Multilin™
D60
LINE DISTANCE PROTECTION SYSTEM

High-Speed Transmission Line Protection with Single and Three-Pole Tripping

KEY BENEFITS

- High-speed, cost-effective five zone quad or mho, phase and ground distance protection
- Reliable and secure protection on series compensated lines
- Superior phase selection algorithm ensures secure high-speed single-pole tripping
- Supports multiple standard and customizable pilot schemes for fast fault clearance within the protected zone
- Reduced relay-to-relay wiring and associated installation costs through high-speed inter-relay communications
- Flexible programmable logic for building customized schemes
- Simplified teleprotection interfaces with direct I/O communications hardware for transfer trip and pilot-aided distance schemes
- Phasor Measurement Unit (synchrophasor) according to IEEE® C37.118 (2011) and IEC® 61850-90-5 support
- Three independent fiber or copper Ethernet ports for simultaneous/dedicated network connections with advanced 1 microsecond time synchronization via LAN with IEEE 1588 support
- Complete IEC 61850 Process Bus solution provides resource optimization and minimizes total P&G life cycle costs
- Embedded IEC 61850 protocol
- Increase network availability by reducing failover time to zero through IEC 62439-3 “PRP” support
- CyberSentry™ provides high-end cyber security aligned to industry standards and services (NERC® CIP, AAA, Radius, RBAC, Syslog)

APPLICATIONS

- Overhead lines including series compensated lines and underground cables of different voltage levels
- Single and dual-breaker circuits requiring single/three-pole autoreclosing and independent synchrocheck
- Circuits with in-zone power transformers and tapped transformer feeders
- Secure application with Capacitively-Coupled Voltage Transformers (CCVTs)
- Backup protection for generators, transformers and reactors

FEATURES

Protection and Control
- Phase distance (five zones) with independent compensation settings for in-zone power transformers
- Ground distance (five zones) with independent self and mutual zero sequence compensation
- Reverse power, out-of-step tripping and power swing blocking
- Line pickup, thermal protection, under/over frequency
- Phase and negative sequence directional overcurrent, neutral directional with dual polarity criteria, broken conductor and thermal overload
- Over, under and rate of change of frequency, synchronism check for dual breaker applications
- Four-shot dual breaker autorecloser broken conductor
- VT fuse failure detector, compensated overvoltage

EnerVista™ Software
- Graphical Logic Designer and Logic Monitor to simplify designing and testing procedures via EnerVista UR Engineer
- Service and update notification toolset ensures device documents and software are up-to-date via EnerVista Launchpad
- EnerVista Integrator providing easy integration of data in the D60 into new or existing monitoring and control systems

IEC 61850 Process Bus Interface
- Robust communications with up to 8 HardFiber Bricks
- Redundant architecture for dependability and security

Monitoring and Metering
- P & M Class synchrophasors of voltage, current and sequence components: reporting rate 1 to 120 frames/sec
- Metering: current, voltage, power, energy, frequency
- Advanced recording capabilities deliver a 1024 event recorder, configurable and extended waveform capture and data logger
- Setting for security audit trails for tracking changes to D60 configurations

Communications
- Networking interfaces: up to three Ethernet ports 100Mb fiber or copper, RS485, RS232, RS422, G.703, C37.94
- Multiple protocols: IEC 61850, DNP 3.0 and Modbus® serial/TCP, IEEE 1588, IEC 60870-5-104 and 103, PRP, SNTP, HTTP, TFTP
- Direct I/O: secure, high-speed exchange of data between URs for direct transfer trip (DTT) and pilot-aided schemes
- Embedded managed Ethernet switch with four 100 Mbit fiber optic ports and 2 copper ports
Protection & Control

The D60 is a high-end, cost-effective distance protection relay intended for protecting transmission lines and cables, providing reliable and secure operation even under the worst case power system conditions. Part of the Universal Relay (UR) family, the D60 comes with a variety of versatile features, truly integrating protection, monitoring, metering, communication and control in one easy-to-use device. The UR family offers a high degree of modularity in its design and functionality, providing superior performance in protection and control while meeting the toughest requirements of the marketplace.

Distance Protection

The core of the D60 relay is the distance function providing a high degree of sensitivity and selectivity for all types of faults. The distance function comes with five zones of phase distance and ground distance, providing the user maximum flexibility to cater to different applications, including primary line protection and backup protection for busbars, generators, transformers and reactors. The relay can be applied to power systems with different earthing conditions, lines with in-zone transformers or tapped transformer feeders, and overhead lines with series compensation. Each zone element for the phase and ground distance can be independently set as quad or mho characteristics with the flexibility of designing different characteristic shapes to suit different power system conditions.

The advanced comparator-based distance elements provide the utmost security, sensitivity and selectivity for different types of faults. Superior digital filtering techniques provide secure and optimum reach accuracy even under worst case CVT transients. Secure directional discrimination is achieved by using positive sequence memory voltage polarization, providing reliable directionality for worst case close-in faults. Dual distance algorithms deliver exceptional security and speed performance to ensure average operating times of 1.5 cycles for 75% line reach and SIR 30, and <2.5 cycles for 90% line reach and SIR 60. The D60 employs a well-proven algorithm for phase selection, which provides faster, secure and reliable faulted phase identification for single-pole tripping and proper fault distance calculation for a variety of power system conditions. An additional voltage variation.
monitored by the load encroachment function, which can be used to block the distance elements under voltage source fuse failure conditions.

In-Zone Transformer Compensation

Phase distance protection in the D60 can be used to detect faults through different types of three-phase wye/delta transformers, allowing the application of the D60 for backup protection on generators. VTs and CTs can be installed independently of each other on either side of the power transformer. The relay automatically compensates for transformer connections, to guarantee accurate reach for any type of fault.

Load Encroachment

The load encroachment feature offers discrimination between line loading conditions and fault conditions, especially for long lines under heavy loads, by supervising the distance elements or any overcurrent element. This prevents unwanted tripping under heavy line load conditions and enables optimum operation of the line, while meeting regulatory requirements for line loading.

Fault Locator

The fault locator provides distance to fault in kilometers or miles. Parallel line zero-sequence current compensation and load current compensation enable the D60 to provide improved accuracy for fault distance measurement.

Line Pickup (Switch-on-to Fault)

The line pickup feature uses a combination of undercurrent and undervoltage to identify a line that has been de-energized (line end open). Three instantaneous overcurrent elements are used to identify a previously de-energized line that has been closed on to a fault.

Power Swing Detection

Dynamic transients in the power system, due to short-circuits, circuit switching, or load unbalance changes, can travel across the power network as power swings that are characterized by fluctuating currents and voltages. This can result in unwanted tripping since distance elements can respond to these power swings as faults. The D60 power swing detection element provides both power swing blocking and out-of-step tripping functions. The element measures the positive sequence apparent impedance and traces its locus with respect to either a two or three-step user-selectable mho or quad operating characteristic. Negative sequence current supervisors provide extended selectivity for detecting evolving faults that may appear as a power swing event (faults with slow-moving impedance locus).

Series Compensated Lines

D60 provides enhanced stability and security by employing an adaptive distance reach control to cope with the overreaching and sub-synchronous oscillations when applied to, or in the vicinity of, series compensated lines. For directional integrity the relay uses memory voltage polarization and a multi-input comparator to deal with current inversion issues in series compensated lines.

Single-Pole Tripping

The D60 relay uses an advanced phase selection algorithm that provides fast and accurate fault type identification even under weak in-feed conditions. A convenient trip function is built-in to coordinate actions of the key elements of the single-pole tripping package.

Communication Aided (Pilot) Schemes

D60 supports different teleprotection functions for fast fault clearance for any faults within the protected line. The following types of pilot-aided schemes are available in the D60:

- Direct Underreach Transfer Trip (DUTT)
- Permissive Underreach Transfer Trip (PUTT)
- Two Permissive Overreach Transfer Trip (POTT)
- Hybrid Permissive Overreach Transfer Trip (HYB POTT): permissive echo and transient blocking logic incorporated
- Directional Comparison Blocking Scheme (DCB)
- Directional Comparison Unblocking Scheme (DCUB)
- Customizable version of the POTT and DCB schemes (POTT1 and DCB11)

Undervoltage & Overvoltage Protection

Long lines under lightly loaded or no-load conditions may experience voltages exceeding the rated insulation voltage level. Use the three phase overvoltage elements in the D60 to detect and trip on this condition. A second compensated overvoltage element detects overvoltage caused by breakers opening at the remote end. The D60 also provides additional voltage functions, including neutral overvoltage, negative sequence overvoltage and phase undervoltage.

Overcurrent Functions

The D60 provides thermal overload, and time and instantaneous overcurrent elements for phase, neutral, ground, negative sequence, phase and neutral directional. All of them can run in parallel with distance elements or can be programmed to provide overcurrent protection under conditions when the distance element is blocked (example VT fuse failure).

Autorecloser

The D60 provides multi-shot autoreclosing (up to 4 shots) for single or three-pole
autoreclose on all types of faults with independently programmable dead time for each shot. Autoreclosing can be dynamically blocked by user-programmable logic. Four different autoreclose operation modes are available, enabling users to select the reclosing mode to suit specific applications.

**Synchronism Check**
The D60 provides four synchrocheck elements that monitor voltage difference, phase angle difference and slip frequency, to ensure proper breaker closure as per user-defined settings. The D60 provides additional enhancements in synchronizing, by checking dead source conditions for synchronism bypass under these conditions.

**Multiple Breaker Configurations**
The D60 supports dual-breaker busbar configurations, such as breaker-and-a-half or ring bus arrangements, providing dual-breaker autoreclose, dual synchrocheck elements, and dual independent breaker failure elements. The design provides secure operation during external faults with possible CT saturation.

**Breaker Failure**
The D60 is able to provide fully independent breaker failure protection for the breakers associated to the line when connected to a substation with a breaker-and-a-half or ring bus arrangement. The D60 provides the elements to perform two independent breaker failure functions.

**IEC 61850 Process Bus**
The IEC 61850 Process Bus module is designed to interface with the Multilin HardFiber System, allowing bi-directional IEC 61850 fiber optic communications. The HardFiber System is designed to integrate seamlessly with existing UR applications, including protection functions, FlexLogic™, metering and communications.

The Multilin HardFiber System offers the following benefits:
- Communicates using open standard IEC 61850 messaging
- Drastically reduces P&I design, installation and testing labor by eliminating individual copper terminations

- Integrates with existing D60’s by replacing traditional CT/VT inputs with the IEC 61850 Process Bus module
- Does not introduce new cyber security concerns

Visit the HardFiber System product page on the GE Digital Energy website for more details.

**Advanced Automation**
The D60 incorporates advanced automation features including powerful FlexLogic programmable logic, communication, and SCADA capabilities that far surpass what is found in the average line protection relay. The D60 integrates seamlessly with other UR relays for complete system protection, including unit and auxiliary transformers, and balance of plant protection.

**FlexLogic**
FlexLogic is the powerful UR-platform programming logic engine that provides the ability to create customized protection and control schemes, minimizing the need and associated costs of auxiliary components and wiring. Using FlexLogic, the D60 can be programmed to provide required tripping logic along with custom scheme logic for breaker control (including interlocking with external synchronizers), transfer tripping schemes for remote breakers and dynamic setting group changes.

**Scalable Hardware**
The D60 is available with a multitude of I/O configurations to suit the most demanding application needs. The expandable modular design allows for easy configuration and future upgrades.
- Flexible, modular I/O covering a broad range of input signals and tripping schemes
- Types of digital outputs include trip-rated Form-A and Solid State Relay (SSR) mechanically latching, and Form-C outputs
- RTDs and DCmA inputs are available to monitor equipment parameters, such as temperature and pressure

**Monitoring and Metering**
The D60 includes high accuracy metering and recording for all AC signals. Voltage, current, and power 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.

**Fault and Disturbance Recording**
The advanced disturbance and event recording features within the D60 can significantly reduce the time needed for postmortem analysis of power system events and the creation of regulatory reports. Recording functions include:
- Sequence of Event (SOE) - 1024 time stamped events
- Oscillography - 64 digital & up to 40 analog channels - Events with up to 45s length
- Data Logger and Disturbance Recording - 16 channels up to 1 sample/cycle/ channel
- Fault Reports - Powerful summary report of pre-fault and fault values

The very high sampling rate and large amount of storage space available for data recording in the D60 can eliminate the need for installing costly stand-alone recording equipment.

**Advanced Device Health Diagnostics**
The D60 performs comprehensive device health diagnostic tests at startup and continuously during run-time to test its own...
major functions and critical hardware. These diagnostic tests monitor for conditions that could impact security and availability of protection, and present device status via SCADA communications and front panel display. Providing continuous monitoring and early detection of possible issues help improve system uptime.

- Comprehensive device health diagnostic performed at startup
- Monitors the CT/VT input circuitry to validate the integrity of all signals

**Cyber Security – CyberSentry UR**

CyberSentry UR enabled UR devices deliver full cyber security features that help customers to comply with NERC CIP and NIST® IR 7628 cyber security requirements. This software option delivers the following core features:

**AAA Server Support (Radius/LDAP)**

Enables integration with centrally managed authentication and accounting of all user activities and uses modern industry best practices and standards that meet and exceed NERC CIP requirements for authentication and password management.

**Role Based Access Control (RBAC)**

Efficiently administer users and roles within UR devices. The new and advanced access functions allow users to configure up to five roles for up to eight configurable users with independent passwords. The standard “Remote Authentication Dial In User Service” (Radius) is used for authentication.

**Event Recorder (Syslog for SEM)**

Capture all cyber security related events within a SOE element log-in, log-out, invalid password attempts, remote/local access, user in session, settings change, FW update, etc., and then serve and classify data by security level using standard Syslog data format. This will enable integration with established SEM (Security Event Management) systems.

**Communications**

The D60 provides for secure remote data and engineering access, making it easy and flexible to use and integrate into new and existing infrastructures. Fiber optic Ethernet provides high-bandwidth communications allowing for low-latency controls and high-speed file transfers of relay fault and event record information. The available three independent Ethernet ports, redundant Ethernet option and the embedded managed Ethernet switch provide the means to create fault tolerant communication architectures in an easy, cost-effective manner. The D60 supports the most popular industry standard protocols enabling easy, direct integration into monitoring and SCADA systems.

- IEC 61850 with 61850-90-5 support
- DNP 3.0
- IEC 60870-5-103 and IEC 60870-5-104
- IEEE 1588 for time synchronization
- Modbus RTU, Modbus TCP/IP
- PRP as per IEC 62439-3

**Interoperability with Embedded IEC 61850**

The D60 with integrated IEC 61850 can be used to lower costs associated with protection, control and automation. GE Digital Energy’s leadership in IEC 61850 comes from thousands of installed devices and follows on extensive development experience with UCA 2.0.

- Replace expensive copper wiring between devices with direct transfer of data using GOOSE messaging
- Configure GE systems based on IEC 61850 and also monitor and troubleshoot them in real-time with EnerVista Viewpoint Engineer
- Multicast IEEE C37.118 synchrophasor data between PMU and PDC devices using IEC 61850-90-5

**Direct I/O Messaging**

Direct I/O allows for the sharing of high-speed digital information between multiple UR relays via direct back-to-back connections or multiplexed through a standard DSO multiplexer channel bank. Regardless of the connection method, direct I/O provides continuous real-time channel monitoring that supplies diagnostics information on channel health. Direct I/O provides superior relay-to-relay communications that can be used in advanced interlocking and other special protection schemes.
• Communication with up to 16 UR relays in single or redundant rings rather than strictly limited to simplistic point-to-point configurations between two devices
• Connect to standard DS0 channel banks through standard RS422, G.703 or IEEE C37.94 interfaces or via direct fiber optic connections
• No external or handheld tester required to provide channel diagnostic information

LAN Redundancy
Substation LAN redundancy has been traditionally accomplished by reconfiguring the active network topology in case of failure. Regardless of the type of LAN architecture (tree, mesh, etc), reconfiguring the active LAN requires time to switchover, during which the LAN is unavailable. UR devices deliver redundancy as specified by PRP-IEC 62439-3, which eliminates the dependency on LAN reconfiguration and the associated switchover time. The UR becomes a dual attached node that transmits data packets over both main and redundant networks simultaneously, so in case of failure, one of the data packets will reach the receiving device with no time delay.

Multi-Language
UR devices support multiple languages: English, French, Russian, Chinese, Turkish and German. These language options are available on the front panel, in the EnerVista setup software, and in the product manuals. Easily switch between English and an additional language on the local displays without uploading new firmware.

EnerVista Software
The EnerVista suite is an industry-leading set of software programs that simplifies every aspect of using the D60 relay. The EnerVista suite provides all the tools to monitor the status of the protected asset, maintain the relay, and integrate information measured by the D60 into DCS or SCADA monitoring systems. Convenient COMTRADE and SOE viewers are an integral part of the UR setup software included with every UR relay, to carry out postmortem event analysis and ensure proper protection system operation.

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 MultiLin products. The setup software within Launchpad allows for the configuration of 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
• FAQ’s
• Service Bulletins

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:

Power System Troubleshooting
The D60 contains many tools and reports that simplify and reduce the amount of time required for troubleshooting power system events.

Analyze transmission line faults using system voltage, current and appropriate pickup flags that are measured & recorded up to 64 samples/cycle.

Record the operation of the internal D60 elements and external connected devices with 1ms time-stamped accuracy to identify the Sequence of Operation of station devices during faults and disturbances.

Graphically view zone settings for ground phase distance elements for the selected zones and the power swing detection element.
The D60 front panel provides extensive local HMI capabilities. The local display is used for monitoring status messages, fault diagnosis, and device configuration.

User-configurable messages that combine fault diagnosis, and device configuration.

- Automatic Event Retrieval
- Multilin Drivers
- OP/OD/DE Server
- Automatic Waveform Retrieval
- Event/Status Bed and Event Data Retrieval
- EnerVisa Integrator
- Device Health Report
- Single-Click Data Retrieval
- Settings Security Audit Report

Viewpoint Maintenance provides tools that will create reports on the operating status of the relay, simplify the steps to download fault and event data, and reduce the work required for other security compliance audits. Tools available in Viewpoint Maintenance include:

- Graphical System Monitor
- Graphical Logic Monitor
- Graphical System Designer
- Graphical Logic Designer
- Annunciator Alarm Screens
- Trending Reports
- Automatic Waveform Retrieval
- Automatic Event Retrieval
- System Single Line Monitoring & Control

Viewpoint UR Engineer is a set of powerful tools that will allow the configuration and testing of GE relays at a system level and in an easy-to-use graphical environment. Viewpoint UR Engineer provides the following configuration and commissioning utilities:

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

Typical Wiring

Example of wiring diagram for the D60 Line Distance Protection System.