Generator Protection

- Complete, secure protection of small to medium sized generators
- Easy to use generator protection system supported by and industry leading suite of software tools.
- Advanced protection and monitoring features including the use of RTDs for stator and bearing thermal protection and Analog Inputs for vibration monitoring
- Global acceptance as a member of the most renown protection relay product family in the market.
- Draw-out construction allowing for minimized downtime and easy removal/installation of the 489 during maintenance routines
- Large, user-friendly front panel interface allowing for real-time power monitoring and setpoint access with a display that is easily readable in direct sunlight

- Enhanced generator troubleshooting through the use of IRIG-B time synchronized event records, waveform capturing, and data loggers
- Simplified setpoint verification testing using built in waveform simulation functionality
- Cost effective access to information through industry standard communication hardware (RS232, RS485, 10BaseT Ethernet) and protocols (Modbus RTU, Modbus TCP/IP, DNP 3.0)
- Available for use in most extreme harsh locations with the available Harsh Chemical Environment Option
- GL Certification for below deck shipboard applications

Wrapped Generators

- Synchronous or induction generators operating at 25Hz, 50Hz or 60Hz
- Primary or backup protection in cogeneration applications

FEATURES

Protection and Control
- Generator stator differential
- 100% stator ground
- Loss of excitation
- Distance backup
- Reverse power (anti-motoring)
- Overexcitation
- Ground directional overcurrent
- Inadvertent energization
- Breaker failure
- Stator and bearing thermal monitoring
- Stator and bearing vibration monitoring
- Negative sequence overcurrent

Monitoring and Metering
- Metering – current, voltage, power, Energy, frequency, power factor
- Demand – current, watts, vars, VA
- Temperature – 12 RTD inputs
- Vibration and Speed – 4 analog transducer inputs
- Event Recorder – 256 time tagged events
- Oscillography – 12 samples/ cycle up to 128 cycles in length
- Trending – 8 parameters with up to a 5 second sample rate

EnerVista™ Software
- State of the art software for configuration and commissioning GE Multilin products
- Document and software archiving toolset to ensure reference material and device utilities are up-to-date
- Ease to use real time monitoring, control, and data archiving software available
- EnerVista™ Integrator providing easy integration of data in the 489 into new or existing monitoring and control systems

Communications
- Networking interfaces - RS232, RS485, 10Mbps copper Ethernet
- Multiple protocols - ModBus™ RTU, ModBus™ TCP/IP, DNP 3.0 Level 2
Protection and Control

The 489 Generator Protection System provides comprehensive protection, metering, and monitoring of small to medium sized synchronous or induction generators operating at 25, 50 or 60 Hz. The 489 is ideally suited for primary or backup generator protection as well as for use in cogeneration applications. Protection features found in the 489 include:

**Generator Stator Differential**

The 489 utilizes high-speed dual slope differential protection for detecting and clearing of stator phase faults. Advanced CT saturation detection algorithms maintain immunity to saturation conditions that may be caused due to external disturbances through the use of a directional check that provides additional supervision and ensures the fault is internal to the generator before triggering it to trip.

**100% Stator Ground**

100% stator ground fault protection is provided through an overvoltage element and an adaptive voltage differential feature responding to the unbalance of the third harmonic at the machine terminals and at the neutral point. The 489 compares the machine neutral voltage and ground current to determine if ground directional faults are within or outside the generator.

**Backup Phase Distance**

Two separate phase distance elements provide time-delayed backup protection for generator faults that have not otherwise been cleared by the primary system and generator protections. The distance characteristic can compensate for a unit delta/wye power transformer that is located between the generator and the end of the zone of protection.

**Sensitive Directional Power**

The 489 provides low forward power and reverse power elements to prevent generator motoring that can cause damage the prime mover. Independent settings for power pickup levels and operational delays are available for both alarming and tripping of each element.

**Breaker Failure**

The embedded breaker failure function in the 489 allows for improved system dependability without the additional cost of providing an independent breaker failure relay. Upon detection of a breaker failure condition, the 489 can be configured to operate one of its 4 available digital outputs to signal upstream devices to quickly isolate the fault.

**Loss of Excitation**

Generator loss of excitation protection is provided through two negative offset mho characteristics as per IEEEC37.102 and has independent pickup delay setting for each characteristic. The loss of excitation element will be blocked from tripping if a VT fuse fail condition is detected or if the Voltage Supervision characteristic is

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**Functional Block Diagram**

[Diagram showing the functional block diagram of the 489 Generator Protection System]

**ANSI Device Numbers & Functions**

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Overspeed protection</td>
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<tr>
<td>23P</td>
<td>Phase distance</td>
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<tr>
<td>24</td>
<td>Volts/Hz</td>
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<tr>
<td>27P</td>
<td>Phase undervoltage</td>
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<tr>
<td>27/50</td>
<td>Accidental generator energization</td>
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<tr>
<td>27TN/59N</td>
<td>100% stator earth fault</td>
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<tr>
<td>32</td>
<td>Directional power</td>
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<tr>
<td>38</td>
<td>Bearing overtemperature (RTD)</td>
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<tr>
<td>39</td>
<td>Bearing vibration</td>
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<tr>
<td>40</td>
<td>Loss of excitation</td>
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<tr>
<td>46</td>
<td>Stator current unbalance</td>
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<tr>
<td>47</td>
<td>Phase reversal</td>
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<tr>
<td>49</td>
<td>Thermal overload</td>
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<tr>
<td>50BF</td>
<td>Breaker failure</td>
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<tr>
<td>50P</td>
<td>Phase instantaneous overcurrent</td>
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<tr>
<td>50G</td>
<td>Ground instantaneous overcurrent</td>
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<tr>
<td>51F</td>
<td>Phase time overcurrent</td>
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<td>Ground time overcurrent</td>
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<td>51_2</td>
<td>Negative Sequence Time Overcurrent</td>
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<td>Voltage restrained time overcurrent</td>
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<td>59G</td>
<td>Ground directional overcurrent</td>
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<td>81O</td>
<td>Overfrequency</td>
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<tr>
<td>81U</td>
<td>Underfrequency</td>
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<td>86</td>
<td>Lockout</td>
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<tr>
<td>87G</td>
<td>Generator differential</td>
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<tr>
<td>VTFF</td>
<td>VT fuse failure</td>
</tr>
</tbody>
</table>

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enable and the voltage is measured to be above the user defined level.

**Stator Thermal Protection**

The 489 provides thermal modeling overload protection to prevent generator damage caused by generator overheating. The thermal model algorithms incorporate current unbalance biasing and RTD biasing which provides accurate modeling of the actual generator temperature. The 489 can be configured to trip the generator offline when the generator’s thermal limits are reached, or close an Alarm contact that signals operations personnel to take appropriate actions.

**Bearing Overtemperature**

Twelve RTD inputs are provided that may be configured to monitor and protect against bearing overtemperature conditions. The 489 provides the option for using RTD voting which requires that two RTDs simultaneously indicate an overtemperature condition before it will trip the generator offline. RTD voting provides additional security against tripping of generators when an invalid overtemperature signal is received from a malfunctioning RTD.

**Negative Sequence Overcurrent**

Rotor thermal protection is provided through monitoring of negative sequence current, which is a significant contributor to rotor heating, to ensure it does not increase above the generator’s capability limits. The 489 provides a negative sequence definite time overcurrent alarm element and a negative sequence timed overcurrent curve tripping element to ensure the generator stays within its short time and continuous negative sequence current rated limits.

**Abnormal Frequency Protection**

Operation of generators at off-nominal frequencies can have extremely detrimental effects on both the generator itself and the associated prime mover, in particular with steam turbine generators operating below normal frequency. The 489 provides overfrequency and underfrequency elements needed to provide protection of generators from operation at off-nominal frequencies. The 489 has alarm level settings to alert operations of abnormal frequency conditions as well as multiple trip levels that have independent tripping delay settings for each magnitude of abnormal frequency detected.

**Overcurrent Backup**

Three voltage restrained overcurrent elements provide backup protection for system faults. The pickup level for the inverse time curves of the overcurrent elements are adjusted in conjunction with the measured phase-to-phase voltage. This feature is provided to protect against prolonged generator contribution to a fault on the system.

**Monitoring and Metering**

The 489 includes high accuracy metering and recording for all AC signals. Voltage, current, frequency, power, energy, and demand metering are built into the relay as a standard feature. Current and voltage parameters are available as total RMS magnitude, and as fundamental frequency magnitude and angle. Metered values can be read from the relay using one of the available communications ports or on the relay’s front panel display.

**Event Recording**

The 489 simplifies power generator troubleshooting by creating a sequence of events record that timestamps and logs events of internal relay operations and the operation of external devices connected to the relay’s inputs. With each of the last 256 events the 489 stores, the relay will create a detailed event report that includes the time and date of the event, and the instantaneous value of all of the voltages, phase currents, and differential currents that were measured at the time the event occurred.

**Oscillography**

Postmortem analysis of generator faults can be performed using the waveform capture feature in the 489. The 489 samples the currents and voltages inputs at a rate of 12 times per cycle and can record records up to 128 cycles in length. The recorded waveforms can be retrieved and viewed using the EnerVista 489 Setup Software and allows users to examine the magnitudes and relationships of the measured signals at the time of the fault.
IRIG-B Time Synchronization
The 489 supports receiving an input from an IRIG-B time synchronization clock that will synchronize the 489 internal clock with other devices found in the substation or distributed across the power system. IRIG-B time synchronization will provide timestamping of events in the Event Record with 1ms accuracy thereby providing a means of accurately determining the sequence of operation of events that occurred across multiple devices in the power system.

Simulation Mode
The 489 has a built in simulation feature that allows for testing the functionality and relay response to programmed conditions without the need for external inputs. When placed in simulation mode the 489 suspends reading of the actual inputs and substitutes them with the simulated values. Pre-trip, fault, and post fault states can be simulated, with currents, voltages, system frequency, RTD temperatures, and analog inputs configurable for each state.

Automation
The 489 offers a multitude of different analog and digital inputs and outputs to allow the 489 to be seamlessly integrated into most generator automation schemes.

Outputs Relays
The 489 provides six output contacts for the purpose of controlling or signaling other devices and operations personnel.

Analog Outputs
Four analog outputs are available for signaling the value of measured analog quantities to external process control devices such as PLCs. The analog outputs can be ordered to operate over a 4 to 20mA range or a 0 to 1mA range and can be configured to signal a representation of most analog quantities measured by the 489 including currents, voltages, frequency, RTD temperature, power and demand.

Communications
The 489 provides advanced communications technologies for remote data and engineering access, making it easy and flexible to use and integrate into new or existing monitoring and control systems. Multiple communication ports are available including a front panel RS232 serial port for easy local computer access, two RS485 serial ports and a 10Mbps copper Ethernet port that provide direct integration in most communications architectures.

User Interfaces
Keypad and Display
The 489 has a keypad and 40 character display for local monitoring and relay configuration without the need for a computer. Up to 20 user-selected default messages can be displayed when the relay is protecting the generator. In the event of a trip, or an alarm, the display will automatically default to the proper message indicating the cause of the operation.

LED Indicators
The 489 front panel features 22 LED indicators that provide a quick indication of 489 status, generator status, and output relay status.
**EnerVista™ Software**

The EnerVista™ Suite is an industry-leading set of software programs that simplify every aspect of using the 489 relay. The EnerVista™ suite provides all the tools to monitor the status of your protected asset, maintain the relay and integrate information measured by the 489 into DCS or SCADA monitoring systems. Convenient COMTRADE and Sequence of Events viewers are an integral part of the 489 Setup software included with every relay to carry out post-mortem event analysis.

**EnerVista™ Launchpad**

EnerVista™ Launchpad is a powerful software package that provides users with all of the setup and support tools needed for configuring and maintaining GE Multilin products. The setup software within Launchpad allows configuring devices in real-time by communicating using serial, Ethernet, or modem connections, or offline by creating setting files to be sent to devices at a later time. Included in Launchpad is a document archiving and management system that ensures critical documentation is up-to-date and available when needed. Documents made available include:

- Manuals
- Application Notes
- Guideform Specifications
- Brochures
- Wiring Diagrams
- FAQs
- Service Bulletins

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**Features**

**489 FRONT**

489 STATUS INDICATORS
- 489 status
- Generator status
- Output relays

NUMERIC KEYPAD
Numeric keys allow for simple entry of setpoint values. Control keys allow simple navigation through setpoint and actual value message structures. Help key provides context sensitive help messages.

VALUE KEYS
Value Up, and Value Down keys to change setpoint values

PROGRAM PORT INTERFACE
RS232 for connection to a computer, 9600 baud

**489 REAR**

RTD INPUTS
Twelve RTD inputs are individually field programmable to measure platinum, nickel, or copper type RTDs.

RS485 COMMUNICATIONS
Two independent RS485 communication ports may be accessed simultaneously using ModbusRTU and DNP 3.0 protocol at baud rates up to 19200 bps.

OUTPUT RELAYS
Six, trip duty, form C output relays may be assigned to trip, alarm and control functions.

VT INPUTS
Four VT inputs provide wye or open delta system voltage sensing as well as neutral voltage sensing.

**489 FRONT**

LARGE DISPLAY
Forty character display for viewing setpoints and actual value messages. Diagnostic messages are displayed when there is a trip or alarm condition. Default messages are displayed after a period of inactivity.

CONTROL AND PROGRAMMING KEYS
Menu, Escape, Reset, Enter, Menu Up, and Menu Down keys for complete access without a computer.

DRAWOUT HANDLE
With provision for a wire lead seal to prevent unauthorized removal

ANALOG SIGNALS
Four isolated 4-20 mA analog outputs may be used to replace costly transducers. They may be field programmed to reflect any measured parameter. Four 0-1 or 4-20 mA analog inputs may be used to monitor any transducer signal. Possible applications include vibration and field current monitoring.

DIGITAL INPUTS
Access jumper input provides setpoint programming security. Breaker status input tells 489 if the generator is online or offline. Seven assignable digital inputs may be field programmed for a variety of functions including tachometer.

TRIP COIL SUPERVISION
Monitors the trip circuit for continuity when the generator is online and alarms if that continuity is broken.

GROUND
Separate safety and filter ground. All inputs meet C37.90 EMI, SWC, RFI interference immunity.

AC/DC CONTROL POWER
Universal power supply 90-300 VDC 70-265 VAC

CT INPUTS
Seven CT inputs provide three-phase output, three-phase neutral and ground current sensing.
Typical Wiring
Viewpoint Monitoring

Viewpoint Monitoring is a simple-to-use and full-featured monitoring and data recording software package for small systems. Viewpoint Monitoring provides a complete HMI package with the following functionality:

- Plug & Play Device Monitoring
- System Single-Line Monitoring & Control
- Annunciator Alarm Screens
- Trending Reports
- Automatic Event Retrieval
- Automatic Waveform Retrieval

Technical Specifications

**PROTECTION**

**OVERCURRENT ALARM**
- Pick-up Level: 0.10 to 1.50 x FLA in steps of 0.01 average phase current.
- Time Delay: 0.1 to 250 s in steps of 0.1.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±0.05% or ±50 ms of total time.

**OFFLINE OVERCURRENT**
- Pick-up Level: 0.05 to 1.00 x CT in steps of 0.01 of any one phase.
- Time Delay: 3 to 99 cycles in steps of 1.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**INADVERTENT EREVITIZATION**
- Pickup Signal: undervoltage and/or offline from breaker status.
- Time Delay: 0.05 to 3.00 x CT in steps of 0.01 of any one phase.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±0.5% total time.

**NEGATIVE SEQUENCE OVERCURRENT**
- Pickup Level: 3 to 100% FLA in steps of 1.
- Curve Shapes: 1/2 trip defined by k, definite time alarm.
- Time Delay: 0.1 to 100 s in steps of 1.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±100 ms or ±5% of total time.

**GROUND OVERCURRENT**
- Pickup Level: 0.05 to 200.0 x CT in steps of 0.01.
- Time Delay: 0.00 to 100.0 s in steps of 0.01.
- Pickup Accuracy: as per Ground Current Input.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**PHASE DIFFERENTIAL**
- Pickup Level: 0.05 to 1.00 x CT in steps of 0.01.
- Curve Shapes: 0.1 A trip.
- Time Delay: 0 to 100 cycles in steps of 1.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**GROUND DIRECTIONAL**
- Pickup Level: 0.05 to 200.0 x CT in steps of 0.01.
- Curve Shapes: 1/2 trip defined by k, definite time alarm.
- Time Delay: 0.1 to 120.0 s in steps of 0.1.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**UNDERCURRENT**
- Pickup Level: 0.50 to 0.99 x rated V in steps of 0.01.
- Curve Shapes: Inverse Time, definite time alarm 1.
- Time Delay: 0.2 to 120.0 s in steps of 0.1.
- Pickup Accuracy: as per Voltage Inputs.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**Elements:** Trip and Alarm.

**PROTECTION**

**VOLTAGE OVERVOLTAGE**
- Pick-up Level: 1.01 to 1.50 x rated V in steps of 0.01.
- Curve Shapes: Inverse Time, definite time alarm.
- Time Delay: 0.1 to 250.0 s in steps of 0.1.
- Pickup Accuracy: as per Voltage Inputs.
- Timing Accuracy: ±50 ms or ±0.5% of total time.

**VOLTAGE UNDERVOLTAGE**
- Pick-up Level: 0.99 to 0.90 x rated voltage in steps of 0.01.
- Curve Shapes: Inverse Time, definite time alarm.
- Time Delay: 0.1 to 250.0 s in steps of 0.1.
- Pickup Accuracy: as per Voltage Inputs.
- Timing Accuracy: ±50 ms or ±0.5% of total time.

**REVERSE POWER**
- Pickup Level: 0.02 to 1.50 x rated MW (positive) and Mvar (negative).
- Time Delay: ±100 ms or ±0.5% of total time.
- Pickup Accuracy: see power metering.
- Timing Accuracy: ±0.100ms or ±0.5% of total time.

**LOW FORWARD POWER**
- Pickup Level: 0.02 to 1.99 x rated MW.
- Time Delay: ±100 ms or ±0.5% of total time.
- Pickup Accuracy: see power metering.
- Timing Accuracy: ±0.100ms or ±0.5% of total time.

**DIRECTIONAL OVERLOAD**
- Pickup Level: 0.01 to 1.20 x rated speed in steps of 0.1.
- Curve Shapes: as per Phase Current Inputs.
- Time Delay: ±100 ms or ±2% of total time.
- Pickup Accuracy: ±1.00% or ±10% of total time.
- Timing Accuracy: ±100 ms or ±0.5% of total time.

**NEUTRAL OVERVOLTAGE**
- Pick-up Level: 20.0 to 1.00 V secondary in steps of 0.01.
- Curve Shapes: 1 level alarm, 2 level trip definite time.
- Time Delay: ±100 ms or ±0.5% of total time.
- Pickup Accuracy: ±100 ms or ±0.5% of total time.
- Timing Accuracy: ±1.00ms or ±2% of total time.

**NEUTRAL UNDERVOLTAGE**
- Pick-up Level: 0.50 to 0.99 x rated voltage in steps of 0.01.
- Curve Shapes: as per Neutral Voltage Input.
- Timing Accuracy: ±50 ms or ±0.5% of total time.

**LOSS OF GENERATION**
- Pickup Level: 0.05 to 1.00 x CT in steps of 0.01.
- Curve Shapes: 0.1 A trip defined by k, definite time alarm.
- Time Delay: 0 to 100 s in steps of 1.
- Pickup Accuracy: as per Phase Current Inputs.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**FIELD BREAKER DISCREPANCY**
- Pickup Level: 0.05 to 1.00 x CT in steps of 0.01.
- Curve Shapes: as per Phase Current Inputs.
- Timing Accuracy: ±0.5% or ±50 ms of total time.

**DIGITAL INPUT**

**GENERATOR INPUT A TO G (DIGITAL INPUT)**
- Configurable: Assignable to Digital Inputs 1 to 7.
- Time Delay: 0.1 to 5000 s in steps of 0.1.
- Block From Online: 0 to 5000 s in steps of 1.
- Timing Accuracy: ±100 ms or ±0.5% of total time.

**SEQUENTIAL TRIP (DIGITAL INPUT)**
- Configurable: Assignable to Digital Inputs 1 to 7.
- Time Delay: ±100 ms or ±0.5% of total time.
- Field Breaker Discrepancy (Digital Input)
- Configurable: Assignable to Digital Inputs 1 to 7.
- Time Delay: ±100 ms or ±0.5% of total time.
- Tachometer (Digital Input)
- Configurable: Assignable to Digital Inputs 4 to 7.
- Duty Cycle of Pulse: >10%.
- Pickup Level: 10 to 175 x rated speed in steps of 1.
- Time Delay: 1 to 250 s in steps of 1.
- Timing Accuracy: ±0.5 or ±50 ms of total time.

**EnerVista™ Integrator**

EnerVista™ Integrator is a toolkit that allows seamless integration of GE Multilin devices into new or existing automation systems. Included in EnerVista Integrator is:

- OPC/DDE Server
- GE Multilin Drivers
- Automatic Event Retrieval
- Automatic Waveform Retrieval

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### Technical Specifications (continued)

#### Analog Inputs

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Analogs Outputs</th>
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<tbody>
<tr>
<td><strong>RTD Inputs</strong></td>
<td><strong>RTD Inputs</strong></td>
</tr>
<tr>
<td>Type:</td>
<td>Type:</td>
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<tr>
<td>100Ω Platinum</td>
<td>100Ω Platinum</td>
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<tr>
<td>100Ω Nickel</td>
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<tr>
<td>10Ω Copper</td>
<td>10Ω Copper</td>
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<tr>
<td><strong>RTD Sensing</strong></td>
<td><strong>RTD Sensing</strong></td>
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<td>36 VpV (isolated with analog inputs and outputs)</td>
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<tr>
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<tr>
<td>±3°C for Copper</td>
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#### Analog Outputs

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<td><strong>Power Supply</strong></td>
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<tr>
<td>Options:</td>
<td>Options:</td>
</tr>
<tr>
<td>LO / HI</td>
<td>LO / HI</td>
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<td><strong>Frequency</strong></td>
<td><strong>Frequency</strong></td>
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#### Grounding

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<tr>
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<td><strong>Burden</strong></td>
<td><strong>Burden</strong></td>
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<tr>
<td>1 A</td>
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<tr>
<td>2 A</td>
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<td>20 A</td>
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#### Voltage Inputs

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<td>Resitive</td>
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<td></td>
<td>10 A</td>
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<td></td>
<td>30 A</td>
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#### Power Supply Specifications

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<tr>
<td>6 V minimum, 10 Hz/sec</td>
<td>6 V minimum, 10 Hz/sec</td>
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</tbody>
</table>

#### Ordering

**489**

- 489 Generator Protection Learning CD
- Multilink Ethernet Switch
- Multinet
- Viewpoint Maintenance
- Viewpoint Monitoring

### Accessories for the 489

- 489 Generator Protection Learning CD
- Multilink Ethernet Switch
- Multinet
- Viewpoint Maintenance
- Viewpoint Monitoring

### Visit www.GEMultilin.com/489 to:

- View Guideline specifications
- Download the instruction manual
- Review applications notes and support documents
- Buy a 489 online
- View the 489 brochure