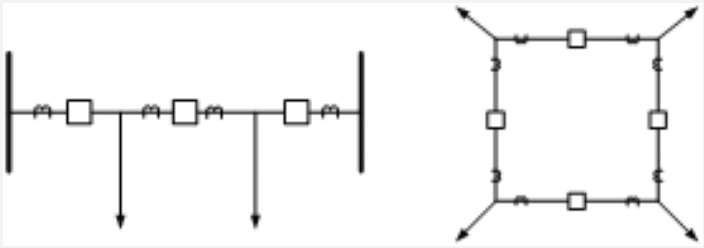


Figure 8. Breaker and a half and Ring Bus applications

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.

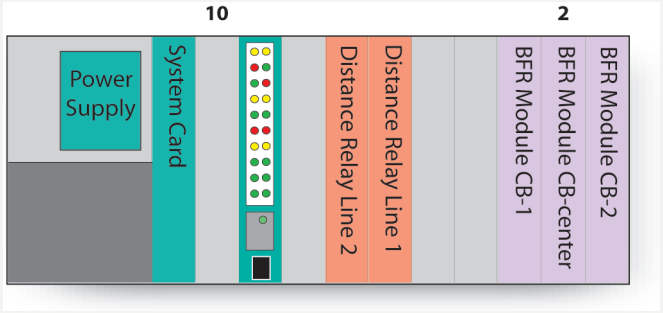


Figure 9. GARD 8000 Distance Protection for a Breaker and a half application

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

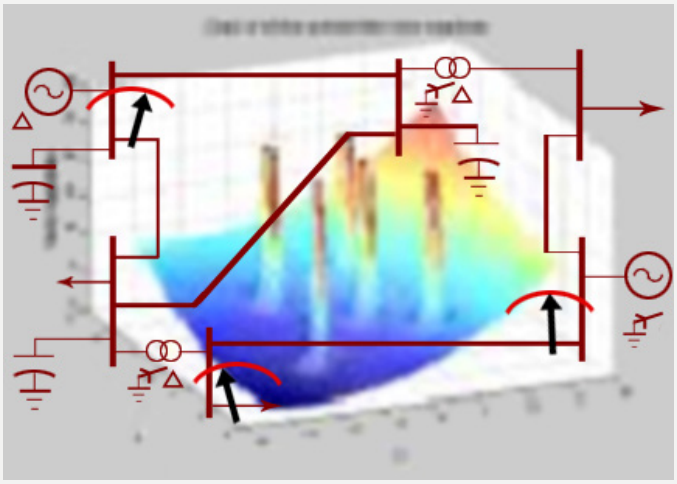


Figure 10. GARD 8000 Synchrophasor Measurement

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.

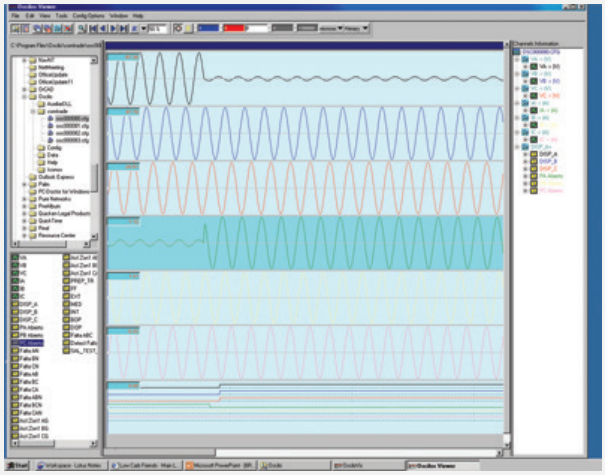


Figure 11. Digital Fault Record

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 moduleIn 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.

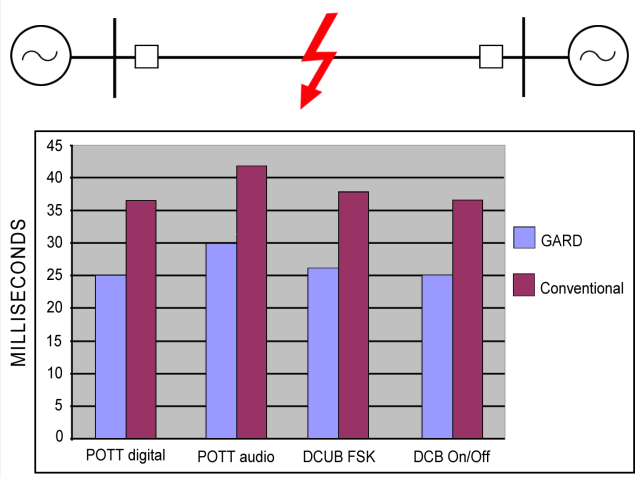


Figure 12. End-to-End Trip Times

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.

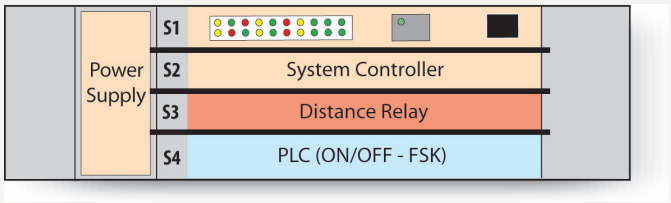


Figure 13. Distance Relay with Power-Line Carrier

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.

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

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):

3	30.	Hz	Shift:	26.47 ms
3	42.5	Hz	Shift:	20.57 ms
3	60.	Hz	Shift:	14.78 ms
3	75.	Hz	Shift:	12.65 ms
3	120.	Hz	Shift:	11.05 ms
3	150.	Hz	Shift:	10.12 ms
3	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 31 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

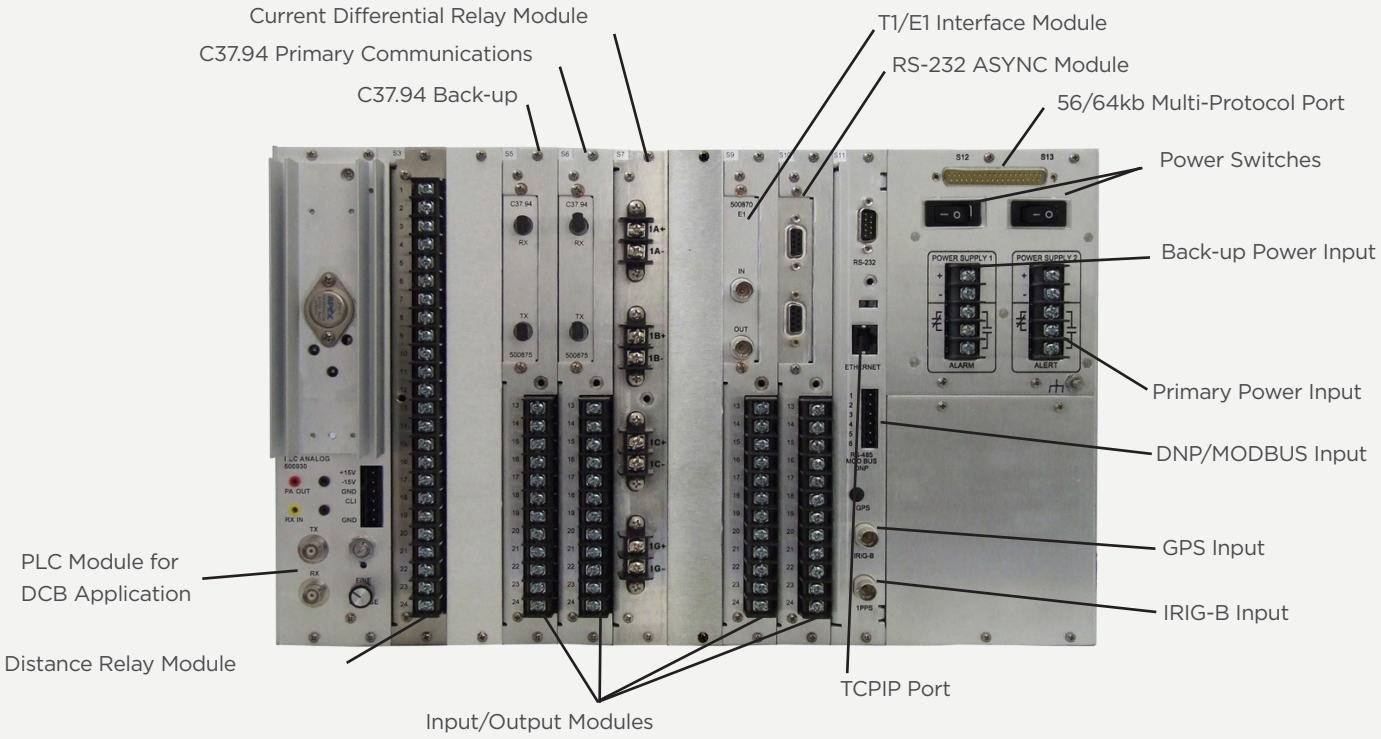


Figure 14. Rear View 6U GARD 8000 with Distance Module with Powerline Carrier Interface and Current Differential Relay with Primary and Back-Up Communications

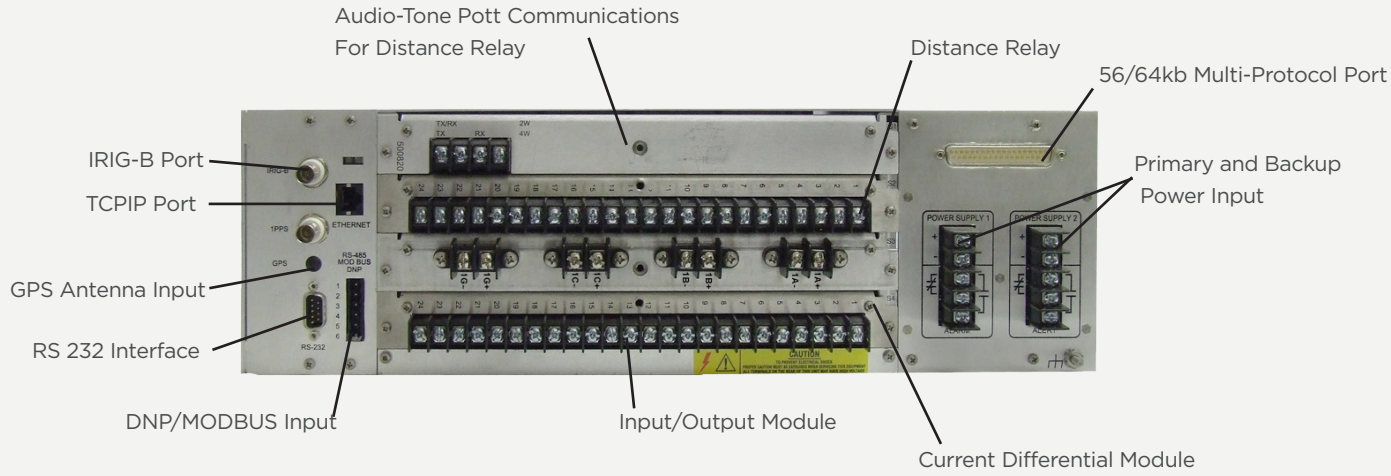


Figure 15. Rear View 3U GARD 8000 with Current Differential Module with Digital Communications and a Distance Module with Audio-Tone Communications

Dimensions

GARD 8000
Single Function PLC
3U System Dimensions

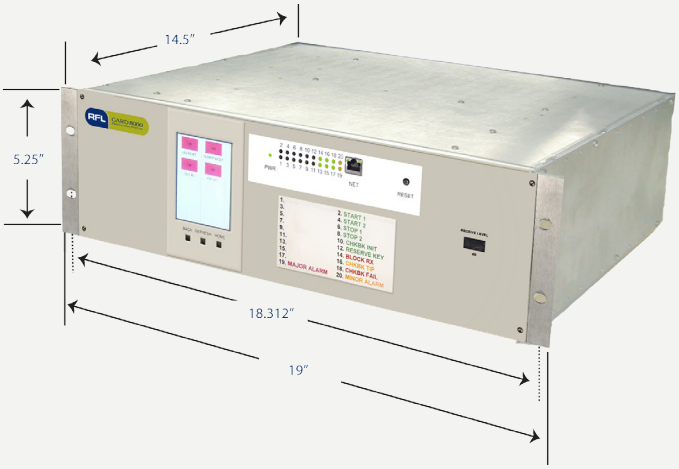


Figure 11. Rack or Cabinet Mounting (3U)

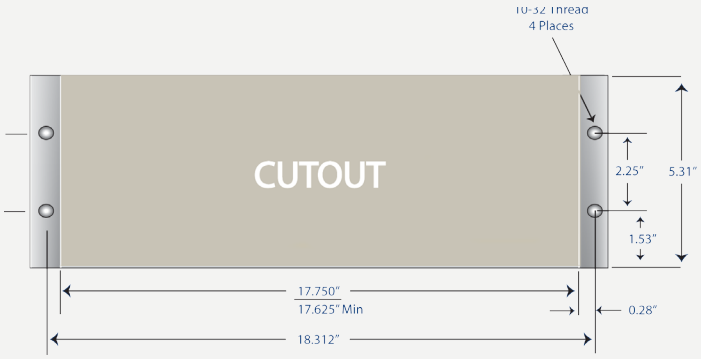


Figure 12. Panel Mounting (3U)

6U System Dimensions

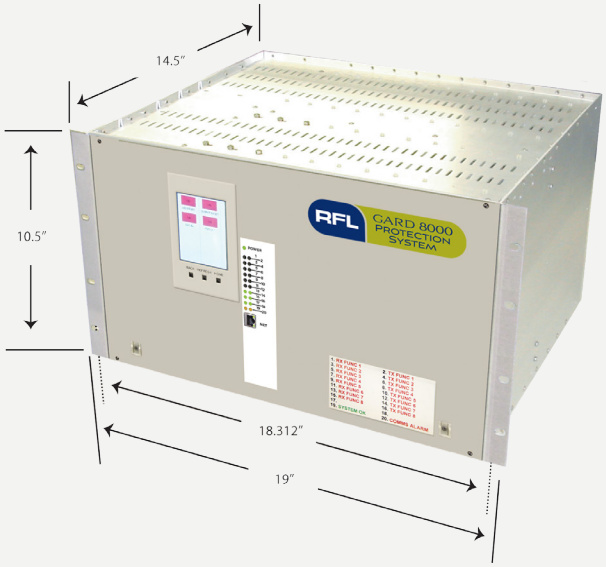


Figure 13. Rack or cabinet Mounting (6U)

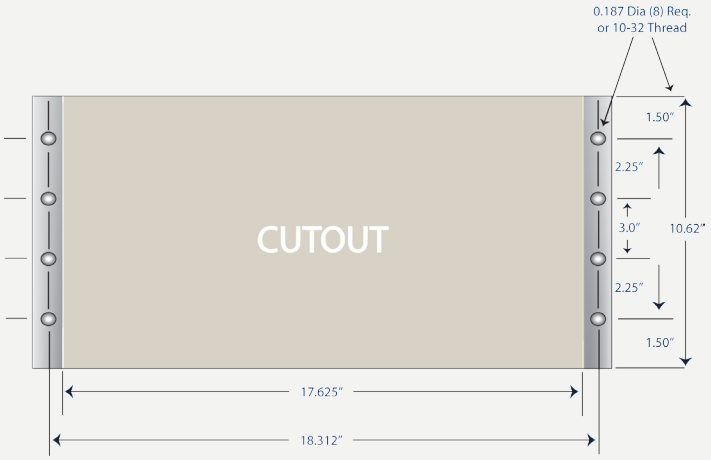
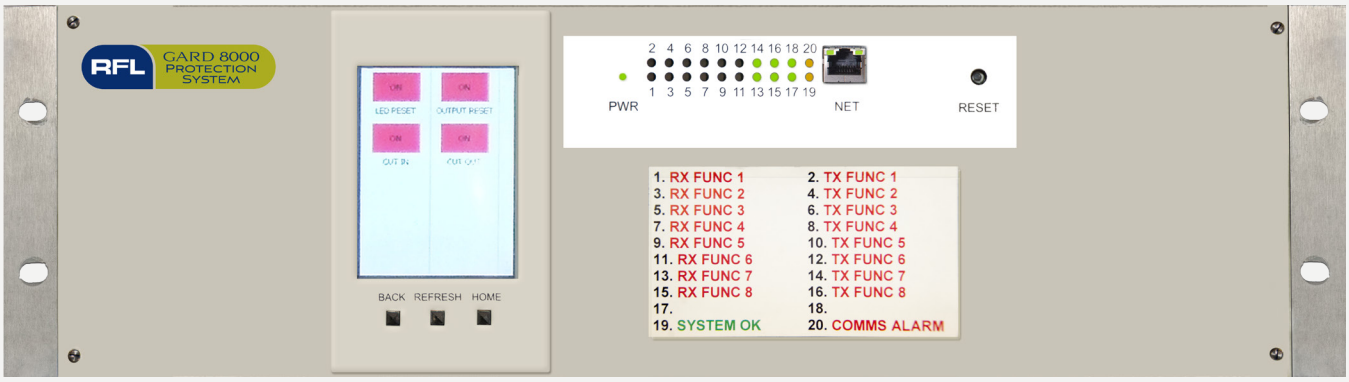


Figure 14. Panel Mounting (6U)

SOLUTIONS FOR AN EVOLVING WORLD

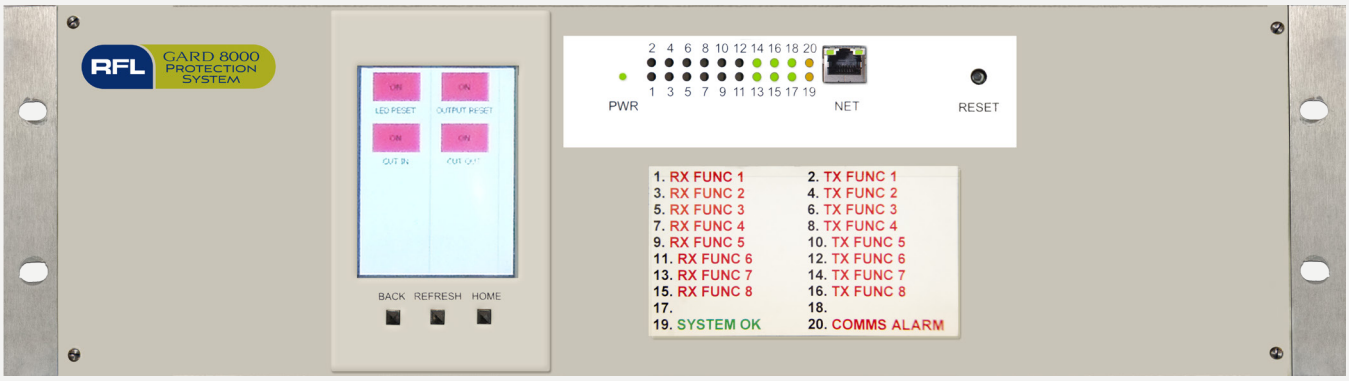
RFL GARD 87L

Current Differential Relay



GARD 8000

Current Differential Relay



System Features

A complete Current Differential Protection in the GARD 8000 Protective Relay and Communications System

Stand-alone or together with a GARD 8000 Distance Protection Module as communications independent back-up

Duplicates the highly successful RFL 9300 measuring principle with added features

Unaffected by up to +/- 4 ms channel asymmetry, giving a tolerance of 8 ms difference in transmit and receive path delays

Dual Breaker option for breaker and a half or ring bus applications

Single Pole trip

Ideal for series compensated line applications

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

Supports NERC/FERC security standards

Phase-segregated measurement; three phase elements, one ground element

High speed operation; 10 ms minimum

Single or redundant communications interface

Extensive Sequence of Event Reporting

Digital fault records in COMTRADE; 32 samples per cycle

Supports DNP 3.0

10 Year Warranty

A wide range of communication interfaces to choose from:

- T1/E1, electrical or fiber
- RS 449, 56-768 kbps
- X.21, 64-768 kbps
- V.35, 64-768 kbps
- G.703, co-directional, 64 kbps
- C37.94 fiber
- Fiber, multi-mode or single-mode; up to 80 km

Two- or three-terminal line applications

System Description

The Current Differential Protection Module in the GARD 8000 System is a proven current-only, high speed line protection system. The advantages with current-only schemes are well known:

- potentials not required
- unaffected by CCVT transients
- never overreach, never underreach
- is not affected by mutual coupling on parallel lines
- unaffected by power swings

Current Differential Protection was traditionally reserved for short line applications due to the limitation of the required pilot wire. However, with the advantage of new communications technology, digital communications become increasingly available for longer lines as well.

Current Differential Relaying is unquestionably the simplest form of line protection, requiring very few settings to be entered for the actual line. The GARD 8000 Current Differential Protection System provides high-speed fault clearing and high sensitivity without compromising security.

The GARD 8000 Current Differential Protection System can be used for two- or three-terminal lines as well as tapped load applications.

The GARD 8000 Current Differential Protection System is suitable for series compensated lines and is inherently phase selective, making it an excellent choice for single pole trip applications.

The GARD 8000 Current Differential Protection Module can be complemented with an independent full Line Distance Protection Module within the same GARD 8000 chassis for full redundant Pilot Protection or as channel failure back-up for the Current Differential Protection. The Distance Protection Module provides additional protection elements such as voltage elements, recloser and synch check.

The two protection modules can be applied in pilot schemes over the same communications channel, or use independent communications interfaces. Or each can be provided with an independent communications interface and use a third as a common redundant channel.

It has been shown that using independent protection modules within the same chassis with redundant power supplies and redundant communications interfaces provides a higher degree of redundancy than physically separate protection devices. A direct comparison based on component failure rates between conventional, redundant Main 1 and Main 2 pilot protection, with redundant pilot protection within one GARD 8000 chassis shows an increased MTBF (Mean Time Between Failure) of a factor of 10 in favor of the GARD 8000 hardware configuration.

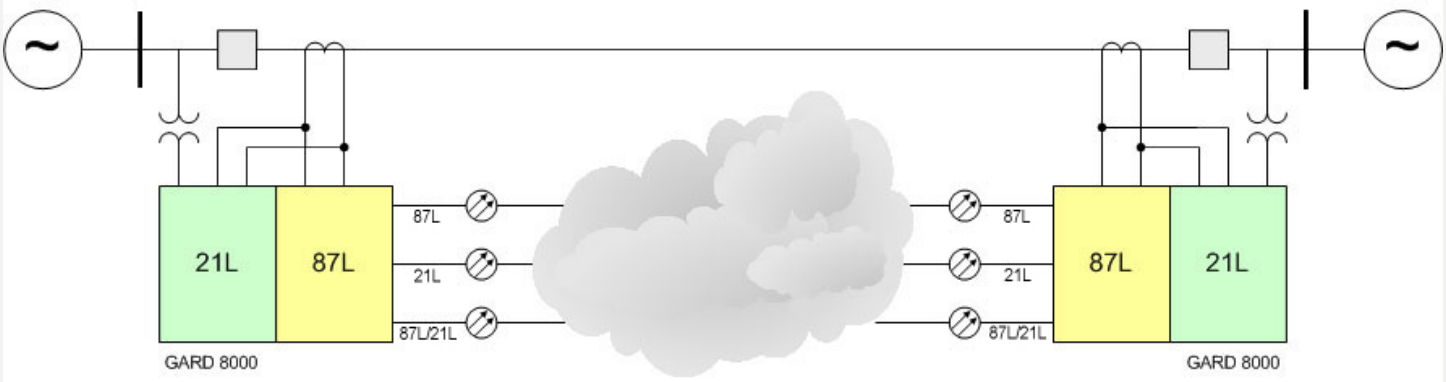


Figure 1. Typical Current Differential Relay (87L) and Distance Relay (21L) Application

Protection

Current Differential relaying is a method of extending the benefits of differential protection as applied to transformers, buses or generators to the protection of transmission lines. Comparing current flowing into a line to the current flowing out of the same line allows for a simple protection scheme with high sensitivity and high speed simultaneous tripping of both line terminals. At the same time, the differential scheme is unaffected by external effects such as faults, load and power swings.

The differential current can be measured with different methods:

- Magnitude comparison
- Phase comparison
- Phasor comparison (magnitude and angle)
- Charge comparison
- Combinations of the above

Regardless of the method used, all line differential relays operate on a difference in current into the line compared to the current out of the line.

For an internal fault, the current will flow into the line from both line terminals with the polarity of the current transformers as shown in Figure 2. The local current IL will be practically in phase with the remote current IR. A small phase difference between the two currents is caused by different source angles at the local and remote end.

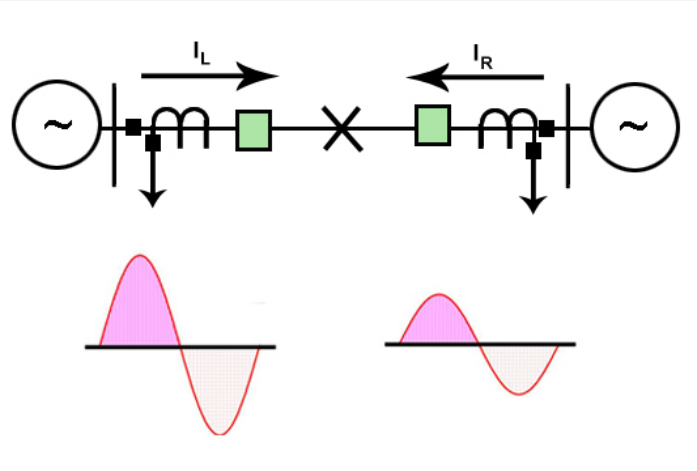


Figure 2. Currents for an Internal Fault

For an external fault, the current will flow into the line in one terminal and out of the other as shown in Figure 3.

The local current, IL will be 180 degrees out of phase with the remote current, IR and they will be of equal magnitude.

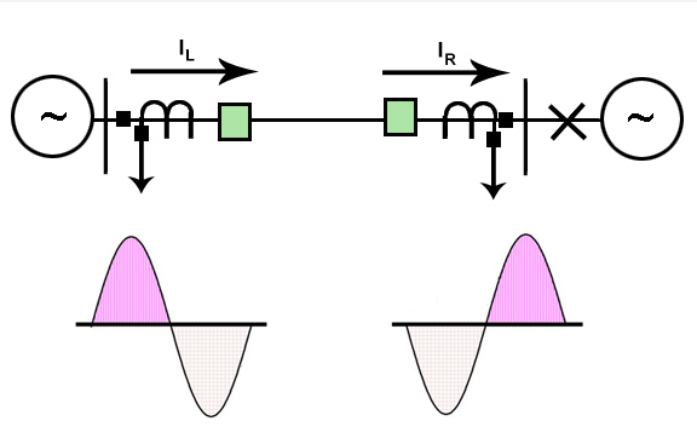


Figure 3. Currents for an External Fault

Most digital current differential relays emulate the electromechanical pilot wire relays operating principle, but more complexity is added due to the communication medium. While the pilot wire relay does its comparison in real-time, a digital current differential relay needs to compensate for the delay introduced by the communications channel for transmitting the digitized current information from one line terminal to the other.

The characteristics of the communications channel need to be taken into account both by the relay's communications interface design and the measuring principle used. The communications interface has to block a corrupted data message from being delivered to the relay and ensure that the two relays remain synchronized to each other. Accurate channel time delay measurement has to be performed so that proper alignment of the measuring quantities can be made. The relay's measuring principle needs to properly handle errors introduced by any asymmetric channel delay (different transmit and receive paths) on switched communications networks in addition to dealing with power system issues causing false differential currents, mainly from ct errors.

The GARD 8000 Current Differential Relay, like its predecessor RFL 9300, has been designed for use with digital communication media. The communications interface and the relay operating algorithm work in synergy to provide the optimum performance of any current differential relay available on the market. The unique design allows for high sensitivity and high speed operation for internal faults while maintaining high security for external faults.

Measurement

The Current Differential Measuring Principle used in GARD 8000 is based on RFL's patented Charge Comparison Measurement Principle.

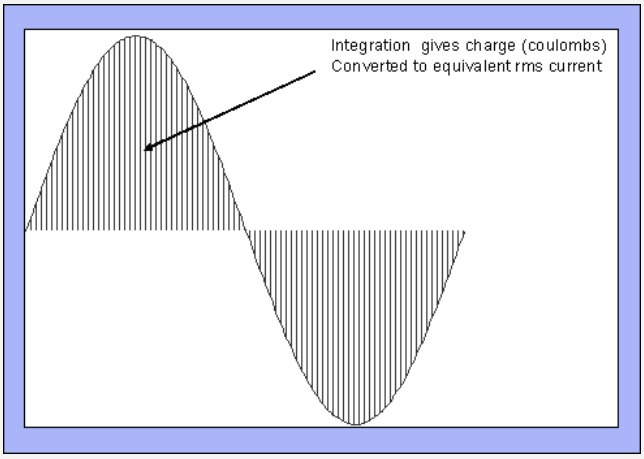


Figure 4. Integration of Current Samples

To perform charge comparison, the current wave of each phase and residual is sampled every Ð ms. The half-cycle area under each wave is measured by integrating current samples between zero-crossings. For each phase and ground, the resulting ampere-seconds area (coulombs of charge) is stored in local memory, along with polarity and start/finish time tags. This storage operation occurs only if the magnitude exceeds 0.5 A rms equivalent and the half-cycle pulse width is larger than 6 ms, but does not exceed 10 ms.

Every positive (negative for 3I0) magnitude is transmitted to the remote terminal, along with phase identification and some timing information related to the pulse width. When the message is received at the remote terminal, it is assigned a received time tag. A time interval representing the channel delay compensation is then subtracted from the received time tag. The adjusted received time tag is then compared with the locally stored time tags looking for a coincidence, or a 'nest'.

A nest is achieved when the adjusted received time tag falls between the local start and finish time tags for a given half-cycle stored in memory, as illustrated in Figure 5.

When the nesting operation is successful, the local and remote current magnitudes (actually charges converted to equivalent currents) are added to create the scalar sum (sum of absolute magnitudes) and arithmetic sum (absolute magnitude of the sum of the signed magnitudes). The scalar sum becomes the effective restraint quantity and the arithmetic sum becomes the effective operate quantity, per the bias characteristic shown in Figure 6.

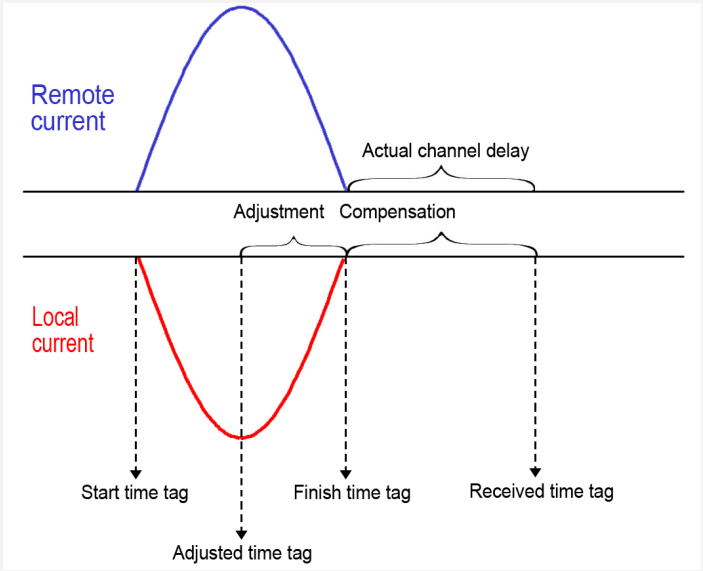


Figure 5. Channel Delay Compensation (external fault)

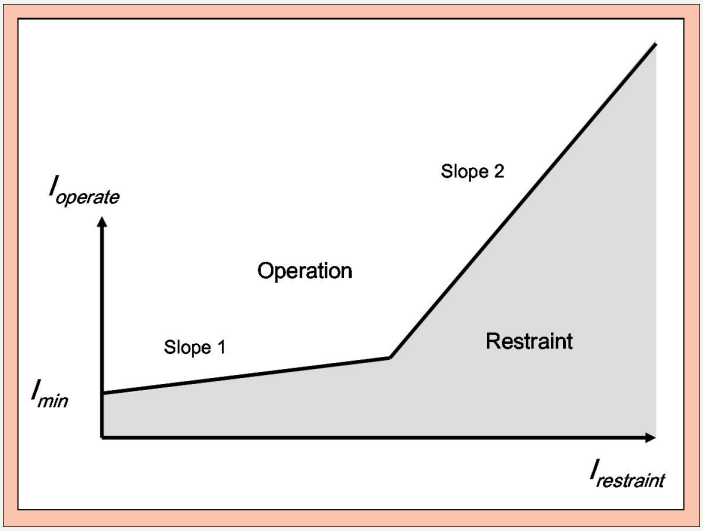


Figure 6. Bias Characteristic

The bias level is an operate threshold which provides security in the presence of spurious operate current due to line charging current, current transformer mismatch and other errors. As shown in Figure 6, the bias level rises sharply after the scalar sum reaches a high value. This provides security for unequal ct saturation during high current external faults. At lower currents, the bias level is much lower allowing for a high sensitivity without sacrificing security.

Measurement (continued)

The operating principle of the charge comparison relay is very similar to that of a percentage differential current differential relay, but instead of comparing phasor quantities, the differential measurement is based on half-cycle charges. The local relay receives a current value equivalent to the positive half-cycle charge from the remote end (negative for the ground subsystem). This value is compared to the corresponding half-cycle charge in the local end. For an internal fault, they are both positive and the scalar and arithmetic sums are formed and compared to the operating criteria.

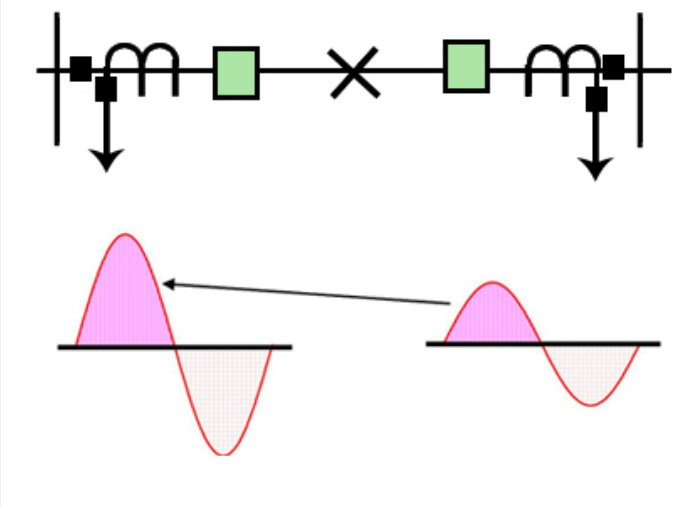


Figure 7. Operation for an Internal Fault

For an external fault, the received positive charge from the remote end coincides with the local negative charge and the relay restrains properly.

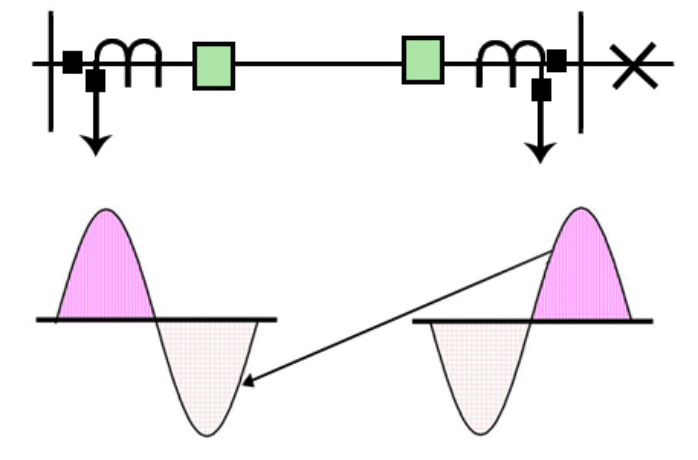


Figure 8. Restraint for an External Fault

Three Terminal Operation

The GARD 8000 is suitable for two or three terminal operation. The three terminal version uses a similar measuring principle, with the major difference being that a third component is added to the scalar and restraint quantity. The scalar sum (restraint quantity) is the time-adjusted sum of the currents in the three line ends; |IL| + |IR1| + |IR2|. The arithmetic sum (operating quantity) is the time-adjusted sum of the signed magnitudes of the currents in the three line ends; $\overline{I_L} + \overline{I_{R1}} + \overline{I_{R2}}$.

Each of the three GARD 8000 is transmitting to and receiving from the two remote relays over two 64 kbps channel slots. The communication can be over separate communication interfaces, or by using two time slots in one interface via a multiplexed network.

The three terminal system will remain operational in case of a break in the communication link between two of the three relays. For instance, if the link between R1 and R2 is non-functional, the relay at L will still have complete current information from all three line ends to make a trip decision for an internal fault, and subsequently trip the two remote relays.

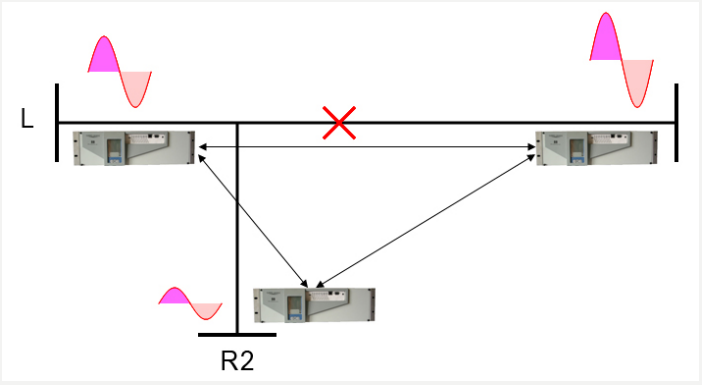


Figure 9. Three Terminal Operation

Input Transformers

CT saturation is always a concern for current differential relays. In addition to the secure dual slope characteristic, the GARD 8000 Current Differential Relay has a patented input transformer design. The transformers faithfully reproduce the current input wave forms, with any dc offset and ct saturation by the use of a flux cancellation technique that creates a near perfect current transformer. The input transformer consists of a small toroidal core with a single turn looped through its center. This single turn is an

extension of the secondary winding of the ct supplying the phase current waveform. An active circuit cancels out the flux in the toroidal core. This allows the toroid to handle large dc offsets without saturating. The circuit maintains its accuracy over a 250-ampere (rms) dynamic range. This patented procedure prevents any dc offsets that may be present in the current waveform from saturating the core.

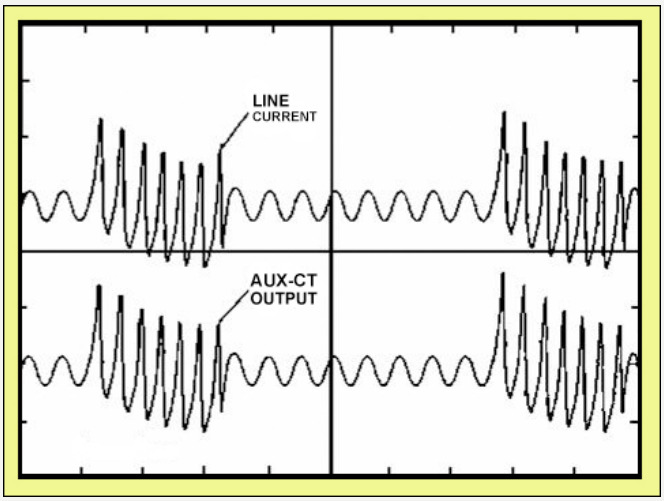


Figure 10. Response of Input Transformers

Input and Output Modules

The GARD 8000 Current Differential Relay provides very high speed tripping combined with high sensitivity and security. In addition, the operating time is very constant (small difference between minimum and maximum operate times) which enables shorter time settings for breaker failure relaying and other back-up elements, resulting in an overall faster protection scheme.

The operating speed is largely independent of current magnitude versus pick-up settings when the operating threshold is exceeded by as little as 0.25 A.

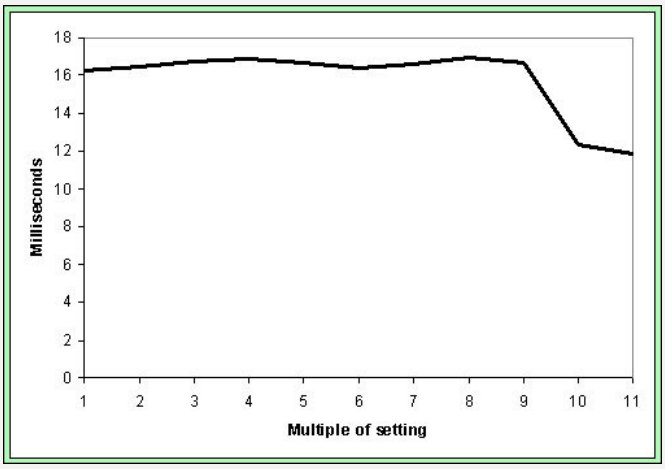


Figure 11. Operating Times for Single Phase to Ground Faults

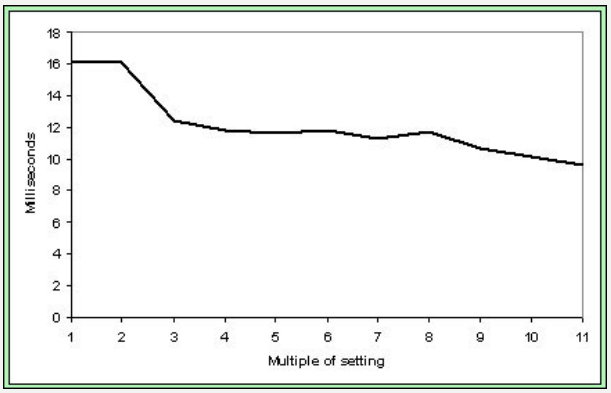


Figure 12. Operating Times for Three Phase Faults

Direct Transfer Trip

The GARD 8000 Current Differential Relay includes one High Speed Direct Transfer Trip function, as well as 8 additional logic signals transmitted to the remote end. The 1 + 8 transfer trip functions can be triggered by any input and/or logic signal in the GARD 8000 System. The receiving relay routes the signals to output contacts, and/or delivers them to the internal logic for use by other protection elements, such as the distance relay.

High Set Trip

The Current Differential measuring element is complemented by a High Set current comparison element that will provide even faster operation for high current faults. The typical operating time from this element is 12 ms, including relay output time.

Overcurrent Back-Up Functions

In case of channel failure, the Current Differential Function is disabled. For these situations, back-up phase and ground overcurrent elements with inverse time characteristics can be enabled. Optionally, the GARD 8000 System can be supplied with an independent Distance Line Protection Terminal.

Protection Specifications

Fault Recording

In addition to the GARD 8000 System SOE, the Current Differential Protection Module provides a detailed log of its operational elements.

IRIG-B or the optional GPS receiver provides a maximum 1ms time stamp resolution.

The Current Differential Protection detailed event log stores up to 15 events, in addition to the 600 events available in the GARD 8000 Main System.

The Current Differential Protection Module has an internal Digital Fault Recorder (DFR).

All analog channels used by the Current Differential Protection function are recorded with 32 samples per cycle (40 samples for 50 Hz). Protection and measuring element status are available as digital channels, facilitating comprehensive fault analysis.

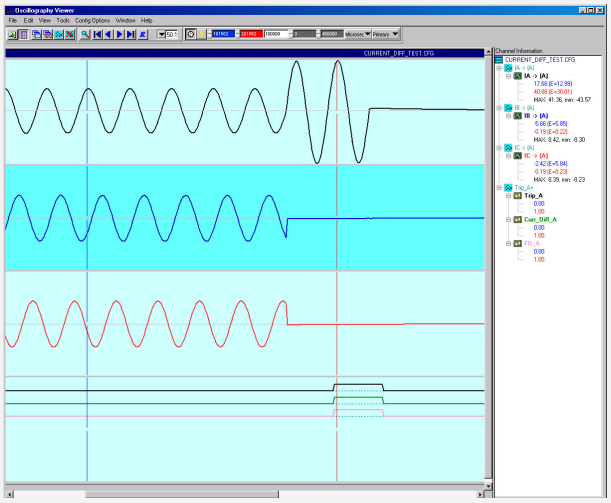


Figure 13. Digital Fault Record

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 an optional reader.

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

Frequency

Frequency	50 or 60 Hz

Current Differential Elements

Bias	5A nominal	1.0 - 30.0 A
	1A nominal	0.2 - 6.0 A
Slope 1	0-200%	
Slope 2	0-200%	
Cross-over point	5A nominal	1.0 - 30 A
	1A nominal	0.2 - 6.0 A
High Set Trip	5A nominal	10 - 30.0 A
	1A nominal	2 - 6.0 A
CT ratio	40 - 4000	

Overcurrent Fault Detectors

5A nominal	1.0 - 30.0 A
1A nominal	0.2 - 6.0 A

Instantaneous/Definite Time Overcurrent Elements

5A nominal	1.0 - 50.0 A
1A nominal	0.2 - 10.0 A
Time delay	0.01 - 1.00 seconds

Time Overcurrent Elements

5A nominal	0.20 - 25.00 A
1A nominal	0.04 - 5.00 A
Time Dial	0.05 - 15.00
US	Moderately inverse
	Inverse
	Very inverse
	Extremely inverse
IEC curves	Type A / Type B / Type C

Communication Interfaces

T1/E1; 1.544 Mbps/2.084 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; co-directional, 64 kbps

C37.94 fiber

Fiber; 64 - 768 kbps,
as specified in the following table:

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	6 dB	59 km/37 miles
1550nm Laser	Singlemode	ST	30 dB	90 km/56 miles

Protection Specifications (continued)

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. In addition each input and output has an inverter and a timer associated with it that has settings for both pick-up (de-bounce) 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 de-bounce 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 optically isolated inputs, power supply inputs, solid state outputs and relay outputs meet the following specifications:
ANSI C37.90-1989 (Dielectric)

ANSI C37.90.1-2002 (SWC and Fast Transient)

IEC 255-5 (1500 Vrms Breakdown Voltage and Impulse Withstand)

IEC 255-22-1 (SWC Class III)

IEC 255-22-2 (ESD Class III)

IEC 255-22-4 (Fast-Transient Class III)

IEC 834-1

Certifications
ISO: The GARD 8000 System with all its functional modules is designed and manufactured using ISO 9001-2000 certified quality program.

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

Specifications subject to change without notice

General Specifications

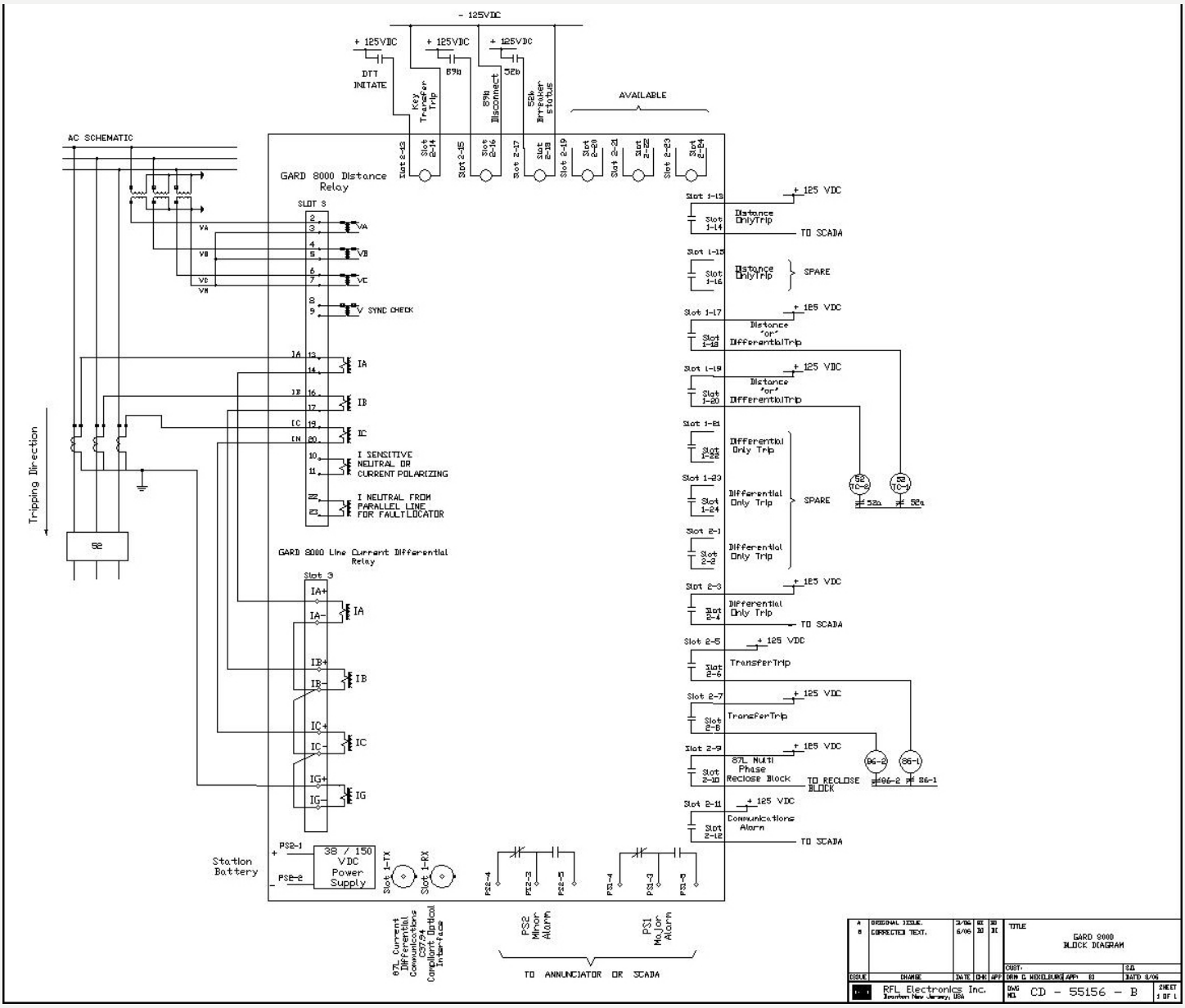


Figure 14. GARD 8000 Current Differential Module AC/DC Schematics

Examples of GARD 8000 System Configurations

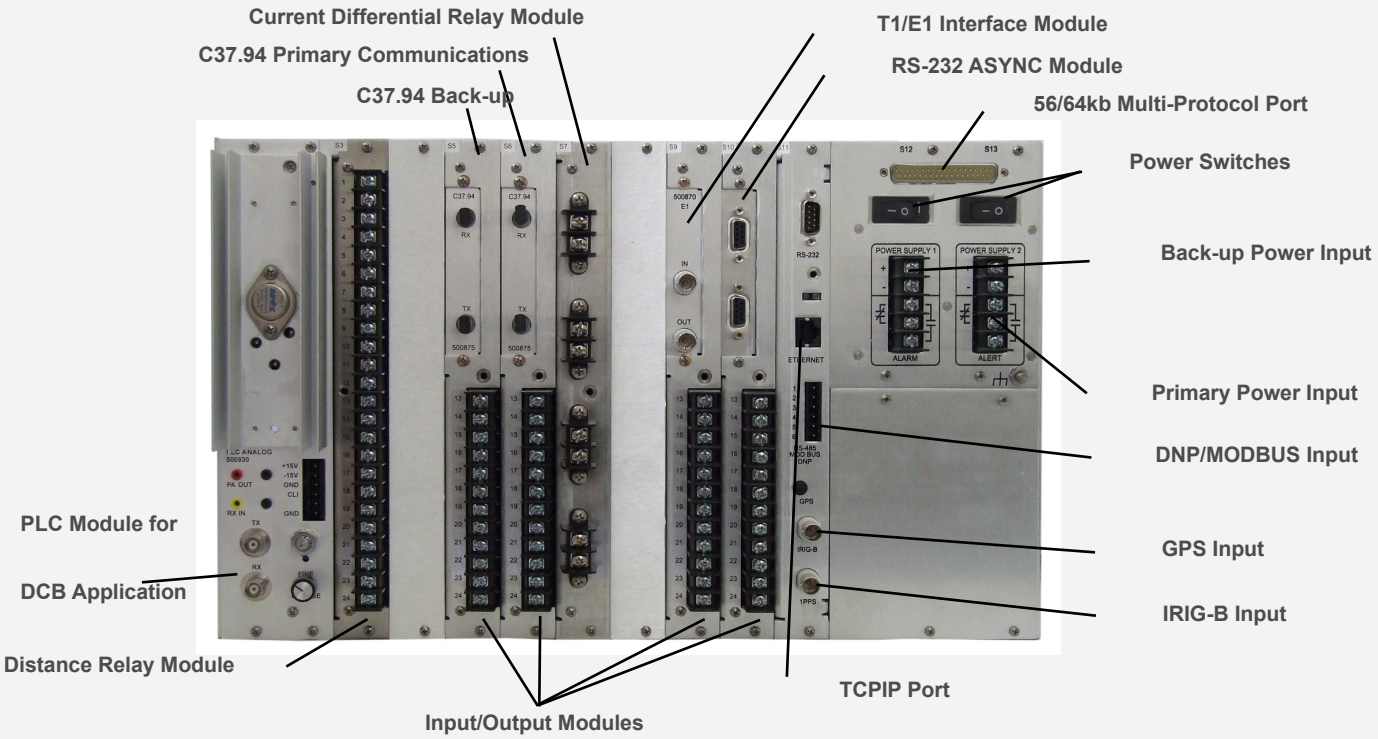


Figure 15. Rear View 6U GARD 8000 with Distance Module, Powerline Carrier Interface, Current Differential Relay and Primary and Back-Up Communications

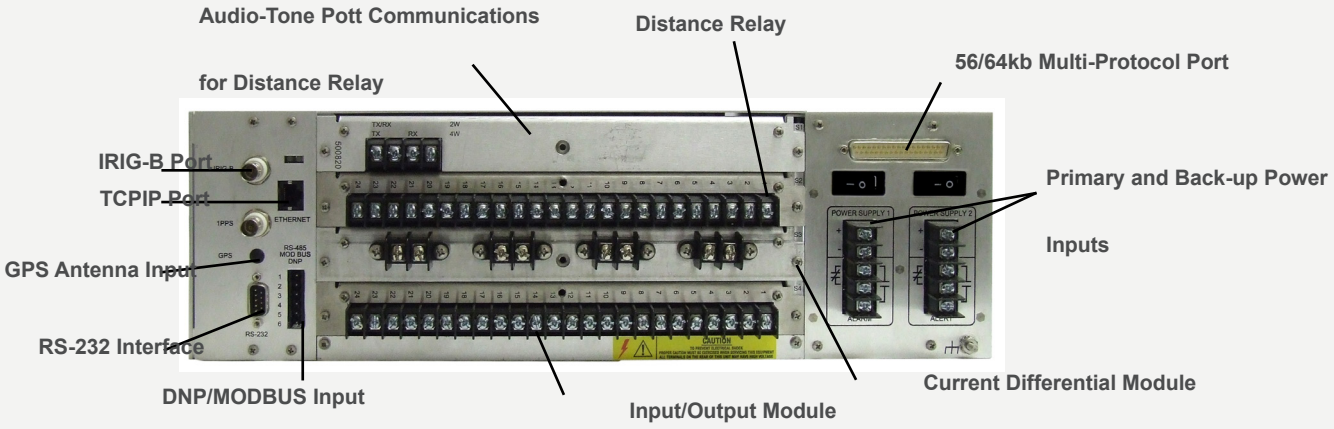


Figure 16. Rear View 3U GARD 8000 with Current Differential Module, Digital Communications, Distance Module and Audio-Tone Communications

Dimensions

GARD 8000
Single Function PLC
3U System Dimensions

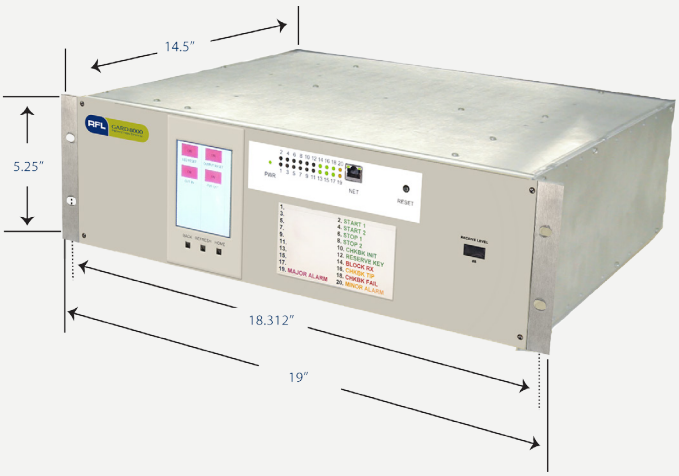


Figure 17. Rack or Cabinet Mounting (3U)

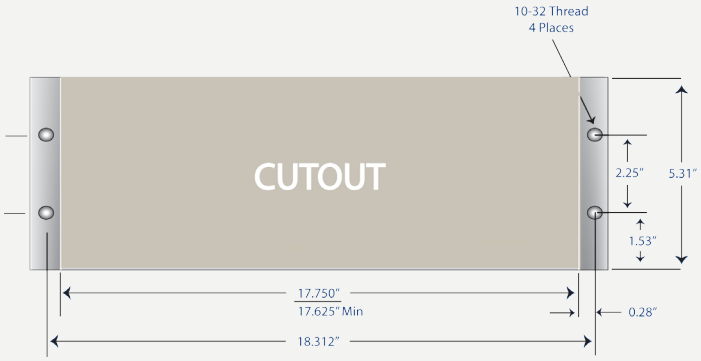


Figure 18. Panel Mounting (3U)

6U System Dimensions

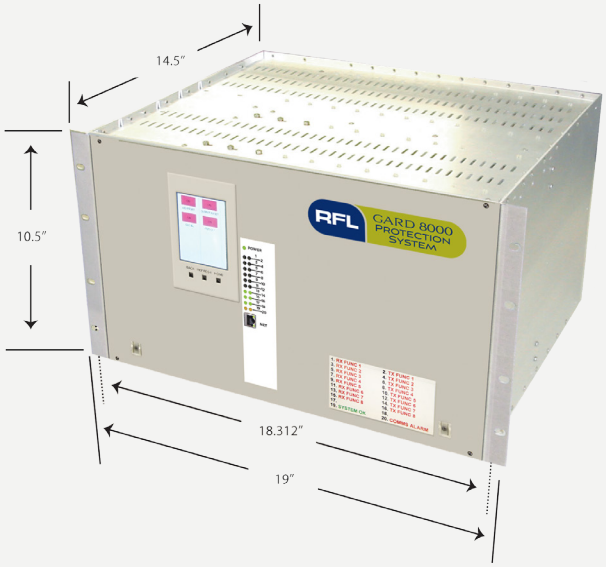


Figure 19. Rack or cabinet Mounting (6U)

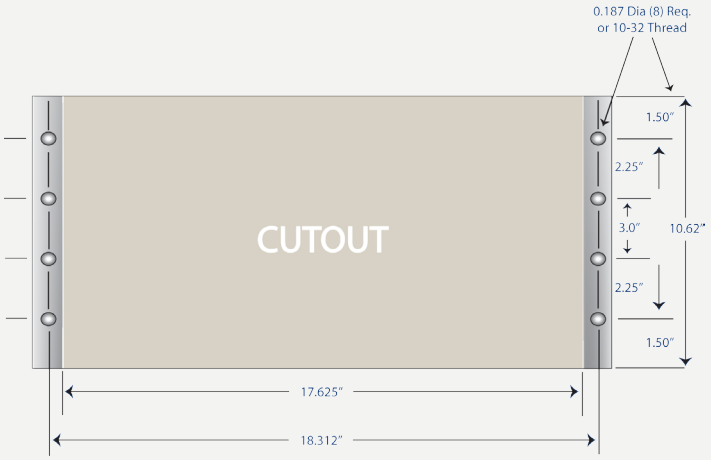
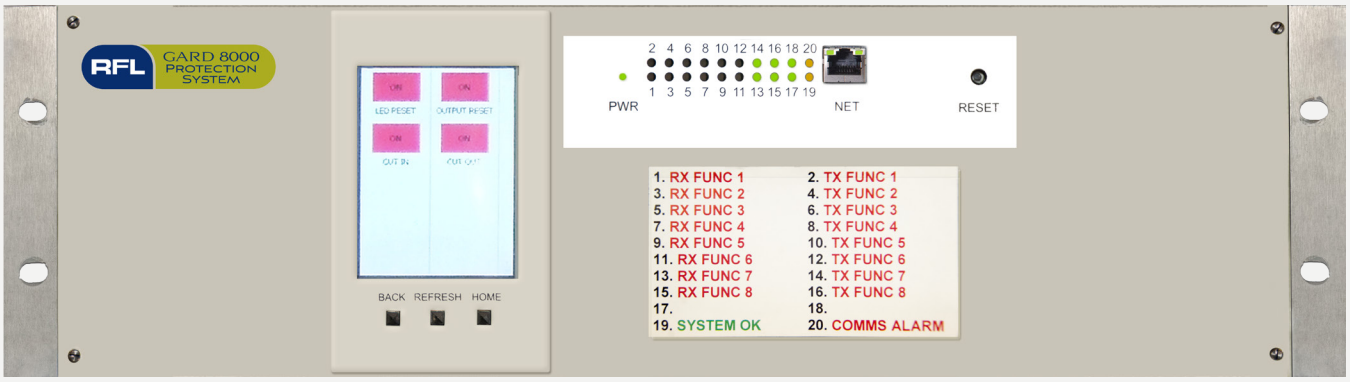


Figure 20. Panel Mounting (6U)

SOLUTIONS FOR AN EVOLVING WORLD

RFL GARD RAS

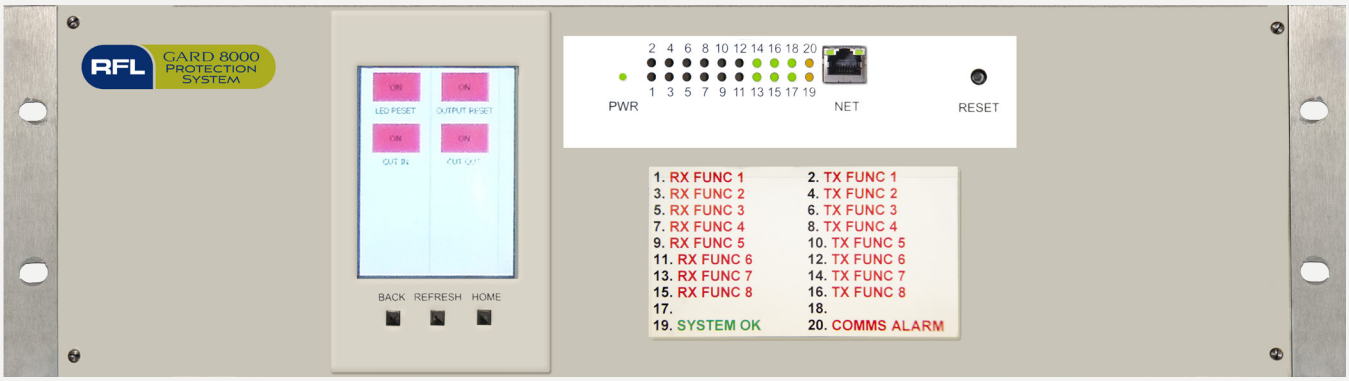
Remedial Action Scheme (RAS) Module



HUBBELL

GARD 8000

Remedial Action Scheme (RAS) Module



System Features

Each RAS module processes four voltages and five currents from 5 A, 120 V rated input transformers

Alternatively, the RAS telemetry module can be used for +/- 20 mV transducer inputs

Watts, VArs, RMS currents, RMS voltages and frequency

- RAS telemetry module can be used for +/- 20 mV transducer inputs
- Settable thresholds
- Programmable math functions include scaling, offset, adding, subtracting and multiplying

Analog values are sent via DNP 3.0 over TCP/IP

High capacity status transfer unit sends 96 binary states over a single 64 kbps channel slot

Install up to eight RAS vModules in one chassis

Use for different circuits or in redundant configuration

Supports NERC/FERC security standards

DNP3, Level 2 compliant•

A wide range of communication interfaces to choose from:

- T1/E1
- RS-449, 56 -768 kbps
- X.21, 64-768 kbps
- V.35, 64-768 kbps
- G.703, co-directional, 64 kbps
- ANSI C37.94 fiber
- Fiber, multi-mode or single-mode; up to 100 km
- Audio Tone, 2 wire or 4 wire

Install up to ten communications interfaces in one chassis

One GARD 8000 supports up to 24 64 kbps communication channels

Selectable type and number of inputs and outputs

Opto-coupler inputs

Solid state, relay, or latching outputs

Applications

Remedial Action Schemes (RAS) are designed to monitor and protect electrical systems by automatically performing switching operations in response to adverse network conditions to ensure the integrity of the electrical system and avoid network collapse.

Typical automatic remedial actions include:

- Generator tripping for reduction of energy input to the system
- Tripping of load, insertion of braking resistors, series capacitors, opening of interconnecting lines and system islanding

Remedial Action Schemes (RAS) are often applied to large power systems for control of the system during severe abnormal conditions when traditional localized control is inadequate. Recent events such as 9/11, Hurricane Katrina, Tsunamis, and others have shown that now more than ever, complete backup RAS control centers are essential to disaster recovery.

RAS systems are typified by large numbers of diverse communication paths providing real time information from a wide geographic area. The communications paths are usually a mix of every media available from lease circuits, to audio circuits, to dark fiber, and recently, IP networks. These communication systems are all designed to transport data from substations and deliver it in real time to a single site for use by the RAS control computers. Traffic from the control centers to the substations allows control of the power network.

In planning a second control center, the issue of delivering the same information to two geographically separated sites at the same time becomes paramount. Today technology allows the users to meet the challenge to accomplish this with a minimum of impact on field equipment while using the existing communications paths. The use of modern IEDs can minimize the equipment needed to collect the field data and to transport the variety of processed or raw information needed for operation of RAS.

The amount of raw data available in a power system can easily overwhelm the bandwidth available to communicate it back to the control center. The GARD 8000 RAS module provide ways to reduce the amount of raw data by pre-processing it prior to transmission. It can prove to be very inefficient to transport all of the raw data only to combine the various values after the data arrives at the control center. If the mathematical combination and simplification can be done at remote sites, the required communication bandwidth is reduced.

Once mathematical capabilities are introduced at the measurement sites or substation level, data can be normalized so that all of the variability in collection methods and sensors is isolated from the control center. Localized changes only need to be normalized to the previously expected values, thereby eliminating any impact on the control center programming.

The RAS action is generally performed by a central controller. The controller needs data collected by field units; the GARD 8000 RAS Module. The field units are capable of measuring currents and voltages and/or transducer quantities (W, VAr) and deliver these to the central unit for evaluation and comparison with data from other points in the power system. The GARD 8000 also acts as a remote controller, such as performing breaker operations via programmable logic and inputs/outputs when a command is received from the central unit.

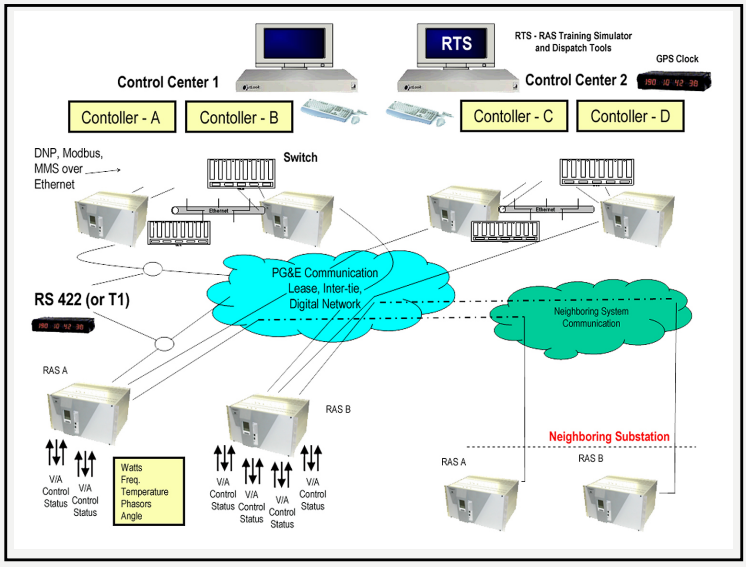


Figure 1. Typical RAS Application

Technical Specifications

Metering Module

The Metering Module measures/calculates floating point values and sends them via a control bus to a Status Webpage. Each of the measured values has a settable lower and upper threshold. For all of the thresholds, multiple units can be set with different pickup values and time delays. The following 32 bit values are measured.

The result of these threshold measurements are web page status indications and logic bit outputs that can be sent via the teleprotection system function. The analog values can be displayed on a web page and eventually combined with other values mathematically and sent via DNP over an IP link to a control center.

Phase A current	Positive sequence current
	Reactive power
Phase B current	Negative sequence current
	Apparent power
Phase C current	Zero sequence current Power Factor
Neutral current	Positive sequence voltage
	Frequency
Phase A voltage	Negative sequence voltage
	Rate of Change of frequency
Phase B voltage	Zero sequence voltage
Phase C voltage	Real power

Ratings

AC Current Inputs

Nominal	5 Amps rms
Coninuous rating	20 Amps rms
One second rating	500 Amps rms
Max reading	160 Amps peak
Accuracy	+/- 0.1% or +/- 2 ma (whichever is greater)

AC Voltage Inputs

Nominal	110/120 Vac
Continuous rating	220 Vac
Max reading	300V Peak
Accuracy	+/- 0.1% (60 to 300V)

Frequency

Range	45-65 Hz
Accuracy	+/-0.001 Hz (15 ppm)

Power Accuracy (>1 Amp load current)

Watts	(0 o,180o)	+/- 0.3%
	(15 o,165o)	+/- 0.5%
	(45 o,135o)	+/- 1%
	(74 o,105o)	+/- 5%
Vars	(15 o,165o)	+/- 5%
	(45 o,135o)	+/- 1%
	(74 o,105o)	+/- 0.5%
	(90o,- 90o)	+/- 0.3%

Settings

Phase A-C Voltage Inputs

- Nominal Level
- Input Scaling
- Lower Threshold
- Upper Threshold
- All thresholds are provided with hysteresis

Phase A-C Current Inputs

- Nominal Level
- Input Scaling
- Lower Threshold
- Upper Threshold

Frequency

- Phase to be used for frequency measurement
- Lower Threshold
- Upper Threshold

General

- Station Label
- Watts Lower Threshold
- Watts Upper Threshold
- Vars Lower Threshold
- Vars Upper Threshold
- DNP Slave Address

Status Reported

- Phase A-C
- RMS Voltage
- Lower Voltage threshold not exceeded
- Upper Voltage threshold not exceeded
- RMS Current
- Lower Current threshold not exceeded
- Upper Current threshold not exceeded
- Megawatts
- Mvars
- Frequency
- Frequency Lock achieved
- Station Label

Technical Specifications (continued)

Telemetry Module

The telemetry module has 8 analog -10V to +10V signal inputs.

Precision resistors on the board will be jumper selectable to allow ranges of

-20 to +20 ma (250 ohms)
-50 to +50 ma (100 ohms)
-5 to +5 ma (1000 ohms)

Programmable gain stages will allow the fine tuning of these ranges into 4 to 20 ma. The programmable offsets and gains will allow scaling of the input to any value.

Analog Inputs

-10V to + 10V

Input Impedance

Greater than 5.0 M Ohms for both differential and common mode

Calibration Input

-10V to + 10V

Accuracy

@ +25 o C +/- 0.05% of full scale

Drift 0.003% /ºC over operating temperature range. Six-month drift for identical input value and identical temperature is 0.01 % maximum.

Resolution

16-Bit

96-bit Digital Teleprotection System Module

The GARD 96-Bit Digital TPS Module consists of a single teleprotection (TPS) channel. The TPS channel is capable of transmitting and receiving up to 96 independent and simultaneous bidirectional commands over a single communications interface. The TPS channel utilizes its own addressing and channel delay measurements. Addressing and Channel Delay measurements are sent and received with each message.

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

I/O Specification

Optically Isolated Inputs

Quantity: Six per module
Jumper selectable
Input Voltage: 24/48/125/250 Vdc
Input current: minimum 1.5mA
Minimum Pulse Width: 0.03 ms, additional debounce timeset with logic time settings

Solid-State Outputs (dry contacts)

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 (dry contacts)

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

Environmental Requirements

Operating Temperature
Full performance
{-20° C to + 70° C (-4 F to 158° F)}
Humidity 0 to 90%

RFL

SOLUTIONS FOR AN EVOLVING WORLD

IMUX 2000

T1/E1 MULTIPLEXER

WITH COMMON LOGIC REDUNDANCY

HUBBELL

IMUX 2000

T1/E1 Multiplexer with Common Logic Redundancy

The Fifth Generation Multiplexer designed to meet the needs of your Telecommunications Network

Designed for harsh environments, the new IMUX 2000 T1/E1 Multiplexer creates a new class of Intelligent Multiplexer with features such as **Redundant Common Logic Module, built in CSU functionality, DS0 squelching capability and Fast Reframing Channel.**

The unit provides full featured, Drop-and-Insert capability for each voice frequency circuit or any signal that can be transmitted in a DS0 channel. The multiplexer has electrical and a wide variety of optical fiber (both singlemode and multimode) interfaces to simplify system configuration. Channel cards are available for voice, data, telemetry, teleprotection, video and ethernet applications. When combined with our IMUX 2000 8-Port DACS-R, the IMUX 2000 T1/E1 Multiplexer supports many types of network layouts such as Spur, Hot Standby and Ring topologies. The IMUX 2000 is both hardware and software configurable. The unit offers the ultimate network management system. It operates in a Windows™ point-and-click environment and provides network visibility from any node which allows for remote provisioning, monitoring and alarm reporting.

The IMUX 2000 T1/E1 Multiplexer is compact, modular in design and compatible with previous generations of RFL Multiplexers. For a product that meets and exceeds your telecommunication needs, advance into this new class of hardened multiplexer and make the Intelligent choice, the IMUX 2000 Intelligent T1/E1 Multiplexer.

Key Features and Benefits

Substation Hardened
The IMUX 2000 T1/E1 Multiplehxer is designed for harsh environments and has a wide temperature range of -20°C to +65°C (-4°F to +149°F). It meets the IEEE/ANSI standards C.37.90-1989, C.37.90.1 and C.37.90.2 for SWC, fast transient and EMI. It is CE approved and has been tested to BS EN 5002:1995. It is also FCC part 15 Class A approved.

Reliability
The IMUX 2000 provides enhanced reliability by offering optional redundant power supplies and common logic modules.

Speed
The IMUX 2000 is designed to handle time sensitive applications such as Protective Relaying. The Drop-and-Insert through-channel delay is less than 25 microseconds. The IMUX 2000 has an average reframe time of less than 25 milliseconds and also has the ability to enable a Fast Reframing Channel (FRC) for less than 1 millisecond reframing.

DS0 Squelching
The IMUX 2000 T1/E1 Multiplexer has the ability to squelch (turn off) the output of a channel module in the Multiplexer upon loss of synchronization. This feature provides security against false tripping on 4-wire analog transfer trip channels and older digital equipment (with limited error checking) during loss of sync and protects against 'pink' noise conditions, which result from cross-talk or the frame search. This feature is ideal for preventing false tripping due to system malfunction.

CSU Functionality
The IMUX 2000 offers a built in CSU functionality that meets applicable standards for protection including FCC Part 68 approval for direct connection into the Public Switched Telephone Network (PSTN). When enabled, the unit will respond to generated loopback codes compliant to either ANSI T1.403 or AT&T TR 54016. It will also maintain and allow local and remote retrieval of performance measurements in accordance with either ANSI T1.403 or AT&T TR 54016.

Modular Design
The IMUX 2000 incorporates a midplane motherboard design. Channel modules plug into the front of the unit, and matching module adapter for I/O connections plug into the rear. This eliminates the need for internal chassis wiring when adding new channel cards, simplifying the upgrade.

Fiber Optic or Electric Interfaces
The IMUX 2000 can be equipped with either electrical T1/E1 interfaces or Optical Interface Adapters (OIA's). The electrical T1 interface is equipped with Line Build-Out (LBO) networks for operation of up to 6,000 feet from the DSX. The OIA's are available in a wide range of multimode, single-mode, LED or laser combinations to accommodate 1300nm and 1550nm wavelengths.

Channel Interfaces
A wide range of interfaces unique to the utility and the transportation market is offered. It also offers a wide range of Voice and Data, Status, Telemetry, Ethernet, Transfer Trip and Video channel interfaces to meet most communications requirements.

Fast Restoration
When applied to diverse communication routes, such as Ring or Hot-Standby networks, the IMUX 2000 is capable of switch times programmable down to 1 millisecond.

Diverse Networks
The IMUX 2000 supports many types of network layouts such as Linear, Spurs, Hot-Standby and Ring topologies. It is also designed for operation over SONET/SDH networks taking into consideration the critical time-delay issues associated with Protective Relaying.

SONET and SDH Applications
Protective Relaying can finally be applied over non-proprietary SONET/SDH equipment. With emphasis placed on rapid break healing, the IMUX 2000 addresses the critical time issues associated with Protective Relaying making it the ideal and Intelligent choice when interfacing to SONET/SDH networks. The IMUX 2000 bridges the gap between SONET and substations providing DS0 gateways onto the network. Also, through its own switching techniques, can overcome the longer switch times and unequal channel delay issues associated with SONET.

Automation
The IMUX 2000 offers the ultimate GUI Network Management system which operates in a Windows™ point-and-click environment. The optional SNMP based management reporting software can be used when integrated as part of a larger enterprise system. Network visibility is available from any node which allows remote provisioning, monitoring and alarm reporting.

Telecommunications Solutions

Electric Power Utilities

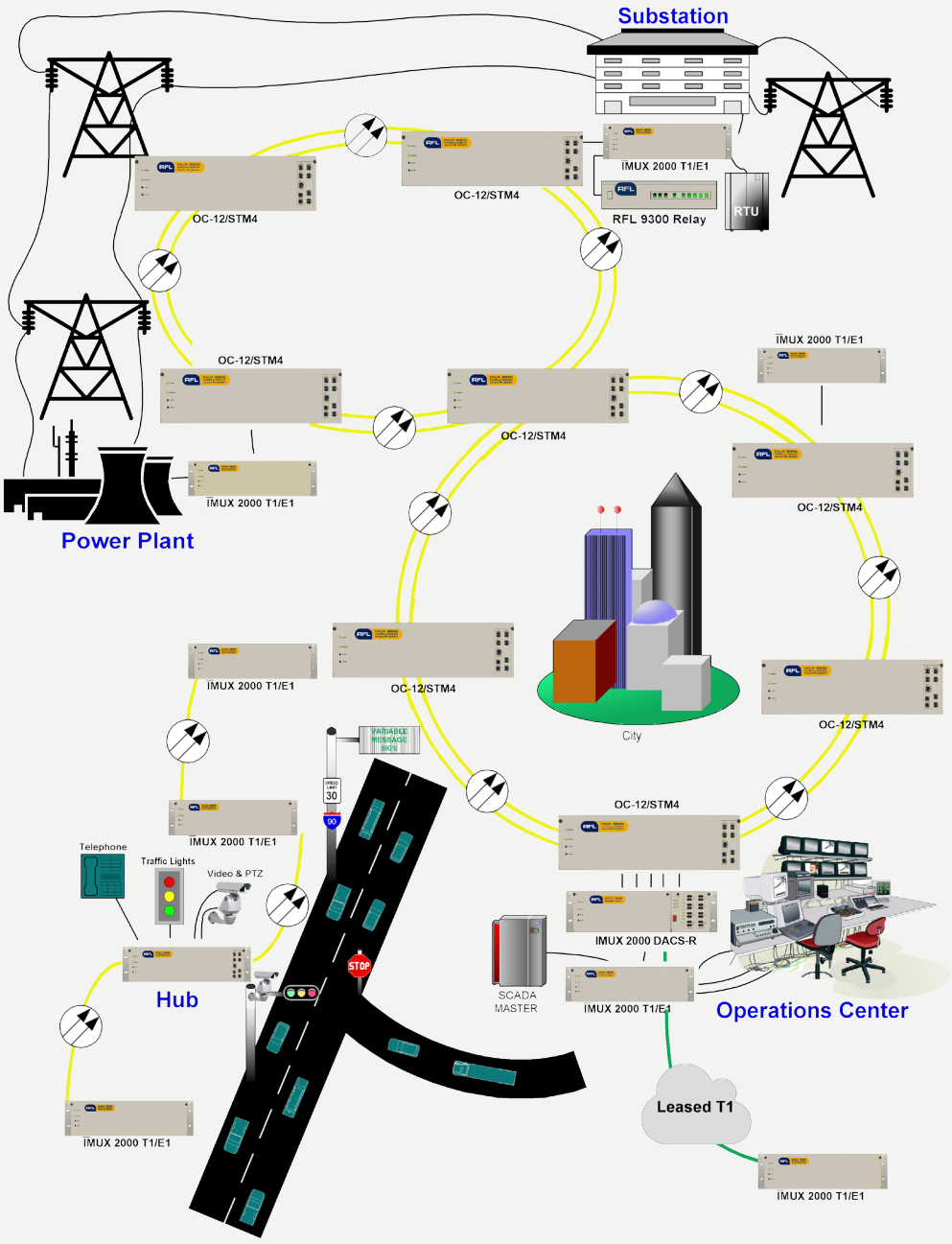
Designed specifically for the unique need of the harsh substation environments, the IMUX 2000 T1/E1 Multiplexer incorporates special design characteristics which allow it to meet ANSI / IEEE / IEC standards for operation in harsh environments (RFI, SWC, EMI and Fast Transient). The Drop-and-Insert through delay is less than 25 microseconds, including the fiber heads (excluding the communications medium). Along with the minimal through delay, a software programmable Fast Reframing channel is available to allow the multiplexer to reframe in less than 1 millisecond. The DS0 squelching (patent pending) capability allows the Common Logic Module to squelch (turn off) the output of a channel module in the Multiplexer upon loss of synchronization. This feature provides security against false tripping on 4-wire analog transfer trip channels and older digital equipment (with limited error checking). These features in the IMUX 2000 T1/E1 Multiplexer, address the critical time issues associated with protective relaying, making it ideal to be used in the electric power utilities industry. In addition, the multiplexer has the Transfer Trip and Current Differential interfaces required for the utility market.

Transportation Industry

With the increasing demand for faster, more efficient ways to manage the flow of traffic, customers need a communication infrastructure that allows the system to advance as the technology develops. That is why the IMUX 2000 T1/E1 Multiplexer, with its unique harsh environments design, is the preferred choice of communication for the Transportation Industry. The IMUX 2000 T1/E1 multiplexer is designed to be used as part of a large traffic management system working in conjunction with higher bandwidth SONET/SDH networks or in stand-alone T1/E1 networks.

Applications for the product include: roadside signal acquisition and transmission from vehicle loop detectors, compressed digital video, camera control, toll collection, status and alarm reporting, tunnel ventilation control, and voice and data traffic signal control systems. The compact and robust design and the ability to work under harsh conditions makes the IMUX 2000 T1/E1 multiplexer the best multiplexer for transportation applications. The network management software provides ease of maintenance with Windows™ based GUI software. The optional SNMP based management reporting software can be used when integrated as part of a larger enterprise system.

Application Solutions



Above is an example of a typical utility / traffic system solution. It is made up of two SONET/ SDH rings as the communications backbone. The IMUX 2000 T1/E1 Multiplexers are configured to work in a Point-to-Point, Star and Stand-Alone Linear topology over the SONET/SDH system.

The IMUX 2000 carries RTU and phone circuits from several substations to the operations center. It also carries current differential relay data between substations.

The IMUX 2000 carries roadside signals, transmission data from vehicle loop detectors, compressed digital video, camera control, toll collection information, status and alarm reporting, voice and data traffic signal controls back to the operations center.

Technical Specifications

T1 INTERFACE

Interface:
DSX-1 interface per ANSI T1.102-1993

Rate:
1.544 Mbps per ANSI T1.102-1993
(Transmit 3 30 PPM using internal timing)

Transmit Pulse Shape:
Per ANSI T1.102-1993

Formats:
Extended Superframe (ESF) per AT&T 62411,
D4/ Superframe (SF) per AT&T 43801

Line Codes:
Bipolar with 8 Zero Substitution (B8ZS)
& Alternate Mark Inversion (AMI)

Output Impedance:
100 Ohms nominal per ANSI-T1.102-1993

Reframe Time:
Without Fast Reframing Channel (FRC) enabled:
Less than 25 milliseconds. With Fast Reframing
channel (FRC) enabled: Less than 1ms.

TIMING

Primary Timing:
Internal, External, Loop or Through

Fallback:
Automatically enabled in case of primary timing failure.

Timing Output:
T1: 1.544 Mbps, (RJ11 connector)
E1: 2.048 Mbps, G.703 (RJ11 connector)

ENVIRONMENTAL

Temperature:
-20°C to +65°C (-4°F to +149°F) operating

SWC & Fast Transient:
Power supply, alarm contacts, pilot wire interface &
transfer trip interface meet the requirements of ANSI
C.37.90-1989 & ANSI C.37.90.1. EIC 1000-4-2:1995,
IEC 1000-4-3:1997, IEC 1000-4-4:1995, IEC 1000-4-
6:1996, IEC 1000-4-8:1994, DD ENV 50204:1996.

EMI:
The chassis & modules meet ANSI C.37.90.2.

FCC Compliance:
FCC Part 15 class A

Humidity:
0-95% Non-condensing

Shock & Vibration:
The chassis and channel modules shall meet
requirements of IEC 255-21-2 and IEC 255-21-1.

E1 INTERFACE

Interface:
Conforms to ITU G.703

Rate:
2.048 Mbps 3 50 PPM input and output

Jitter Tolerance:
Exceeds ITU G.823

Attenuation:
Greater than 18 dB at 40Hz

Formats:
Frame format per ITU G.704 in 30-channel and 31-
channel modes.

Line Codes:
HDB3 (High Density Bipolar, Order 3 per ITU
G.703, or AMI (Alternate Mark Inversion)

Connection:
75/100 ohm BNC connector or DB-15 connector
for twisted pair.

Frame Synchronization:
Average reframe time non-signaling DS0's:
0.3 ms with fast reframe
0.6 ms without fast reframe
Multi-frame based signals (Signaling): 5ms

PHYSICAL

Dimensions:
Height: 5.25" (144 mm)
Width: 19" (483 mm per EIA RS-310)
Depth: 14.50" (370 mm)
Available in 23" width mounting.

Weight:
15 lbs (6.8 kg). for typical fully loaded shelf.

USER INTERFACE

Functionality:
Remote monitoring, configuration
and alarm reporting.

Local access:
Switch settings

Remote Access:
RS-232C port
Optional 10 BaseT Ethernet Interface

Technical Specifications (continued)

Power Requirements

All shelves can be equipped with a secondary plug-in power supply for redundancy.

Input Voltage:	Range:
24 Vdc	19 to 29.0 Vdc
48/125 Vdc	38 to 150 Vdc
250 Vdc	200 to 300 Vdc
120 Vac	90 to 130 Vac
220 Vac	180 to 265 Vac

Optical Interface Adapters (OIA)

Emitter	Wavelength	Fiber	System Gain
LED	1300 nm	MM	25dB (12mi; 19km)
LED	1300 nm	SM	18dB (17mi; 27km)
Laser	1300 nm	SM	36dB (37mi; 62km)
Laser	1550 nm	SM	30dB (56mi; 90km)
Laser2mw	1550nm	SM	39d (70mi; 113km)

Alarms and Diagnostics

Status Monitoring:

Constant monitoring of equipment with alarm reporting.

Alarm Types:

Alert, cautionary conditions that do not prevent multiplexer operation.

Alarm, conditions that directly affect multiplexer operation.

Interface:

Front panel indicators and alphanumeric display
RS-232 port for remote access and interrogation
Form C relays for shelf alarm and alert.

Loopbacks:

T1: Line, Equipment and Payload
E1: Line and Equipment

DS0 Channel Module Functionality

Voice Units:

2W VF

Type I, II, III & V E & M signaling

2W Foreign Exchange

Loop start signaling
Automatic ring down option

4W VF

Type I, II, III & V E & M signaling
Point-to-point and multi-point
4W FXO and FXS
Channel addressing for added protection
2713Hz detection loop-back mode
Optional SWC rated connection for analog teleprotection

Orderwire:

2W party line voice circuit over a 64 kbps channel
DTMF signaling
Uses a regular 2W phone

Data Units:

Low Speed Data

RS-232 interface Async. and Synchronus
RS-422 interface
RS-485 interface 2 or 4 wire
Sub-rate multiplexing
Point-to-point and multi-point

High Speed Data (56/64 kbps rates)

RS-449, V.35, X.21 and G.703
Channel addressing for added protection
ANSI C37.94 optical interface

High Speed Data (N x 64 kbps Rates)

N = 1 to 24 64 kbps
RS-449 & V.35 interfaces
ANSI C37.94 optical interface

Office Channel Unit Data Port (OCUDP)

ANSI T1.410

Technical Specifications (continued)

DS0 Channel Module Functionality

Status:

Contact Input/Output
16 input
16 output
8 input / 8 output

Teleprotection Units:

Modular Teleprotection System

Application: DTT, POTT, PUTT, DCB & DCU
Four independent bidirectional function
Solid state or relay output
Channel delay measurements
Sequence of events log
Channel addressing for added protection
Optional I-RIG B synchronization module

Analog Telemetry

Transport of telemetry voltage or current
Bus voltage remote synchronizing application

Ethernet:

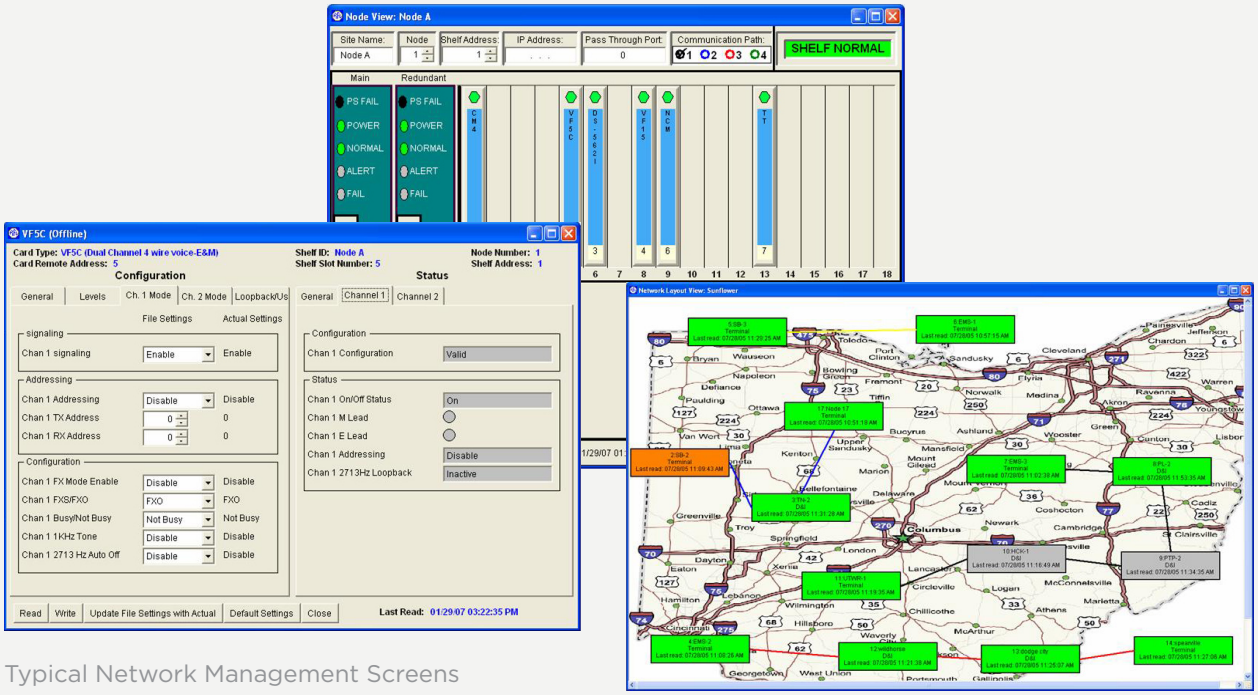
IP connectivity
LAN / WAN interconnect
10 BaseT Ethernet learning bridge
Support half or full duplex
IEEE 802.3

Video:

NTSC or PAL analog video signal transport
ITU H.261 compression algorithm
1-20 frames/second
64 to 1536 Kbps bandwidth
352 x 288 resolution

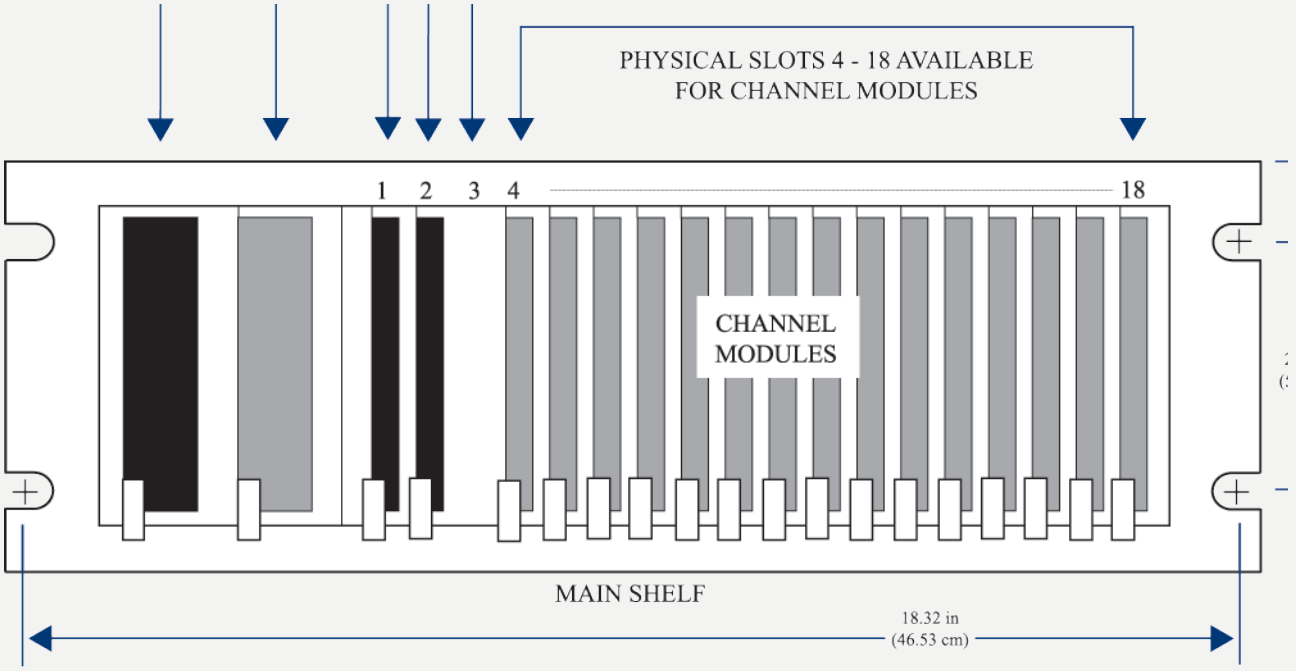
Network Management

WindowsTM based PC NMS
3 User Level Password
Access from any node for full system provisioning, monitoring and diagnostics
Alarm logging and time stamping
RS-232 craft interface
Optional faster NMS communication using a single 64 kbps channel
Optional 10 BaseT Ethernet Interface
Optional interface for SNMP manager
Network password protection for added security

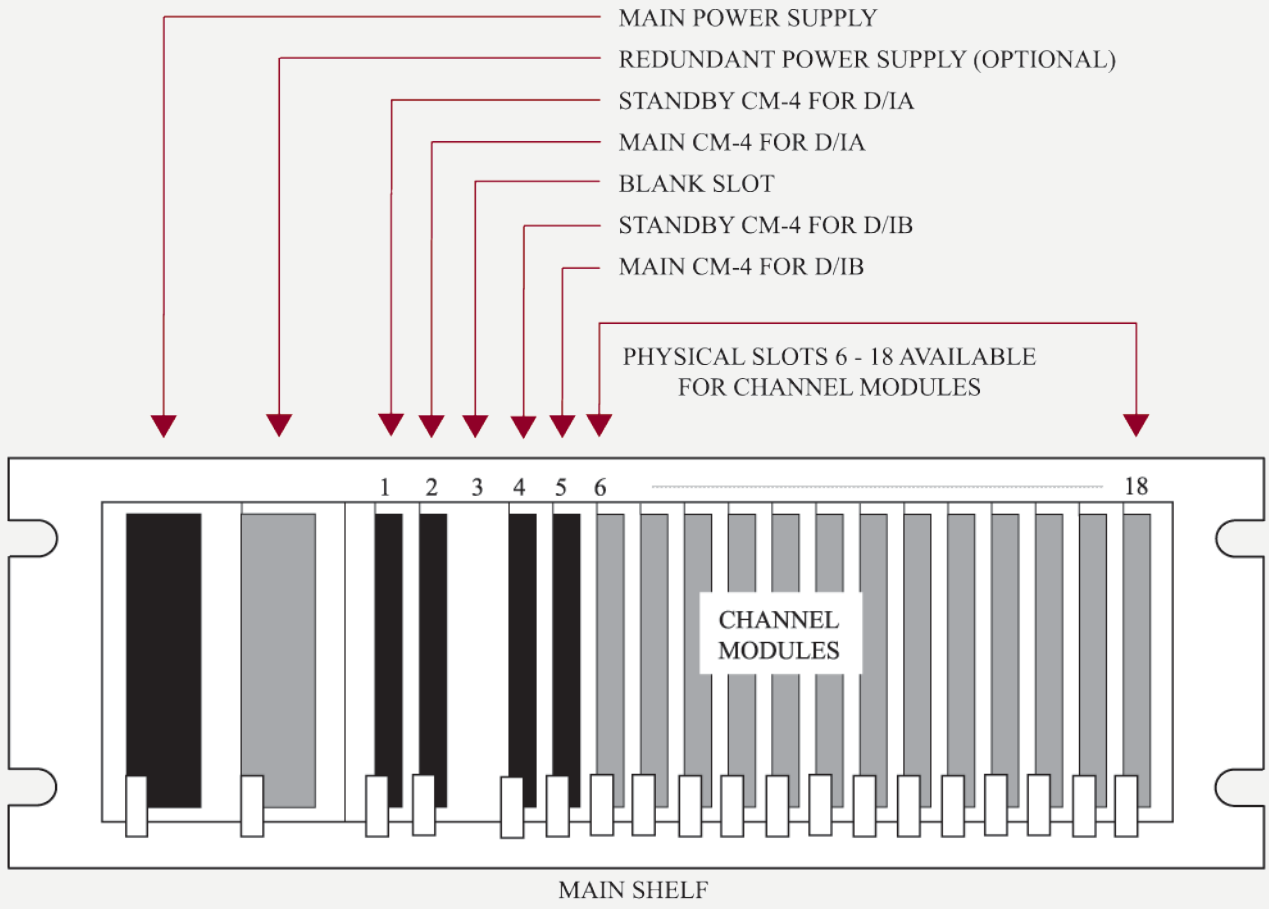


Typical Network Management Screens

Layout and Dimensions



a. Terminal



b. Drop and Insert

RFL

SOLUTIONS FOR AN EVOLVING WORLD

IMUX 2000s

SONET/SDH MODULE

HUBBELL

IMUX 2000s

The IMUX 2000s SONET/SDH Module kit provides a cost-effective solution to increase bandwidth 400x using existing IMUX 2000 T1/E1 networks; delivering Gigabit Ethernet services over SONET/SDH while continuing to support existing traditional TDM services.

This expansion allows the customers to:

- Grow networks to include bandwidth-intensive traffic such as Video, VoIP, and other IP-based data.
- Deliver resilient, managed IP-based services with Gigabit Ethernet access while retaining a TDM backbone.
- Minimize the cost and complexity of installing a SONET system by leveraging existing interfaces, wiring and configurations.

Key Features and Benefits

Instant 400x Bandwidth Upgrade

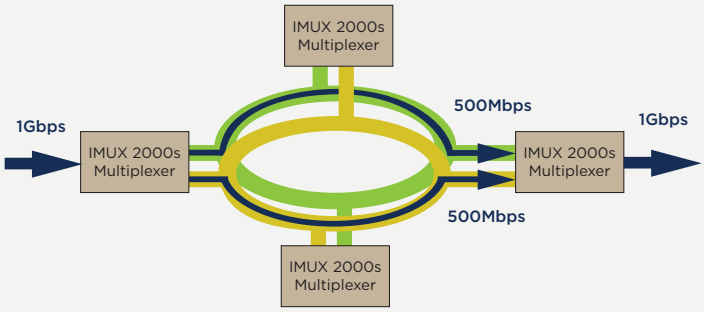
The 2000s SONET/SDH module, designed to fit into an existing IMUX 2000 T1/E1 Multiplexer and MDACS, allows for instant upgrade from T1/E1 to OC-12/STM-4, communications backbone, to provide greater bandwidth capacity for video and other high-bandwidth applications.

Low-cost and easy migration path to SONET/SDH

With a straightforward migration path to a SONET/SDH communications infrastructure, the IMUX 2000s SONET/SDH module leverages existing IMUX 2000 T1/E1 multiplexers and/or MDACS and provides cost savings while eliminating risk and complexity of installing a new SONET/SDH system. Because the IMUX2000s module is fully backwards compatible with existing installations, customers can perform a staged upgrade - one node at a time - minimizing troubleshooting and risk.

Gigabit Ethernet Services

The IMUX 2000s SONET/SDH module drives E-Line and E-LAN services to the network edge, delivering resilient, managed IP-based services including Gigabit Ethernet services using VCAT with dynamic LCAS at speeds up to 622 Mbps. By utilizing both primary and back-up fiber paths, full GigE bandwidth can be achieved over OC-12:



Ethernet over SONET (EoS)

The module offers Ethernet over SONET with layer 1 physical separation

Security

The IMUX 2000s system with the SONET/SDH module offers features and customizable operations for meeting customer's NERC-CIP requirements

Data Separation

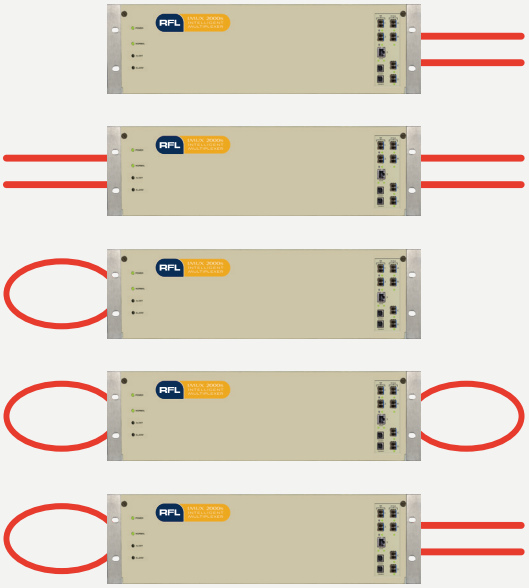
- Physical separation of Ethernet traffic from critical protection data
- Ethernet and TDM services transported over SONET, a non-routable protocol
- Layer 1 Ethernet transport means external sources cannot access ports remotely

User Access Management

- Password protection with no back door service access
- Customized operations to optionally disable management access through Telnet

Network Topologies for Survivability

The IMUX 2000s SONET/SDH module has four fiber optic SONET/SDH interfaces which support a wide range of protection topologies.



1+1 Terminal Mux

1+1 Linear / 1+1 Line APS and MSP

USPR/SNCP Protected Ring

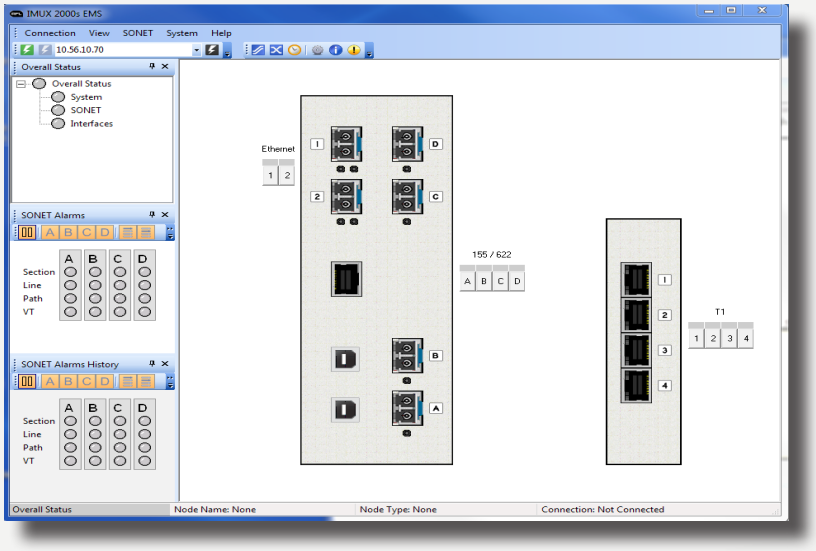
USPR/SNCP Ring Interconnects

USPR/SNCP Ring to 2 tails

Element Management Software

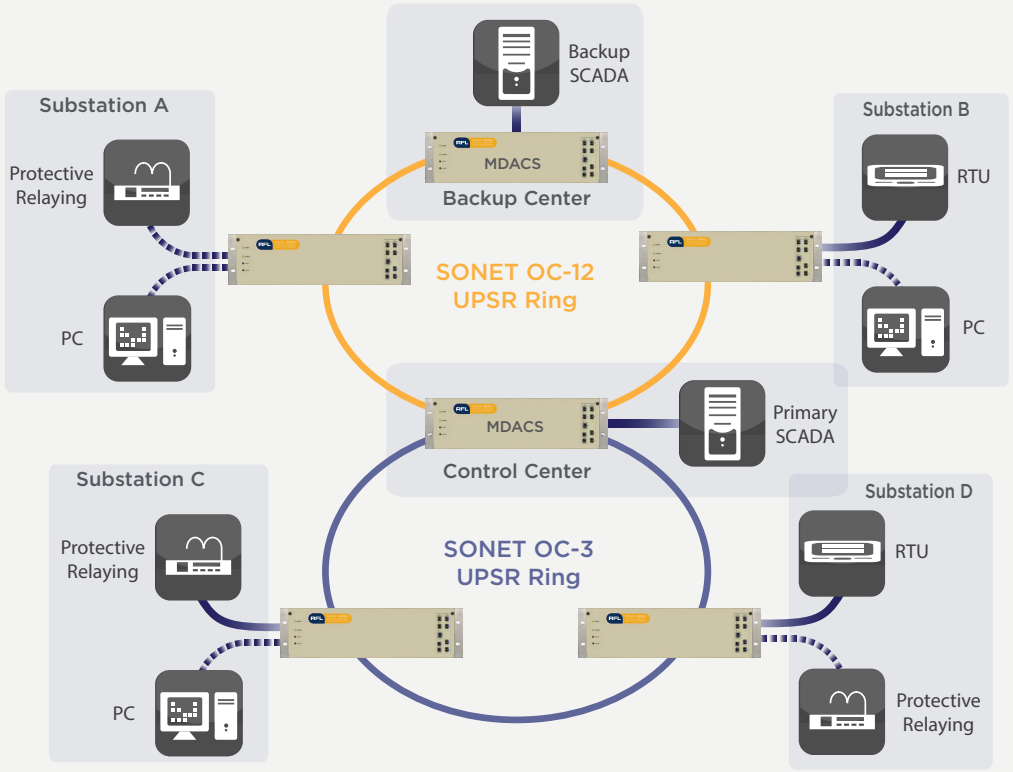
The IMUX 2000s Element Management System (EMS) communicates with the IMUX 2000s SONET/SDH module via the USB craft port, or via TCP/IP connection over a 10/100 Ethernet port. Remote IP-based management is accomplished over DS1/E1 to the management channel, or PPP/IP connectivity over the DCC channel. In addition, the integrated management router can extend the reach of the existing IP management network using SONET/SDH DCCs. The IMUX 2000s EMS supports concurrent SNMP management with Syslog monitoring and reporting.

The IMUX 2000s EMS features a real time visual display of node status, and gathers performance and fault statistics from all connected IMUX 2000s SONET/SDH Multiplexers. For IMUX 2000s MDACS units, cross connecting Ethernet and T1/E1 tributaries across the full duplex and non-blocking switch fabric is simple using the DACS configuration tool.



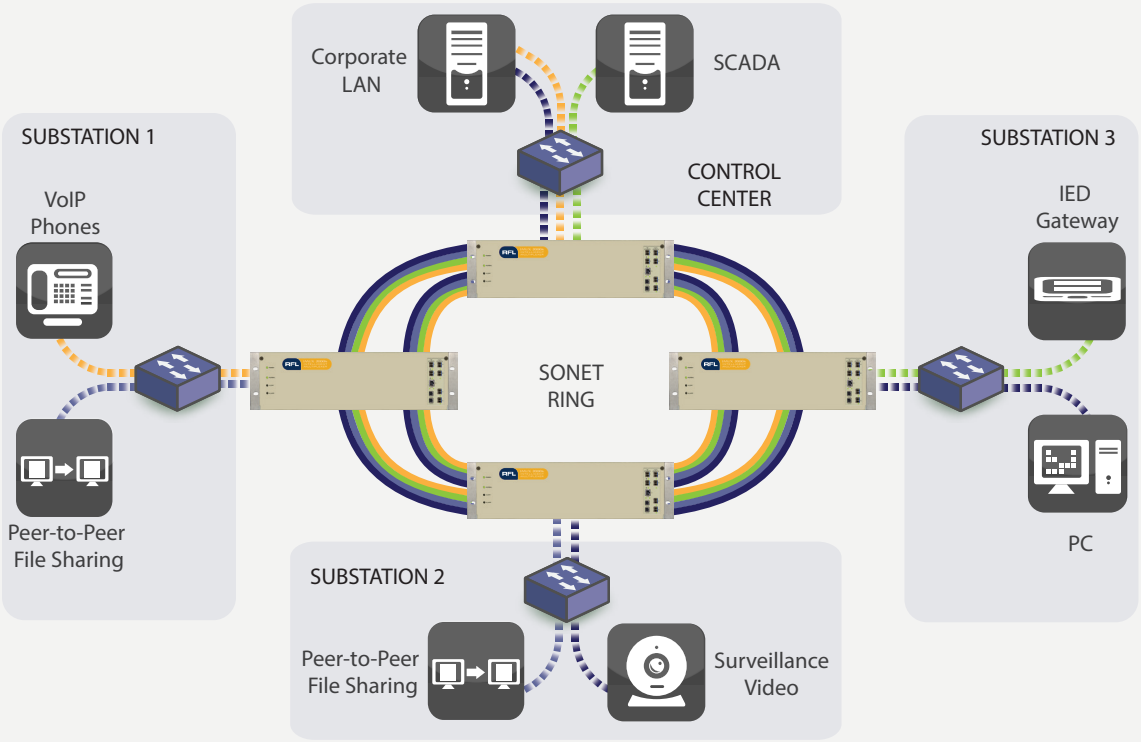
The IMUX 2000s EMS is a powerful tool that enables management of a network comprising local and remote units. The IMUX 2000s EMS intuitive graphical user interface empowers operators to realize the full potential of their services with the amenity of remote management and diagnostics.

Application Examples



Subtended Ring Topology

with VT cross-connect feature that allows data to cross from one ring to the other



Ethernet over SONET

emulates an Ethernet ring over a secure non-routable backbone for IP services

Technical Specifications

System Timing

The IMUX 2000s SONET/SDH module can be configured to generate an internal “master” network clock using its integrated Stratum 3 (4.6 ppm) clock. It can also recover clocking from trunk ports or DS1/E1 circuits.

Interfaces

The IMUX 2000s SONET/SDH module is equipped with the following interfaces:

SONET/SDH Trunk SFP receptacles

2x 622Mbps/155Mbps
2x 155Mbps

Ethernet SFP receptacles

2x Gigabit Ethernet

TDM

4x DS1/E1 RJ45 ports

Management via Ethernet or Serial

1x 10/100BaseT RJ-45 port, TCP/IP protocol

2x USB Type B craft ports for command line interface

Available SFP Tranceivers

OC-12 LC Connector

15km/9.3mi SONET OC-12 IR-1 / SDH STM S-4.1 1310nm Single Mode
40km/24.9 SONET OC-12 LR-1 / SDH STM L-4.1 1310nm Single Mode
80km/49.7 SONET OC-12 LR-2 / SDH STM L-4.2 1550nm Single Mode
120km/74.5mi SONET OC-12 LR-2 / SDH STM L-4.2 1550nm Single Mode

OC-3 LC Connector

2km/1.2mi SONET OC-3 SR-0 / SDH STM-1 1310 Multimode
15km/9.3mi SONET OC-3 IR-1 / SDH STM S-1.1 1310nm Single Mode
40km/24.9mi SONET OC-3 LR-1 / SDH STM L-1.1 1310nm Single Mode
80km/49.7 SONET OC-3 LR-2 / SDH STM L-1.2 1550nm Single Mode
120km/74.5mi SONET OC-3 LR-2 / SDH STM L-4.2 1550nm Single Mode

Gigabit Ethernet

1000Base-T Copper RJ-45
550m/1800ft 1000Base-SX 850nm Multimode LC Connector
10km/6.2mi 1000Base-LX 1310nm Single Mode LC Connector
40km/24.9mi 1000Base-FX 1310nm Single Mode LC Connector
80km/49.7mi 1000Base-ZX 1550nm Single Mode LC Connector
120km/74.5mi 1000Base-ZX 1550nm Single Mode LC Connector

Technical Specifications (continued)

Temperature:

-20°C to 65°C (IEEE 1613-2009)

Humidity:

0% to 95% non-condensing

Management:

Windows™-based NMS,
HP XView EMS for module

Remote Management & Software Update:

Yes

SNMP Control & Monitoring:

Yes

System Event Logging:

Yes

Routing for Data Command Channel:

RIP v1/2, OSPF

SFP DDMI:

Multi Source Agreement for SFPs (SFF-8472)

Power consumption:

14 Watts maximum

Compliance:

Environmental:

RoHS

Safety:

IEC60825-1 & 2 for Laser Safety

Immunity:

EN 61000-4-6:2009 for conducted immunity

IEEE 1613-2009 class 2; IEEE C37.90.2-2004; EN 61000-4-3:2006 for radiated immunity

Front panel: IEEE 1613-2009 class 2; IEEE C37.90.3-2001; IEC 61000-4-2:2008 for ESD

Power Supply, Alarm Contacts, and T1/E1 ports: IEEE 1613-2009 class 2; IEEE C37.90.1-2002; IEC 61000-4-4:2004; IEC 60255-22-1:2005 for Oscillatory SWC

Shock & Vibration:

Stationary Vibration sinusiodal, IEC 60870-2-2 Section 4, Class Cm Shock

Emmissions:

EN 55022 Class A; FCC Part 15 Class A

Upgrade Information

The IMUX 2000s SONET/SDH Module can be purchased two ways: as an upgrade to existing systems or as a standalone.

The module kit is a complete package to upgrade an installed IMUX 2000 T1/E1 multiplexer and/or IMUX 2000 T1/E1 MDACS system. RFL will provide technical services to provide an engineered solution that will maintain the existing payload and expand the network.

The following systems can be upgraded to use the IMUX 2000s SONET/SDH module:

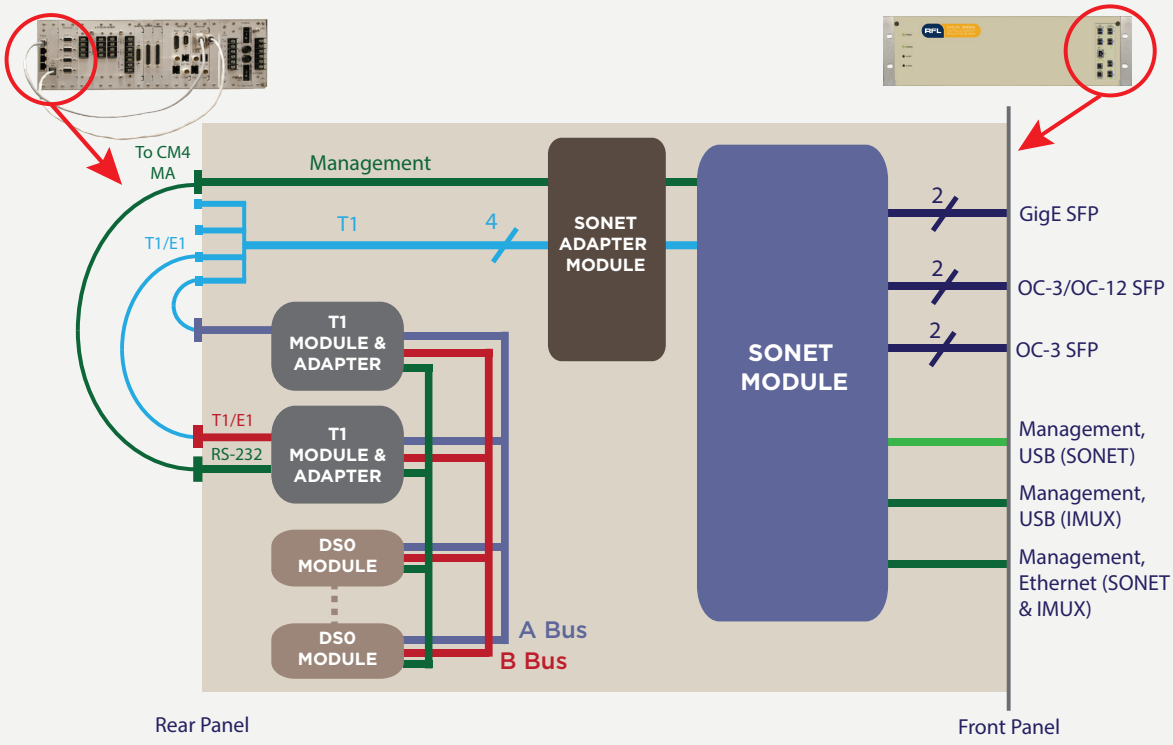
- IMUX 2000 T1/E1 Multiplexer Terminal End/ Drop & Insert with CM-4
- IMUX 2000 T1/E1 MDACS Multiplexer
- MUX 2000 E1 Multiplexer with CM-6B

The upgrade kit will include the 2000s SONET/SDH module, the Module Adapter for T1/E1 connections, new front panel and all necessary cables for management and external T1/E1 connections.

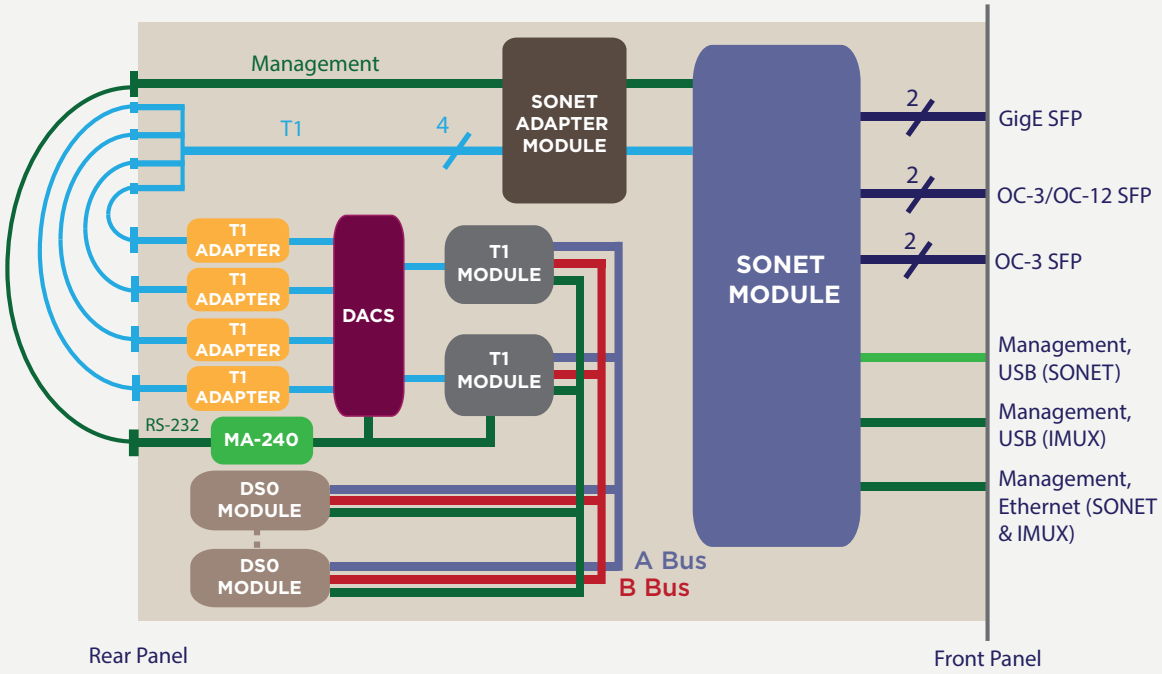
Alternatively, the IMUX 2000s SONET/SDH Module can also be supplied as a new fully integrated SONET or SDH system configured per the customer's needs and requirements. This solution would be fully engineered, tested, documented, and ready to be commissioned right out of the box.

For more information to determine if older IMUX 2000 T1 Multiplexer systems can be upgraded, please contact Sales and Application Engineering Group at RFL.

Module Interconnection Diagram



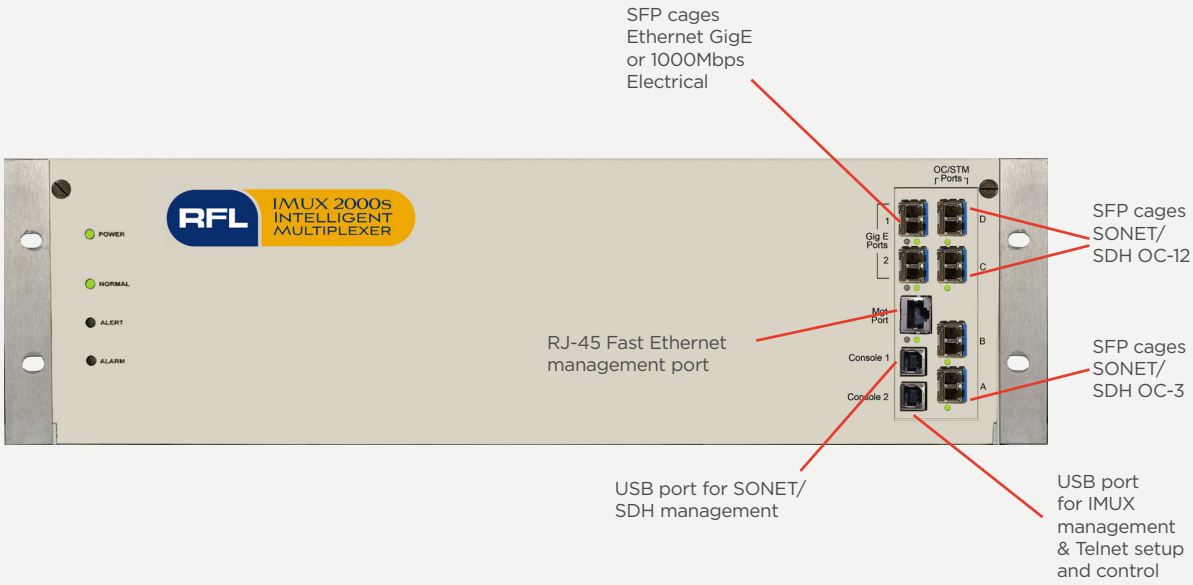
IMUX 2000s SONET/SDH Multiplexer



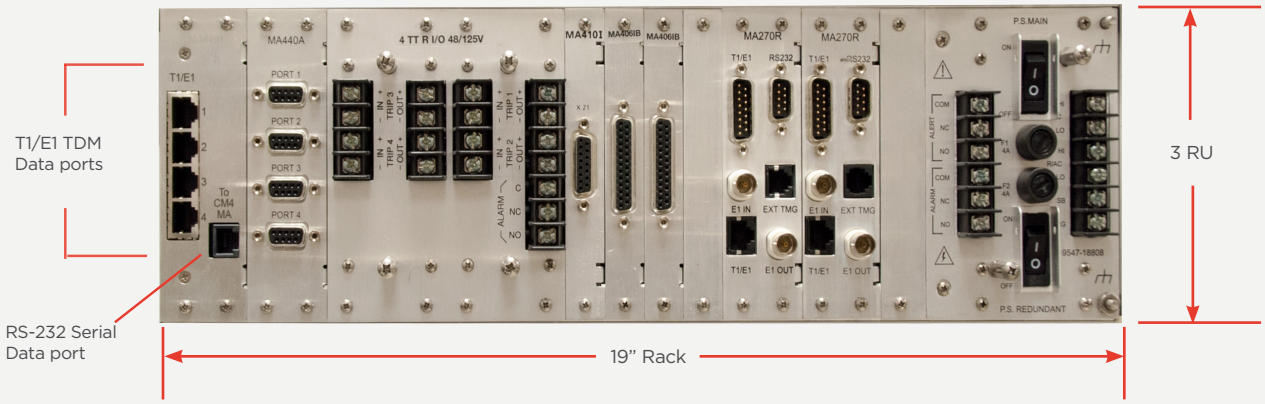
IMUX 2000s SONET/SDH MDACS

IMUX 2000s Chassis Overview

Front View:

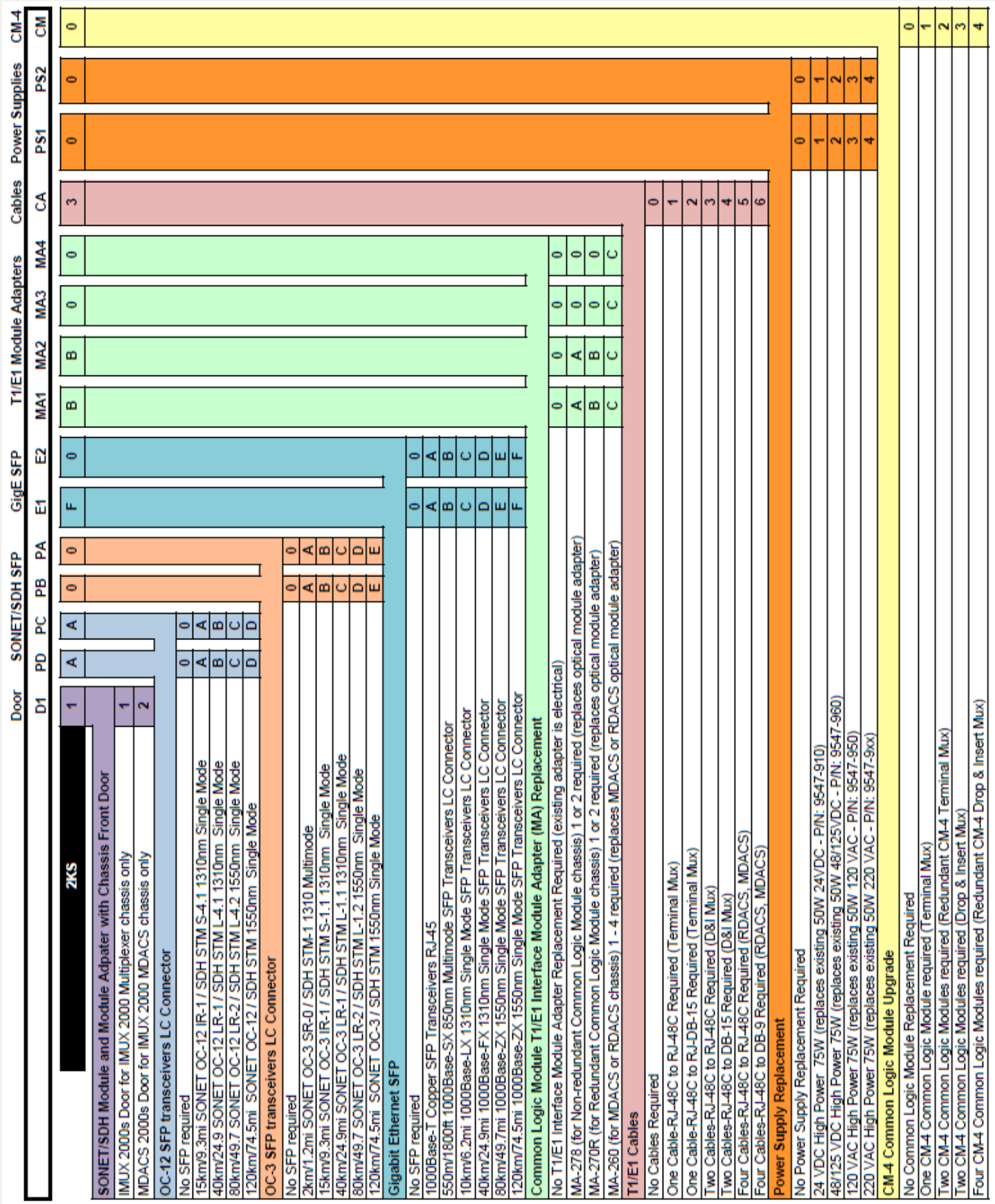


Back View:



Module Cards:

Ordering Information



2KS	Door D1	PD	SONET/SDH SFP PC	PB	PA	GigE SFP E1	E2	T1/E1 Module Adapters MA1	MA2	MA3	MA4	Cables CA	Power Supplies PS1	PS2	CM-4 CM
	1	A	A	0	0	F	0	B	B	0	0	3	0	0	0
SONET/SDH Module and Module Adpater with Chassis Front Door															
IMUX 2000s Door for IMUX 2000 Multiplexer chassis only	1														
MDACS 2000s Door for IMUX 2000 MDACS chassis only	2														
OC-12 SFP transceivers LC Connector															
No SFP required		0	0												
15km/9.3mi SONET OC-12 IR-1 / SDH STM S-4.1 1310nm Single Mode		A	A												
40km/24.9 SONET OC-12 LR-1 / SDH STM L-4.1 1310nm Single Mode		B	B												
80km/49.7 SONET OC-12 LR-2 / SDH STM L-4.2 1550nm Single Mode		C	C												
120km/74.5mi SONET OC-12 / SDH STM 1550nm Single Mode		D	D												
OC-3 SFP transceivers LC Connector															
No SFP required				0	0										
2km/1.2mi SONET OC-3 SR-0 / SDH STM-1 1310 Multimode				A	A										
15km/9.3mi SONET OC-3 IR-1 / SDH STM S-1.1 1310nm Single Mode				B	B										
40km/24.9mi SONET OC-3 LR-1 / SDH STM L-1.1 1310nm Single Mode				C	C										
80km/49.7 SONET OC-3 LR-2 / SDH STM L-1.2 1550nm Single Mode				D	D										
120km/74.5mi SONET OC-3 / SDH STM 1550nm Single Mode				E	E										
Gigabit Ethernet SFP															
No SFP required						0	0								
1000Base-T Copper SFP Transceivers RJ-45						A	A								
550m/1800ft 1000Base-SX 850nm Multimode SFP Transceivers LC Connector						B	B								
10km/6.2mi 1000Base-LX 1310nm Single Mode SFP Transceivers LC Connector						C	C								
40km/24.9mi 1000Base-FX 1310nm Single Mode SFP Transceivers LC Connector						D	D								
80km/49.7mi 1000Base-ZX 1550nm Single Mode SFP Transceivers LC Connector						E	E								
120km/74.5mi 1000Base-ZX 1550nm Single Mode SFP Transceivers LC Connector						F	F								
Common Logic Module T1/E1 Interface Module Adapter (MA) Replacement															
No T1/E1 Interface Module Adapter Replacement Required (existing adapter is electrical)								0	0	0	0				
MA-278 (for Non-redundant Common Logic Module chassis) 1 or 2 required (replaces optical module adapter)								A	A	0	0				
MA-270R (for Redundant Common Logic Module chassis) 1 or 2 required (replaces optical module adapter)								B	B	0	0				
MA-260 (for MDACS or RDACS chassis) 1 - 4 required (replaces MDACS or RDACS optical module adapter)								C	C	C	C				
T1/E1 Cables															
No Cables Required												0			
One Cable-RJ-48C to RJ-48C Required (Terminal Mux)												1			
One Cable-RJ-48C to RJ-DB-15 Required (Terminal Mux)												2			
Two Cables-RJ-48C to RJ-48C Required (D&I Mux)												3			
Two Cables-RJ-48C to DB-15 Required (D&I Mux)												4			
Four Cables-RJ-48C to RJ-48C Required (RDACS, MDACS)												5			
Four Cables-RJ-48C to DB-9 Required (RDACS, MDACS)												6			
Power Supply Replacement															
No Power Supply Replacement Required													0	0	
24 VDC High Power 75W (replaces existing 50W 24VDC - P/N: 9547-910)													1	1	
48/125 VDC High Power 75W (replaces existing 50W 48/125VDC - P/N: 9547-960)													2	2	
120 VAC High Power 75W (replaces existing 50W 120 VAC - P/N: 9547-950)													3	3	
220 VAC High Power 75W (replaces existing 50W 220 VAC - P/N: 9547-9xx)													4	4	
CM-4 Common Logic Module Upgrade															
No Common Logic Module Replacement Required															0
One CM-4 Common Logic Module required (Terminal Mux)															1
Two CM-4 Common Logic Modules required (Redundant CM-4 Terminal Mux)															2
Two CM-4 Common Logic Modules required (Drop & Insert Mux)															3
Four CM-4 Common Logic Modules required (Redundant CM-4 Drop & Insert Mux)															4