

Multilin F650

Feeder Protection & Bay Controller

The Multilin™ F650 has been designed for the protection, control and automation of feeders or related applications. The Multilin F650 provides high speed protection and control for feeder management and bay control applications, and comes with a large LCD and single line diagrams that can be built for bay monitoring and control for various feeder arrangements including ring-bus, double breaker or for breaker and half.

Designed with advanced communications options and detailed monitoring capabilities, the Multilin F650 provides advanced functionality, including high-performance protection, extensive control functions and flexible configuration capabilities. The Multilin F650 can also be used for a variety of applications other than feeder protection and control.

Key Benefits

- Comprehensive and flexible protection and control device for feeder applications
- Increased system uptime and improved system stability with load shedding and transfer schemes
- Advanced automation capabilities for customized protection and control solutions
- Human Machine Interface (HMI) with graphical LCD, programmable buttons, and easy keys for selecting setting menus, and submenus
- Reduced replacement time with modular draw-out construction
- Reduced troubleshooting time and maintenance costs with IEEE® 1588 (PTP), IRIG-B and SNTP time synchronization (configuration of two different SNTP masters), event reports, waveform capture, and data logger
- Simplified system integration with communications supporting serial and Ethernet interfaces as well as multiple protocols
- Embedded IEC® 61850 protocol (and support for edition 2), IEC 60870-5-103/104, IEC 62439/PRP/HSR, IEEE 802.1D/RSTP
- Proven interoperability and KEMA 61850 Edition 2 certified

Applications

- Primary or back-up protection and control for feeders on solidly grounded, high impedance grounded or resonant (Peterson Coil) grounded systems
- Bus blocking/interlocking schemes
- High-speed fault detection for arc flash
- Throw over schemes (bus transfer scheme applications)
- Load shedding schemes based on voltage and frequency elements
- Distributed Generation (DG) interconnect protection, including active and passive anti-islanding



Protection & Control

- Time, instantaneous & directional phase, neutral, ground and sensitive ground overcurrent
- 2nd Harmonic restraint
- CT Supervision
- Manual close with cold load pick up control, forward power and directional power units
- Load encroachment supervision
- Wattmetric ground fault detection
- Positive and negative sequence based over/under voltage elements
- Four-shot autorecloser with synchronism check
- Trip circuit supervision, breaker control and breaker failure
- Frequency protection (rate of change and six stages of under and over frequency)
- Broken conductor and locked rotor
- Programmable digital inputs and outputs
- 6 Setting Groups

Monitoring & Metering

- Fault locator, fault and event recorder
- Comprehensive breaker monitoring
- High resolution oscillography and data logger with programmable sampling rate
- Metering: V, I, Hz, W, VA, PF
- Demand: Ia, Ib, Ic, Ig, Isg, I2, MW, MVA

EnerVista Software

- Simplified setup, configuration and commissioning
- Strong document archive and management system
- Simplified full featured monitoring and data recording
- Seamless integration toolkit



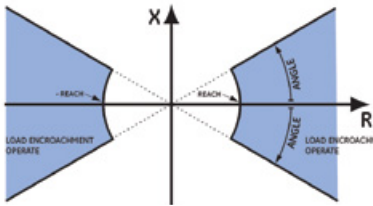
Protection and Control

The F650 provides high speed protection and control for feeder management and bay control applications, including:

Overcurrent Protection

Instantaneous and time overcurrent functions are available for phase, neutral, ground/sensitive ground and negative sequence currents. A variety of time curves are provided including IEEE/ANSI®, IEC A/B/C/long time inverse/short time inverse, GE IAC, I²t, definite time, rectifier curve and four user-programmable curves.

Directional Elements



Flexible load encroachment characteristic in F650 can be set by adjusting the load angle and the reach.

Directional supervision is available for phase, neutral, ground and sensitive ground currents. The neutral/ground directional elements can be programmed to work under zero-sequence voltage, ground sensitive current or dual polarization.

Over/Under Voltage Protection

The F650 includes the following voltage elements:

- Phase undervoltage/overvoltage elements (each element has three individual phase undervoltage/overvoltage components)
- Auxiliary undervoltage/overvoltage element
- Neutral overvoltage element

Following are some of the key applications where voltage elements can be used:

- Source transfer schemes
- Load shedding schemes
- Back up capacitor bank protection and control
- Backup motor protection to prevent automatic restart

Over/Under Frequency Protection

The F650 offer six stages of overfrequency and underfrequency elements to improve network (grid) stability using voltage or frequency based loadshedding techniques. It also allows to provide back up protection and trip breakers directly when protecting feeders and other frequency sensitive power equipment.

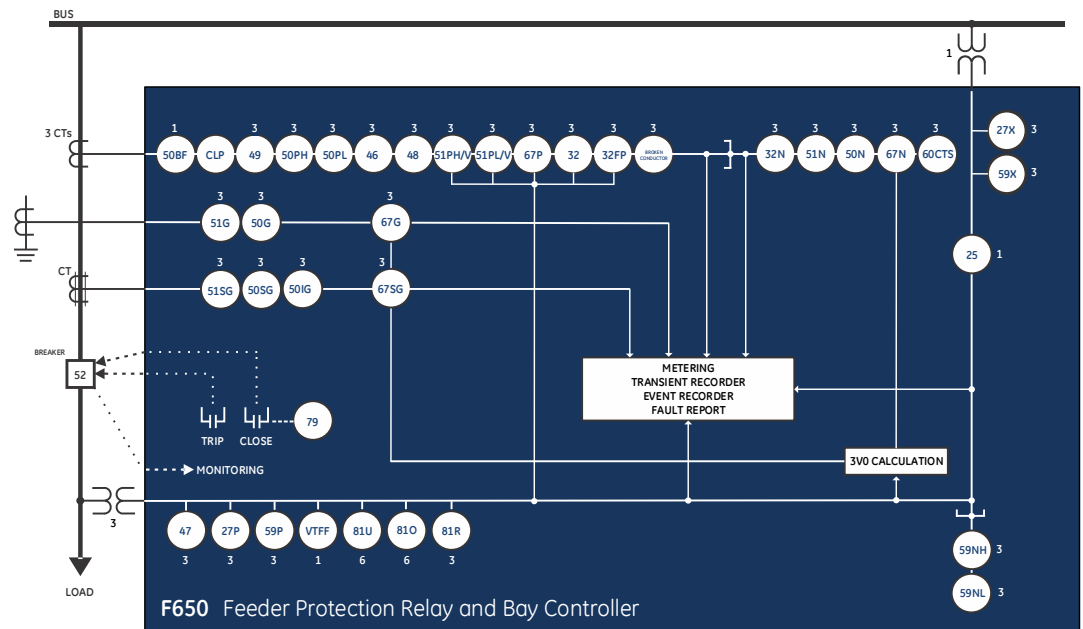
Frequency Rate of Change Protection

Frequency rate of change (df/dt) elements included in the F650 provide protection against system disturbances through load shedding.

Wattmetric Zero-sequence Directional

Applications include ground fault protection in solidly grounded transmission networks, grounded/ungrounded/resistor-grounded/resonant-grounded distribution networks. The wattmetric zero-sequence directional element responds to power derived from zero-sequence voltage and current in a direction specified by the element characteristic angle. The angle can be set within all four quadrants and the power can be active or reactive. Therefore, the

Functional Block Diagram



ANSI Device Numbers & Functions

DEVICE NUMBER	FUNCTION
25	Synchrocheck
27/27X	Bus/Line Undervoltage
32	Sensitive Directional Power
32FP	Forward Power
32N	Wattmetric zero-sequence directional
46	Negative Sequence Time Overcurrent
47	Negative Sequence Voltage
48	Blocked Rotor
49	Thermal Image - overload protection
50 BF	Breaker Failure
50PH/PL	Phase Instantaneous Overcurrent (High/Low)
50N	Neutral instantaneous Overcurrent

DEVICE NUMBER	FUNCTION
50G	Ground Instantaneous Overcurrent
50SG	Sensitive Ground Instantaneous Overcurrent
50IG	Isolated Ground Instantaneous Overcurrent
51N	Neutral Time Overcurrent
51G	Ground Time Overcurrent
51SG	Sensitive Ground Time Overcurrent
51PH/V	Voltage Restraint Phase Time Overcurrent
51PL/V	Voltage Restraint Phase Time Overcurrent
59/59X	Bus/Line Overvoltage
59NH/NL	Neutral Overvoltage - High/Low
67P	Phase Directional Overcurrent
60CTS	CT supervision

DEVICE NUMBER	FUNCTION
67N	Neutral Directional Overcurrent
67G	Ground Directional Overcurrent
67SG	Sensitive Ground Directional Overcurrent
79	Autorecloser
81 U/O	Under/Over Frequency Broken Conductor Detection
81R	Frequency Rate of Change
VTFF	VT Fuse Failure Detection
	Load Encroachment

element may be used to sense either forward or reverse ground faults in either inductive, capacitive or resistive networks. The inverse time characteristic allows time coordination of elements across the network.

Breaker Failure and Control

The breaker failure function determines if a trip command sent to a breaker has not been executed within a selectable time delay. In the event of a breaker failure, the unit will issue an additional signal to trip the breakers connected to the same busbar, potential sources of fault current.

The F650 incorporates 3 levels of current and time, together with a trip without current unit, and an internal arc detection unit. The breaker failure unit has three levels: "Retrip" or "Supervision" used to generate a second trip signal to the corresponding breaker on which the initial opening has been executed, "High Level", and "Low Level" used to executing complex protection schemes. The function can be initiated/blocked via digital inputs as well as communications.

The relay also provides for control of one or two breakers from faceplate pushbuttons, remote communications or contact inputs. A breaker pole discrepancy is included in the breaker control scheme. Breaker position is indicated by LEDs on the faceplate.

Load Encroachment

Feeders may experience very heavy load increases due to various contingency situations. The Load Encroachment function in F650 provides the capability to manage such load growth in feeders. The load encroachment element can be set for the feeder's expected maximum load, reducing the likelihood of false tripping for load conditions while maintaining dependability to trip for legitimate faults.

The load encroachment supervision in F650 is based on positive-sequence voltage and current and applies a characteristic as shown in the figure above. It allows the user to set the phase overcurrent elements below peak load current to see end-offline phase faults in heavily loaded feeder applications.

Autorecloser

This function is applicable to three-pole tripping schemes and single breaker applications. Four reclosing "shots" are possible prior to locking out, each with an independent time setting. Autoreclosure outputs can be used to modify circuit protection settings between shots.

Synchronism Check

One synchronism check element is available. The algorithm allows breaker close time compensation to optimize close conditions. The element monitors maximum difference in voltage magnitudes

(ΔV), phase angles ($\Delta \Phi$), and frequencies

(Δf) as well as the dead source condition.

Multiple Settings Groups

Six separate groups of protection settings may be stored in the F650 non-volatile memory. The user can edit the active settings internally and externally via contact inputs and communications.

Broken Conductor

F650 incorporates a broken or fallen conductor detection function. The relay uses the ratio between the negative sequence current, I_2 , and the positive sequence current I_1 . In normal and balanced load situations, this ratio is zero, while in severe load fault conditions, an unbalance is produced and this ratio increases.

In order to avoid trips or pickup with very weak loads, there is a current level threshold (I_2/I_1) to inhibit the operation of the element when the three phase currents are below a fixed level.

Locked Rotor

F650 incorporates a locked rotor element. Protection element 48 produces a trip when current (primary values) exceeds the set value. This current setting value is the product of the set Full Load Current by the pickup setting.

Advanced Automation

The F650 incorporates advanced automation features including powerful programmable logic, communication, and SCADA capabilities that far surpass what is found in the average feeder relay. The F650 integrates seamlessly with other Multilin relays for complete system protection.

F650 Logic Configuration

F650 Logic Configuration is the powerful programming logic engine that provides the ability of creating customized protection and control schemes thereby minimizing the need, and the associated costs, of auxiliary components and wiring. Using F650 Logic Configuration, the F650 can be programmed to provide required tripping logic along with custom scheme logic for auto transfer schemes (Main-Tie-Main), load shedding based on frequency, voltage and communication, loop restoration schemes, other remedial action schemes and dynamic setting group changes. F650 provides a comprehensive set of analog operands for two digital or analog inputs.

Inputs and Outputs

A choice of 16 to 64 inputs and 0 to 16 outputs are available. The F650 also provides a comprehensive set of analog operands for two digital or analog inputs. Digital inputs may be user defined with a separate debounce and chatter time. Programmable "quasi" analog input levels allow the use of different voltage levels in the same model via setting the requested thresholds. EnerVista™ software allows easy configuration of all the interlocking and switching sequences. A graphic HMI interface provides access to monitoring, metering and alarm panel screens.

Virtual Inputs/Outputs

Traditionally, protective relay logic has been relatively limited. Use virtual inputs and outputs in conjunction with the programmable logic capabilities of the F650 for unusual applications involving interlocks, blocking, or supervisory functions, to minimize the requirement for auxiliary components and wiring while making more complex schemes possible.

The virtual inputs and outputs are digital signals associated with the F650 internal logic. Virtual inputs include signals generated remotely via communications. The virtual outputs are outputs of programmable logic equations used to customize the device. Virtual outputs can also serve as inputs to programmable logic equations.

CAN BUS Remote I/O (CIO)

The F650 can be ordered with up to two additional communication cards on the rear. Besides two identical ports, COM1 and COM2, the cards may incorporate a port for CAN BUS communications used to connect the Remote CAN BUS I/O module (CIO Module). Use the CIO Module to double the number of I/Os of the F650, when the maximum number of I/Os available inside the relay (up to 64 inputs and 16 outputs) is not sufficient to meet the needs of specific applications.

In addition to increasing the number of I/Os, the CIO Module allows the F650 to monitor signals located at a remote location with only a connection between both devices, resulting in significant savings in installation costs.

Transducer Inputs

dcmA inputs are available to monitor system parameters such as temperature, vibration, pressure, wind speed, and flow.

Remote I/O

The remote I/O feature provides a means of sharing digital point state information between F650s or other IEC 61850 compliant IEDs or controllers. The remote outputs interface seamlessly to the remote inputs of other F650 devices via the IEC 61850 GSSE messaging. User secure peer-to-peer communications to develop complex schemes in distributed logic and I/Os.

Monitoring and Metering

The F650 provides advanced monitoring and metering that includes:

Current Transformer Failure

In event of abnormal behaviour of the CT or a loss of phase the F650 detects a change in zero sequence current to initiate a CT failure event and an output that can be used to block critical protection functions. This feature can be inhibited either by zero sequence voltage, ground /sensitive ground current.

2nd harmonic inhibit

The F650 provides 2nd harmonic detection that can be used to block sensitive elements, especially during transformer energization. The setting can be based on any phase, any two phases, all three phases or an average of the 3 phases.

VT Fuse Failure

Use the VT Fuse Failure feature to issue an alarm and/or to block voltage driven protection functions that can operate incorrectly due to an abrupt partial or total voltage loss. This loss is caused by the voltage transformers secondary circuit protection fuse failure. Different methods are used to detect the different types of VT fuse failure.

Trip Circuit Monitoring

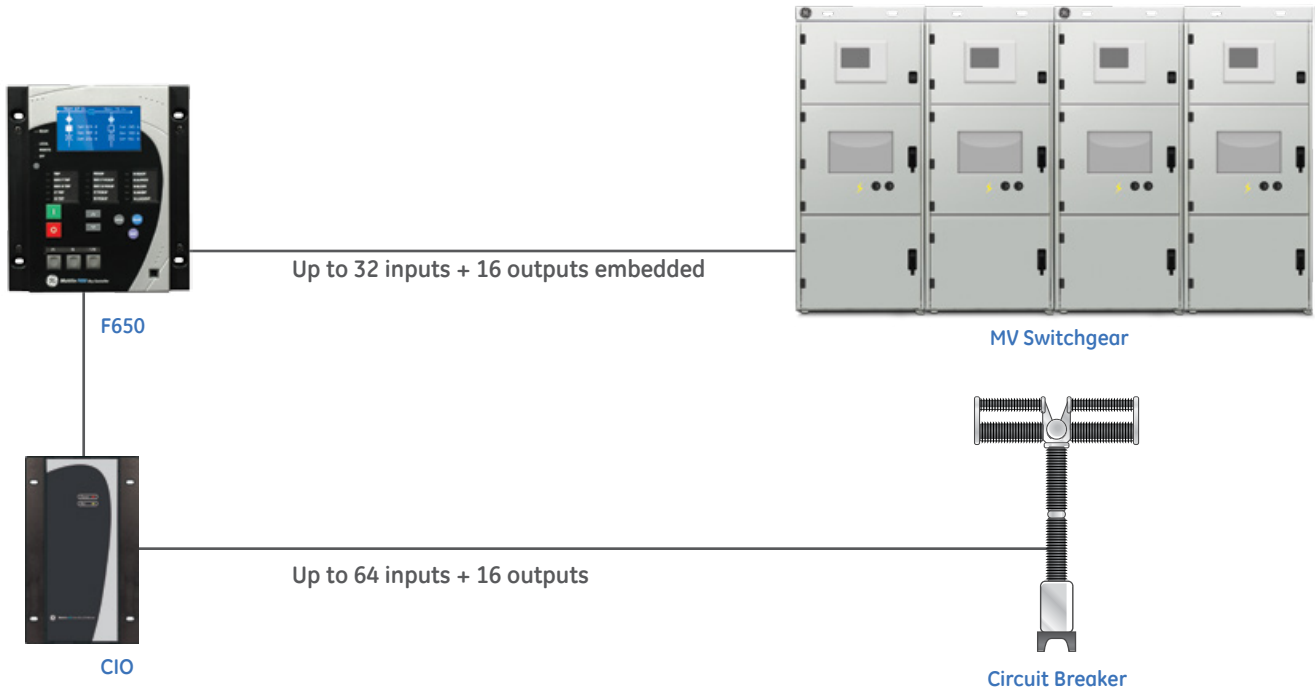
F650 can be used to monitor the integrity of both the breaker trip and closing coils and circuits. The supervision inputs monitor both the battery voltage level, while the outputs monitor the continuity of the trip and/or closing circuits, by applying a small current through the circuits.

Basic Metering

Metered values include:

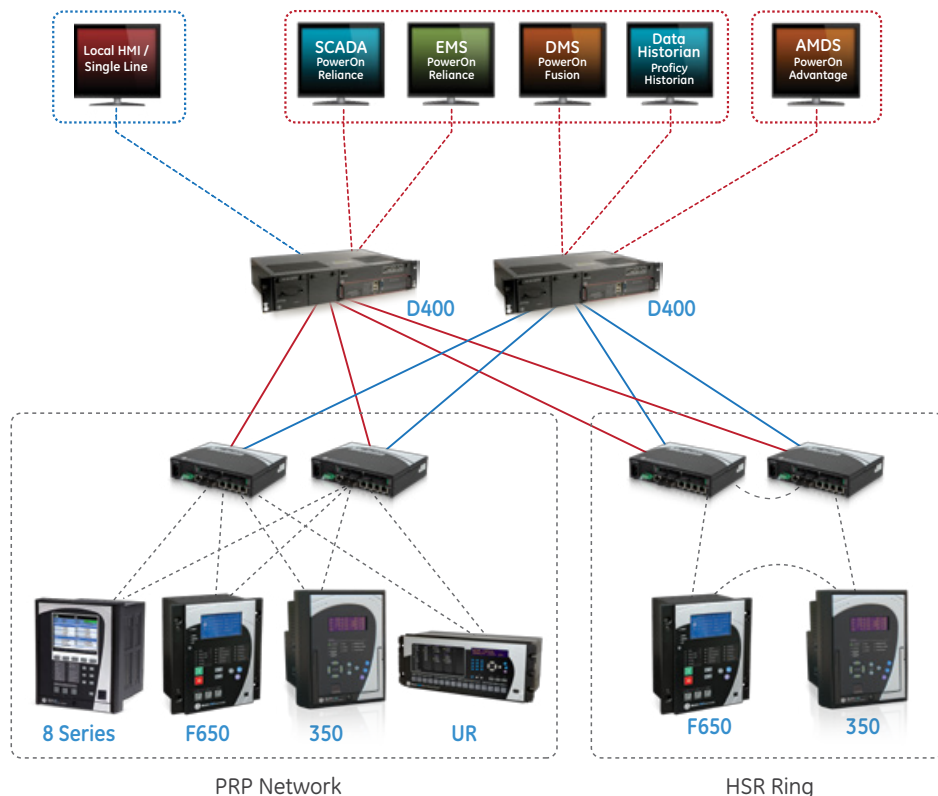
- Current: $I_a, I_b, I_c, I_n, I_g, I_{sg}$
- Phase-to-phase and phase-to-ground voltages for bus and line: $V_{an}, V_{bn}, V_{cn}, V_{bb}, V_{ab}, V_{bc}, V_{ca}$
- Active power (per-phase and total): W_a, W_b, W_c, W
- Reactive power (per-phase and total): VAR_a, VAR_b, VAR_c, VAR
- Total active and reactive energy: MWh, Mvarh
- Power factor (per-phase and total)
- Frequency
- Demand
- $I_a, I_b, I_c, I_g, I_{sg}, V_a, V_b, V_c$ and V_x signals are available locally and remotely and can be stored in the oscillography record or data logger.

Double the Number of I/O's of F650



CAN BUS to connect to a remote CAN BUS I/O module (CIO module)

Example of Redundant HSR and PRP Architecture



Redundancy protocols (PRP and HSR) can be used for various networking architectures including combined PRP/HSR topologies.

Event Recording and Oscillography

The F650 is capable of storing 1024 or 512 (depending on the selected model) time-tagged events (1 ms tagging), to help with troubleshooting. The trigger point, the channels, and sampling rate of the oscillography files are user programmable features. Up to five seconds at maximum sample rate can be stored.

Breaker Arcing Current (I^2t)

The relay estimates the total interrupted current as an accumulation of the RMS current measured during the time period taken to open the breaker after a trip. It calculates the per-phase wear on the breaker contacts to establish a threshold. When the breaker maintenance threshold is exceeded the relay can be set to trigger an alarm.

Fault Locator

Fault Locator function provides an estimation of the fault location. Deploying proven single-ended type algorithms, F650 is capable of providing accurate estimation of the location

of faults and is available as default. The F650 provides the estimated distance to the fault in terms of the resistance and reactance of the circuit considering the fault type.

Communications

The F650 incorporates industry-leading communication technologies making it one of the easiest and flexible feeder protection relay for use and integration into new and existing infrastructures.

The F650 provides optional Parallel Redundancy Protocol (PRP), High Availability Seamless Ring (HSR) (IEC 62439-3) and also Rapid Spanning Tree Protocol (RSTP) (IEEE 802.1D) to increase network availability and reliability for critical applications.

The basic concept of both protocols, PRP and HSR, is to send identical frames over different paths and discard one of the copies in reception, at best. If an error occurs or one of the paths goes down, the frame travelling through that path will not reach its destination, but its copy remains intact and will reach the desired destination. This technology ensures high reliability and availability

of communication networks by providing redundancy and zero reconfiguration time in the event of a failure. Failsafe communications systems are crucial for industries and utilities with critical applications where no recovery time is tolerated.

The F650 supports popular industry leading standard protocols enabling easy, direct integration into electrical SCADA and HMI systems. The protocols supported by the F650 include:

- IEC 61850 (and support for edition 2)
- DNP 3.0
- Modbus RTU
- Modbus TCP/IP
- IEC 60870-5-103/104
- IEC 60870-5-103 and IEC 60870-5-104
- PRP & HSR (IEC 62439-3)
- RSTP (IEEE 802.1D)
- IEEE 1588 (PTP) for time synchronization

The F650 includes up to three communication ports that operate simultaneously. Redundant ports are also available for special applications. F650 features an RS232 front port (COM2) and a choice of rear RS485, plastic/glass fiber optics (COM1 and COM2). Additionally, this module may incorporate a port for CAN bus communications, used for the connection to the remote CAN BUS I/O module. F650 COM3 features 10/100 BaseTX and 100 Base FX single or redundant Ethernet ports.

Security

Independent passwords for protection and control allow restricting access via keypad and display, or EnerVista software.

Multi-Language

The F650 supports multiple languages. French, Chinese, Russian language options are available on the local display, front panel, and EnerVista setup software, as well as the product instruction manual. Easily switch between English and an additional user selectable language on the local display. The basic display supports English, French, Spanish, Russian, Turkish and Chinese languages.

Interoperability With Embedded IEC 61850 Protocol

IEC 61850 is the international standard for information exchange and interoperability between intelligent devices within a substation. Use the F650 with IEC 61850 to lower the costs and simplify the engineering, commissioning, operating, and maintenance associated with substation protection and control applications.

The F650 provides integration with 61850 standard edition 2. IEC 61850 allows for the seamless connection of IEDs from multiple vendors. As a KEMA 61850 edition 2 certified device, the F650 is in compliance with the IEC 61850 standard, and seamless interoperability with devices supporting this standard can be assured. In addition to device interoperability, these protocols are designed to control the substation via a LAN instead of through discrete wiring to an RTU. Peer-to-peer communication over Ethernet enables distributed control with several IEDs and eliminates the need for an RTU to remote SCADA master. High-speed message transfer eliminates the need for large and costly hard-wired interconnection.

EnerVista Software

The EnerVista™ Suite is an industry-leading set of software programs that simplifies every aspect of using the F650 relay. The EnerVista suite provides all the tools to monitor the status of your the protected asset, maintain the relay, and integrate information measured by the F650 into DCS or SCADA monitoring systems. Convenient COMTRADE and Sequence of Events viewers are an integral part of the 650 Setup

software included with every F650 relay, to carry out postmortem event analysis to 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 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
- FAQ's
- Service Bulletins

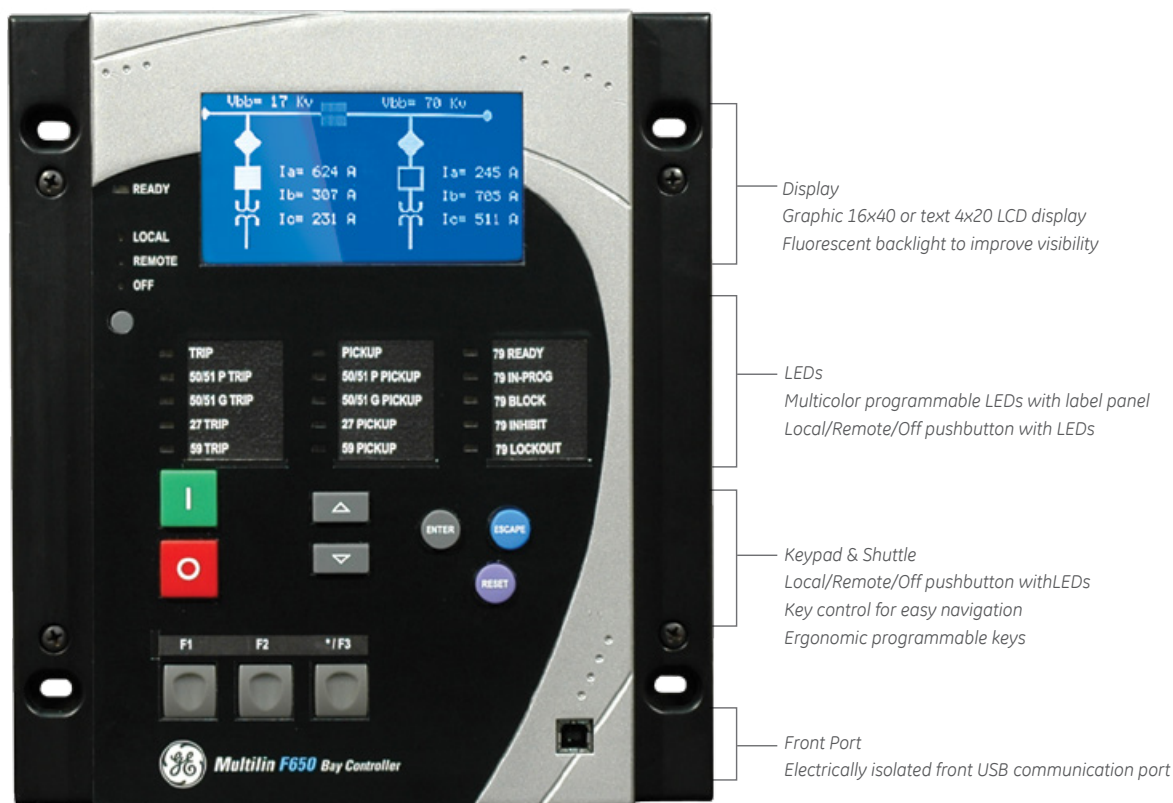
Viewpoint Monitoring

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:

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



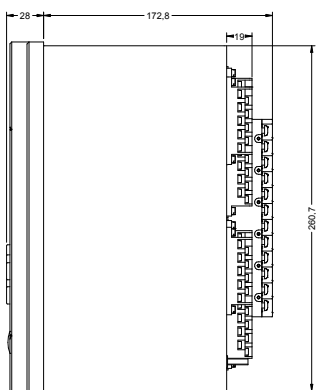
User Interface



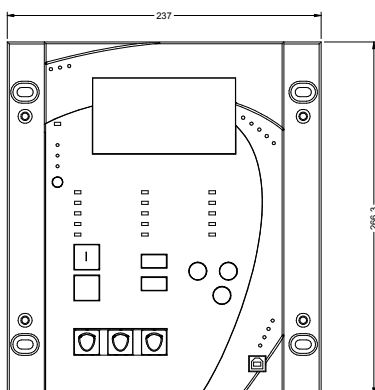
Dimensions

The F650 uses a “shuttle” control for ease of use. A choice of text or graphic display, and up to five configurable keys are available for frequently performed control functions. Up to 15 programmable LEDs are available. The F650 can incorporate (option “N” for the second position of the ordering code) a Graphical display with IEC Symbols.

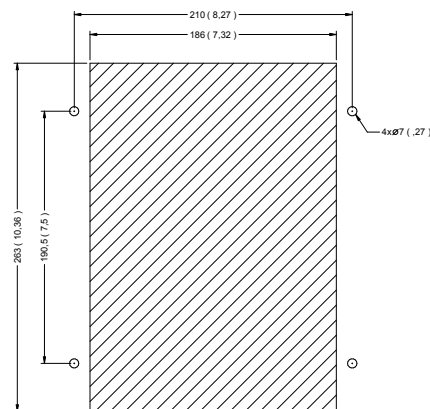
SIDE VIEW



FRONT VIEW



CUTOUT



NOTE: All dimensions are shown in mm (inches)

Dimensions

POWER SUPPLY
H10 H18 + -
H13 H14 H15

REDUNDANT POWER SUPPLY
H1 H9 + -
H4 H5 H6

VOLTAGE INPUTS
A5 V_A
A6 V_A
A7 V_b
A8 V_b
A9 V_c
A10 V_c

CURRENT INPUTS
B1 I_A
B2 I_A
B3 I_B
B4 I_B
B5 I_C
B6 I_C
B9 I_o
B10 I_o
B11 I_{se}
B12 I_{se}

BUS V
A11 V_x
A12 V_x

GE Logo

F650 Digital Bay Controller

POWER H10 H18 + -
READY H13 H14 H15

BACKUP POWER H1 H9 + -
BACKUP READY H4 H5 H6

CAN COM1
RS485 GND: A(-) B(+)
RS485 GND: A(-) B(+)
FIBER TX RX

CAN COM2
FIBER TX RX
FIBER TX RX
FIBER TX RX

CAN COM1
RS485 GND: A(-) B(+)
CABLE GND: CAN L CAN H

ETHERNET1
10/100 UTP RJ45
100FX ST TX
10/100 UTP RJ45

ETHERNET2
100FX ST TX
100FX ST RX

ETHENG
10/100 UTP RJ45

IRIG-B + H19 - H20

RS-232 FRONT

GROUNDING SCREW

OPEN DELTA VT CONNECTION

VOLTAGE INPUTS
A5 V_A
A7 V_b
A8 V_b
A9 V_c
A10 V_c

1 GROUND AT RELAY LOCATION (NOT CT & PT LOCATION)

OPTIONAL ELEMENTS

SLOT G		BOARD TYPE 1, 4, 5		BOARD TYPE 1		BOARD TYPE 4		BOARD TYPE 5	
G1 +	CC1	G19	CC17	G19	CC17	G19	SHIELD 14	G19	
G2 +	CC2	G20	CC18	G20	CC18	G20	A11	G20	
G3 +	CC3	G21	CC19	G21	CC19	G21	A12	G21	
G4 +	CC4	G22	CC20	G22	CC20	G22	A13	G22	
G5 +	CC5	G23	CC21	G23	CC21	G23	A14	G23	
G6 +	CC6	G24	CC22	G24	CC22	G24	A15	G24	
G7 +	CC7	G25	CC23	G25	CC23	G25	A16	G25	
G8 +	CC8	G26	CC24	G26	CC24	G26	A17	G26	
G9	COMMON 1/8	G27	COMMON 17/24	G27	COMMON 17/24	G27	A18	G27	
G10	COMMON 9/16	G28	COMMON 25/32	G28	COMMON 25/32	G28	SHIELD 56	G28	
G11 +	CC9	G29	CC25	G29	CC25	G29		G29	
G12 +	CC10	G30	CC26	G30	CC26	G30		G30	
G13 +	CC11	G31	CC27	G31	CC27	G31		G31	
G14 +	CC12	G32	CC28	G32	CC28	G32		G32	
G15 +	CC13	G33	CC29	G33	CC29	G33		G33	
G16 +	CC14	G34	CC30	G34	CC30	G34		G34	
G17 +	CC15	G35	CC31	G35	CC31	G35		G35	
G18 +	CC16	G36	CC32	G36	CC32	G36		G36	

SLOT F		BOARD TYPE 1, 4, 5		BOARD TYPE 2		BOARD TYPE 1		BOARD TYPE 2		BOARD TYPE 4		BOARD TYPE 5	
F1 +	CC1	F19	CC17	F19	CC17	F19	SHIELD 14	F19					
F2 +	CC2	F20	CC18	F20	CC18	F20	A11	F20					
F3 +	CC3	F21	CC19	F21	CC19	F21	A12	F21					
F4 +	CC4	F22	CC20	F22	CC20	F22	A13	F22					
F5 +	CC5	F23	CC21	F23	CC21	F23	A14	F23					
F6 +	CC6	F24	CC22	F24	CC22	F24	A15	F24					
F7 +	CC7	F25	CC23	F25	CC23	F25	A16	F25					
F8 +	CC8	F26	CC24	F26	CC24	F26	A17	F26					
F9 -	COMMON 1/8	F27	COMMON 17/24	F27	COMMON 17/24	F27	A18	F27					
F10 -	COMMON 9/16	F28	COMMON 25/32	F28	COMMON 25/32	F28	SHIELD 56	F28					
F11 +	CC9	F29	CC25	F29	CC25	F29		F29					
F12 +	CC10	F30	CC26	F30	CC26	F30		F30					
F13 +	CC11	F31	CC27	F31	CC27	F31		F31					
F14 +	CC12	F32	CC28	F32	CC28	F32		F32					
F15 +	CC13	F33	CC29	F33	CC29	F33		F33					
F16 -	CC14	F34	CC30	F34	CC30	F34		F34					
F17 +	CC15	F35	CC31	F35	CC31	F35		F35					
F18 +	CC16	F36	CC32	F36	CC32	F36		F36					

Technical Specifications

PROTECTION

PHASE/NEUTRAL AND GROUND TIMED OVERCURRENT (51PH/51PL/51N/51G)

Current: Fundamental Phasor (w/o harmonics) or RMS
Rated current: For connection to 1 or 5 A CTs.
Pickup level: 0.05 to 160.00 A in steps of 0.01 A
Reset dropout level: 97% to 98% of the pickup level
Accuracy: $\pm 0.5\%$ of the reading ± 10 mA from 0.05 to 10A
 $\pm 1.5\%$ of the reading for values higher than 10A

OPERATION CURVES

IEEE extremely/very/moderately inverse
 IEC Curve A/B/C/Long-Time
 Inverse/ Short-Time Inverse
 ANSI extremely/very/normally/moderately inverse¹
 IAC extremely / very / moderately inverse
 Definite time
 Rectifier curve
 User curve FlexCurve™ A/B/C/D

Reset time type: Instantaneous or time delayed according to IEEE

Snapshot events: Selectable by setting

Timer accuracy: From 1.03 times the pickup, $\pm 3\%$ of operation time or 50 ms. (whichever is greater)

Voltage restraint: Selectable by setting

NEGATIVE SEQUENCE (46)

Current: Fundamental phasor (without harmonics)
Pickup level: 0.05 to 160.00 A in steps of 0.01 A
Reset level: 98% of the pickup level
Accuracy: $\pm 0.5\%$ of the reading ± 10 mA from 0.05 to 10A
 $\pm 1.5\%$ of the reading for higher values

OPERATION CURVES:

IEEE extremely/very/moderately inverse
 IEC Curve A/B/C/Long-Time Inverse/Short-Time Inverse
 Ansi extremely/very/normally/moderately inverse
 I²t
 IAC extremely / very / moderately inverse
 Definite time
 Rectifier curve
 User curve FlexCurve™ A/B/C/D

Reset time type: Instantaneous or time delayed according to IEEE

Timing: Operate at > 1.03 times the pickup $\pm 3\%$ of operate time or 50 ms. (whichever is greater)

SENSITIVE GROUND TIMED OVERCURRENT (51SG)

Current: Fundamental Phasor (w/o harmonics) or RMS
Rated current: For connection to 1 or 5 A CTs
Pickup level: 0.005 to 16.00 A in steps of 0.001 A
Reset dropout level: 97% to 98% of the pickup level
Accuracy: $\pm 1.5\%$ of the reading ± 1 mA from 0.005 to 16 A

OPERATION CURVES:

IEEE extremely / very / moderately inverse
 IEC A/B/C/long-time inverse/short time inverse curve
 IAC extremely / very / normally / moderately inverse
 ANSI extremely / very / normally / moderately inverse I²t
 Definite time
 Rectifier curve
 FlexCurve™ A/B/C/D user curve

Reset time: Instantaneous or time delayed according to IEEE

Timing accuracy: Operate at > 1.03 times the pickup $\pm 3\%$ of operate time or 50 ms. (whichever is greater)

PHASE/NEUTRAL AND GROUND INSTANTANEOUS OVERCURRENT (50PH/50PL/50N/50G)

Current: Fundamental Phasor (w/o harmonics) or RMS
Rated current: For connection to 1 or 5 A CTs.
Pickup level: 0.05 to 160.0 A in steps of 0.01

Reset dropout level: 97% to 98% of the pickup level

Accuracy: $\pm 0.5\%$ of the reading ± 10 mA from 0.05 to 10A

$\pm 1.5\%$ of the reading for higher values

Overreach

Trip Delay: 0.00 to 900.00 s. in steps of 0.01 s.

Operate time: < 30 ms at 3 x Pickup at 50 Hz, typically

Reset time delay: 0.00 to 900.00 s. in steps of 0.01 s.

Timing accuracy: at 0ms time delay (no intentional delay): 50 ms

at non-zero time delay: $\pm 3\%$ of operate time or 50ms (whichever is greater)

SENSITIVE GROUND INSTANTANEOUS OVERCURRENT (50SG)

Current: Fundamental Phasor (w/o harmonics) or RMS
Rated current: For connection to 1 or 5 A CTs.

Pickup level: 0.005 to 16.0 A in steps of 0.001 A.

Reset dropout level: 97% to 98% of the pickup level

Accuracy: $\pm 1.5\%$ of the reading 1 mA from 0.005 to 16A

Overreach:

Trip Delay: 0.00 to 900.00 s. in steps of 0.01 s.

Operate Time: < 30 ms at 3 x Pickup at 50 Hz

Reset time: 0.00 to 900.00 s. in steps of 0.01 s.

Timing accuracy: at 0ms time delay (no intentional delay):

50 ms at non-zero time delay: $\pm 3\%$ of operate time or 50ms (whichever is greater)

PROTECTION

ISOLATED GROUND INSTANTANEOUS OVERCURRENT (50IG)

Current Input: Fundamental Phasor (without harmonics)

Voltage Input: Fundamental Phasor (without harmonics)

Current Pickup level: 0.005 to 0.400 A in steps of 0.001 A

Voltage Pickup level: 2 to 70 V in steps of 1 V

Dropout level: 97 to 98% of the pickup level

Pickup level: for voltage 2 to 70 V in steps of 1 V

Dropout Level: 97-98% of the pickup level

Level Accuracy: $\pm 1.5\%$ of the reading ± 1 mA from 0.005 to 16 A

Trip delay: 0.00 to 900.00 s. in steps of 0.01 s.

Time to instantaneous 0.00 to 900.00 s. in steps of 0.01 s.

Operate time: < 50 ms at 3 x Pickup at 50 Hz, typically

Timing accuracy: at 0 ms time delay (no intentional

delay): 50ms at non-zero time delay:

$\pm 3\%$ of operate time or 50 ms (whichever is greater)

Snapshot Events: Selectable by setting

PHASE DIRECTIONAL UNITS (67P)

Directionality: Forward and reverse selectable by setting

Polarizing: Quadrature Voltage:

ABC seq: Phase A (VBC), Phase B (VCA),

Phase C (VAB)

ACB seq: Phase A (VCB), Phase B (VAC),

Phase C (VBA)

Polarizing voltage threshold: 0 to 300 Vac in steps of 1 V

Current Sensitivity Threshold: 50 mA

Characteristic angle: -90° to $+90^\circ$ in steps of 1°

Block Logic: Permission or Block selectable by setting

Angle accuracy: $\pm 2^\circ$ for > 0.1 A and $V > 5$ Vac

Operate time: < 30 ms, typically

NEUTRAL AND GROUND DIRECTIONAL UNIT (67N/67G)

Directionality: Forward and reverse selectable by setting

Polarizing: Voltage, current, dual

Polarizing Voltage: VN (measured or calculated, selected by setting)

Polarizing Current: Ig (measured from 5th current transformer)

Operating Current: Ig (measured from 4th current transformer)

Polarizing Voltage threshold: 0 to 300 Vac in steps of 1 V

Polarizing Current threshold: 0.005 A

Characteristic angle: -90° to $+90^\circ$ in steps of 1°

Block Logic: Permission or Block selectable by setting

Angle accuracy: $\pm 2^\circ$ for > 0.1 A and $V > 5$ Vac

Operate time: < 30 ms, typically

SENSITIVE GROUND DIRECTIONAL UNIT (67SG)

Polarization By: Voltage

Polarization Voltage: 0 to 300 Vac in steps of 1V

Directionality: Forward and reverse selectable by setting

Characteristic angle: -90° to $+90^\circ$ in steps of 1°

Angle accuracy: $\pm 3^\circ$ from 0.1 A and 5 Vac

Response time: < 30 ms typically

THERMAL MODEL (49)

Current: Fundamental phasor (without harmonics)

Rated current: Valid for connection to 1 or 5 A CTs

Pickup level: 0.05 to 160.00 A in steps of 0.01 A

Dropout level: 97% to 98% of the pickup

$\pm 0.5\%$ of the reading ± 10 mA from 0.05 to 10A

$\pm 1.5\%$ of the reading for higher values

Timer accuracy: $\pm 3.5\%$ of the operating time or 50 ms. (whichever is greater)

Heating constant: Between 3 and 600 minutes

Cooling constant: 1 to 6 times the heating constant

BREAKER FAILURE (50BF)

Current: Fundamental phasor (without harmonics)

Rated current: Valid for connection to 1 or 5 A CTs

Pickup level for supervision: 0.05 to 160.00 A in steps of 0.01 A

Pickup level high level: 0.05 to 160.00 A in steps of 0.01 A

Pickup level low level: 0.05 to 160.00 A in steps of 0.01 A

Pickup level internal arcing: 0.05 to 160.00 A in steps of 0.01 A

Reset dropout level: 97% to 98% of pickup level

$\pm 0.5\%$ of the reading ± 10 mA from 0.05 to 10A

$\pm 1.5\%$ of the reading for higher values

Timer accuracy: $\pm 3.5\%$ of the operating time or 50 ms (whichever is greater)

PHASE OVERVOLTAGE (59P)

Voltage: Fundamental phasor (without harmonics of phase-to phase voltages

3 to 300 in steps of 1 V

Pickup level: 97% to 98% of the pickup level

Accuracy: $\pm 1\%$ of the reading, from 10 to 208 V

Operate time: 0.00 to 900.00 s. in steps of 0.01s

Reset time: 0.00 to 900.00 s. in steps of 0.01s

Timer accuracy: $\pm 3.5\%$ of operation time or 50 ms (whichever is greater)

PHASE UNDERVOLTAGE (27P)

Voltage: Fundamental phasor of phase-to-ground or phase-to phase voltages (selectable by setting)

Pickup level: 3 to 300 in steps of 1 V

Reset dropout level: 102% to 103% of the pickup level

Accuracy: $\pm 1\%$ of the reading, from 10V to 208 V

Operation curves:

Fixed time or inverse curve

Reset type: Instantaneous

Minimum voltage threshold:

3 to 300 in steps of 1V

Logic: Any/two/all phases logic selectable by setting

Supervised by breaker:

Selectable by setting

Timing accuracy: $\pm 3.5\%$ of operation time or 50 ms. (whichever is greater)

PROTECTION

AUXILIARY OVERVOLTAGE (59X)

Pickup level: 3 to 300 in steps of 1 V

Reset dropout level: 97% to 98% of the pickup level

Accuracy: $\pm 1\%$ of the reading, from 10 to 208 V

Timing accuracy: $\pm 3.5\%$ of operation time or 50 ms (whichever is greater)

AUXILIARY UNDERVOLTAGE (27X)

Pickup level: 3 to 300 in steps of 1 V

Reset dropout level: 97% to 98% of the pickup level

Accuracy: $\pm 1\%$ of the reading, from 10 to 208 V

Operation curves: Fixed time or inverse curve

Timing accuracy: $\pm 3.5\%$ of operation time or 50 ms (whichever is greater)

FREQUENCY (81U, 81O)

Pickup level: 20 to 65 Hz in steps of 0.01 Hz

Reset dropout level: 30 MHz higher/lower than the pickup level

Accuracy: 0.05 Hz

Operation time trip delay: 0.00 to 900.00 s. in steps of 0.01 s

Reset time delay: 0.00 to 900.00 s. in steps of 0.01 s

Timer accuracy: $\pm 3.5\%$ of operation time or 100 ms. (whichever is greater)

NEUTRAL OVERVOLTAGE (59NH/59NL)

Voltage: Fundamental phasor of the neutral voltage

Pickup level: 3 to 300 in steps of 1 V

Reset level: 97% of the pickup level

Accuracy: $\pm 1\%$ of the reading, from 10 to 208 V

Trip delay: 0.00 to 900.00 s. in steps of 0.01 s

Reset time: 0.00 to 900.00 s. in steps of 0.01 s

Timing accuracy: $\pm 3.5\%$ of operation time or 50 ms. (whichever is greater)

NEGATIVE SEQUENCE OVERVOLTAGE (47)

Pickup level: 3 to 300 in steps of 1 V

Reset dropout level: 97% to 98% of the pickup level

Accuracy: $\pm 1\%$ of the reading, from 10 to 208 V

Trip delay: 0.00 to 900.00 s. in steps of 0.01 s

Reset delay: 0.00 to 900.00 s. in steps of 0.01 s

Timing accuracy: $\pm 3.5\%$ of operation time or 50 ms. (whichever is greater)

FORWARD POWER (32FP)

Current, Voltage: Fundamental phasor (primary values)

Pickup level (two steps)

0-10000 MW (primary values) in steps of 0.01 MW

Reset dropout level: 97% to 98% of the pickup level

Accuracy for primary magnitudes

$\pm 3\%$ in the complete range.

Reset type: Instantaneous

Trip delay (two steps):

0.00 to 900.00 s in steps of 0.01 s

Timing accuracy: $\pm 3.5\%$ of operation time or 50 ms. (whichever is greater)

SENSITIVE DIRECTIONAL POWER (32)

Current, Voltage: Fundamental phasor (primary values)

Pickup level (two steps):

-10000.00 to 10000.00 MW (primary values) in steps of 0.01

Characteristic angle (two steps):

0.00 to 359.99 in steps of 0.01°

Accuracy for primary magnitudes:

$\pm 3\%$ of complete range

Trip delay (two steps):

0.00 to 900.00s in steps of 0.01s

Timing accuracy: $\pm 3.5\%$ of operation time or 50ms (whichever is greater)

CT SUPERVISION FAILURE (60CTS)

Inputs:

Neutral Current IN

Neutral Voltage VN (from three-phase VTs)

Ground Current Ig

Sensitive Ground Current Isg

Time Delay: 0.00 to 600.00 s in steps of 0.01 s

310 Level Accuracy: $\pm 0.5\%$ of the reading ± 10 mA from 0.05 to 10 A (for ground)

$\pm 1.5\%$ of the reading ± 1 mA from 0.005 to 5 A (for sensitive ground)

3V0 Level Accuracy: $\pm 1\%$ of reading from

Technical Specifications

SECOND HARMONIC INHIBIT

Operating Parameter: Current 2nd harmonic per phase or average
Pickup Level: 0.1 to 40.0% in steps of 0.1%
Dropout Level: 98% of pickup
Level accuracy: 2% or 10mA
Minimum Current: 0.05 to 15.00 A in steps of 0.01
Time Delay: 0.00 to 600.00 s in steps of 0.01
Time Delay Accuracy: ±3% of expected time or 1.5 cycle, whichever is greater
Time accuracy: 3% or 1.5 cycles
Snapshot Events: Selectable by settings

BROKEN CONDUCTOR (I2/I1)

Pickup level: 20.0-100.0% (I2/I1 ratio) in steps of 0.1%
Reset dropout level: 97% to 98% of the pickup level
Trip delay: 0.00 to 900.00 s in steps of 0.01 s
Timing accuracy: ±3.5% of operation time or 30 ms. (whichever is greater)
Minimum phase current threshold: I2/I1 current inhibition level: 0.000-1.000 in steps of 0.001

FREQUENCY RATE OF CHANGE

df/dt trend: increasing, decreasing, bi-directional
df/dt pickup level: 0.10 to 10.00 Hz/s in steps of 0.01
df/dt level accuracy: 80 mHz/s or 3.5%, whichever is greater
Overvoltage supervision: 0.00 to 110.00 % in steps of 0.0
95% settling time for df/dt: < 24 cycles
Operate time:
 at 2 x pickup : 12 cycles
 at 3 x pickup : 8 cycles
 at 5 x pickup : 6 cycles
Frequency Rate min.: 20.00 to 80.00 Hz in steps of 0.01
Frequency Rate max.: 20.00 to 80.00 Hz in steps of 0.01
Frequency Rate delay: 0.00 to 60.00 s in steps of 0.01
Snapshot Events: Selectable by setting

PROTECTION

LOAD ENCROACHMENT

Responds to: Positive-sequence quantities
Minimum voltage: 0.00 to 300.00 V in steps of 0.01
Reach (sec. Ω): 0.02 to 250.00 Ω in steps of 0.01

Impedance accuracy: ±3%
Angle: 5 to 50° in steps of 1
Angle accuracy: ±3°
Pickup delay: 0 to 65.535 s in steps of 0.001
Reset delay: 0 to 65.535 s in steps of 0.001
Time accuracy: ±3.5% or ±60 ms, whichever is greater
Operate time: < 60 ms at 50 Hz
Snapshot Events: Selectable by setting

CONTROL

AUTORECLOSE (79)

Schemes: Three-phase pole tripping schemes
No. of reclosing shots: Up to 4 reclose attempts before lockout
Dead time: Independent dead time setting before each shot adjustable between 0 and 900 s in steps of 0.01 s
Reclaim time: 0.00 to 900.00 s in steps of 0.01 s
Condition permission: Selectable by setting
Hold time: 0.00 to 900.00 s in steps of 0.01 s
Reset time: 0.00 to 900.00 s in steps of 0.01 s
Snapshot Events: Selectable by setting
 Possibility to modify protection settings after each shot

SYNCHRONISM CHECK (25)

Dead/live levels for line and bus: 0.00 to 300.00 in steps of 0.01 V
Maximum voltage difference: 2.00 to 300.00 V in steps of 0.01 V
Maximum angle difference: 2.0° to 80.0° in steps of 0.1°
Maximum frequency slip: 10 to 5000 mHz in steps of 10 mHz
Synchronism time: 0.01 to 600.00 s in steps of 0.01 s
Angle accuracy: 3°
Dead Source function: None
 (DL-DB) Dead Line - Dead Bus
 (LL-DB) Live Line-Dead Bus
 (DL-LB) Dead Line - Live Bus
Snapshot Events: Selectable by setting

FUSE FAILURE

Activation by Algorithm based on positive sequence of voltage and current
 Activation by V2/V1 ratio

BREAKER FAILURE (50BF)

Current: Fundamental phasor (without harmonics)
Rated current: Valid for connection to 1 or 5 A CTs
Pickup level for supervision: 0.05 to 160.00 A in steps of 0.01 A
Pickup level for high level: 0.05 to 160.00 A in steps of 0.01 A
Pickup level for low level: 0.05 to 160.00 A in steps of 0.01 A
Pickup level for internal arcing: 0.05 to 160.00 A in steps of 0.01 A
Reset level: 97% to 98% of pickup level
Accuracy: ±0.5% of the reading ± 10 mA from 0.05 to 10 A
 ±1.5% of the reading for higher values
Reset type: Instantaneous
Timing accuracy: ±3.5% of the operating time or 30 ms. (whichever is greater)

BREAKER MAINTENANCE

KI²t BKR Ph A, B, C Cnt: 0.00 to 9999.99 in steps of 0.01 (KA)²s
BKR Openings Cnt: 0 to 9999 in steps of 1
BKR Closings Cnt: 0 to 9999 in steps of 1
BREAKER SETTINGS
Switchgear number: 1 to 16
Maximum KI²t: 0.00 to 9999.99 in steps of 0.01 (KA)²s
KI²t integ. Time: 0.03 to 0.25 s in steps of 0.01s
Maximum openings: 0 to 9999 in steps of 1
Maximum Openings in an hour: 1 to 60 in steps of 1

SWITCHGEAR

Switchgear number: 1 to 16
Switchgear: 1 to 16 (configurable)
MAXIMUM NUMBER OF STARTS: (depending on ordering code)
Metering algorithm: Fundamental
Tripping Time Accuracy: ±250 ms or 5% whichever is greater
Full load Amps: 0.5 to 10.0 A in steps of 0.1
Breaker Supervision: Selectable by setting
Min. Stop time: 0.0 to 900.0 s in steps of 0.1
Number of starts: 0 to 10 in steps of 1
Time to restart: 0 to 100 minutes in steps of 1
Reset Counter: Selectable by setting
Snapshot Events: Selectable by Setting
Operate time: <45 ms at 50Hz, typically
DIGITAL COUNTERS: (depending on ordering code)
Number of Counters: 8
Counting: Preset, Compare
Programmability: reset, up/down, set to pre-set, freeze/reset, freeze/count

MONITORING

TRIP/CLOSE COIL MONITORS
 Detect open trip and close circuits

OSCILLOGRAPHY

Records: Up to 20 oscillography records.
Samples: Programmable to 4, 8, 16, 32 or 64 samples per cycle
Trigger position: 5% to 95% of total length
Trigger: Programmable via programmable logic
Data: 5 current channels and 4 voltage channels
Storage: Up to 16 digital channels selectable from the available internal states programmable through PLC
 Permanent in non volatile memory (flash) without battery
 Permanent in non-volatile memory (flash) without battery
Format: International Standard COMTRADE ASCII - IEEE C37.111-1999.

FAULT LOCATOR

Method: Single-ended
Positive sequence module: 0.01 to 250.00 Ohm in steps of 0.01 Ohms
Positive sequence angle: 25 to 90° in steps of 1°
Zero sequence module: 0.01 to 750.00 Ohms in steps of 0.01 Ohm
Zero sequence angle: 25 to 90° in steps of 1°
Line length: 0.0 to 2000.0 in steps of 0.1 (miles or km)
Display fault on HMI: Possibility to show the fault report on the display
Accuracy: 5% (typical)

SNAPSHOT EVENTS

Capacity: 512 scrolling events for models with rear ethernet communication board 2 options; G.H.J.K L.M.N
 479 scrolling events for models with rear ethernet communication board 2 options; B,C,D,E
Labeling time tag: 1 ms using an internal clock of 100 µs
Accuracy: 1 ms (using the IRIG-B synchronization input)
Trigger: By pickup or dropout or operate of any element
 By change of state in a Digital input/output change of state
 By virtual inputs and control events
Storage: Permanent in non volatile memory (flash) without battery

CONTROL EVENTS

Capacity: 128 events programmable through PLC
Labeling time tag: 1 ms using an internal clock of 100 µs
Accuracy: 1 ms (using the IRIG-B synchronization input)
Trigger: By any digital signal programmable through PLC
Alarm: Possibility to display the event as an alarm on the alarms panel. Information available always through Communications for all models and also in HMI for models with graphical display (M) in ordering code.
Storage: Permanent in non volatile memory (flash) without battery

DEMAND

Channels: 9
Parameters: I_l(kA RMS), I_b(kA RMS), I_c(kA RMS), I_g(kA RMS), I_{sg}(kA RMS), I₂ (KA), P(MW), Q (MVar) and S (MVA)
Current and Power Method: Thermal Exponential, block interval, Rolling demand
Metering Measurements: Each channel shows the present and maximum measured value, with date and time for the maximum recorded value.
Samples: 5, 10, 15, 20, 30, 60 minutes.
Accuracy: ±1%
DATA LOGGER
Channels: 1 to 16
Parameters: Any of the analog Metering actual values
Samples: 1 second, 1, 5, 10, 15, 20, 30, 60 minutes.
Capacity: Fixed, (32768 measures)

METERING

CURRENT
Accuracy: ±0.5% of the reading ± 10 mA from 0.1 to 10 A (for phases and ground)
 ±1.5% of the reading ± 1 mA from 0.005 to 5 A (for sensitive ground)
 ±1.5% of the reading for higher values
VOLTAGE
Accuracy: ±1% reading, from 10 to 208 V
POWER
Active: ±2.5% of the reading from power factor ±0.8 to 1
Reactive: ±2.5% of the reading from power factor ±0.2 to 0
Apparent: ±2.5% of the reading
ENERGY
Watts- hour (positive and negative)
Accuracy: 2.5%
Range: ±0 to 2147 MWh
Parameters: three-phase
Updating Time: 100 ms
Var-hour (positive and negative)
Accuracy: 2.5%
Range: ±0 to 2147 MVarh
Updating Time: 100 ms
POWER FACTOR
Accuracy: 0.02
FREQUENCY
Accuracy: ±50 mHz
Accuracy angle: 2°

INPUTS

CURRENT INPUTS
Rated current: Appropriate for 1 or 5 A
Load/Relay Burden: < 0.04 Ohm
Overload: 20 A permanent
 500 A during 1 second
Current Withstand:
 Continuous at 20 A
 1 second at 500 A for phases and ground
 1 second at 50 A for sensitive ground

Technical Specifications

VOLTAGE INPUTS

VAC inputs do not need varistors, as the impulse test is applied to 100% of the transformers
Metering range: From 2 to 275 Vac
Load/Relay Burden: 0.05 VA at 120 Vac (50 or 60 Hz)
Voltage withstand: 260 Vac permanent
 Continuous at 275 V to neutral
 420 Vac during 1 min/hr at 420 to neutral

DIGITAL INPUTS

Voltage Threshold: Programmable from 20 up to 230Vdc in steps of 1 V
 > 100 kOhm
Impedance:
Load for voltage supervision inputs: 2 mA + V/100 kOhm
Maximum error: ±10% setting or ± 5 V
Acknowledgement time: < 1 ms
Debounce time: 1 to 50 ms in steps of 1 ms

REMOTE INPUTS

No of input points: 32, configured from 64 incoming bit pairs
No of remote devices: 16
Default states on loss of comms: On, Off, Latest/on, Latest/off

ANALOG INPUTS (dcmA)

Current inputs: 0 to -1; 0 to +1; -1 to +1; 0 to 5; 0 to 10; 0 to 20, 4 to 20
Conversion range: -1 to 20 dcmA
Accuracy: +/-0.2% of full scale
Type: Passive

IRIG-B TIME SYNCHRONIZATION INPUT

Type: Demodulated input (no carrier)
Formats: B000(*) B001, B002 and B003(*)
Level: TTL
Load: 1.5 mA
 (*) Signal combinations recognized in accordance with IRIG Standard 200-95

REAL TIME CLOCK

Accuracy: Typical 20 ppm
Backup energy: More than 1 week

POWER SUPPLY

Options:
F range LO, LOR: DC: 24 to 48 V
H range HI, HIR: DC: 110 to 250 V
 AC: 120 to 230 V
Power: 25 VA nominal, maximum 45 VA
Voltage loss hold-up time:
 High Range (HI): 200 ms typical, worst case 100 ms without unit reset
 Low Range (LO): 24 Vdc 30ms, 48Vdc 100ms

OUTPUTS

TRIPPING CONTACTS/OUTPUT RELAYS
Permanent current Carry continuous 16 A
Closing current Make and Carry for 1 second 60 A during 1 second
Opening current 0.3 A with L/R = 40 ms at 125 Vdc
 0.25 A with L/R = 40 ms at 250 Vdc

REMOTE OUTPUTS

Standard output points 32
User output points 32

COMMUNICATIONS

FRONT PORT (COM2):

Type: RS232
Baude Rate: 300, 600, 1200, 2400, 4800, 9600, 38400, 57600 and 115200 bauds
Default baud rate: 19200 bauds
Protocol: ModBus® RTU / DNP 3.0

ASYNCHRONOUS REAR PORTS:

Two COM1, COM2 (rear COM2 multiplexed with front port)
Type: Depending on model
 Two RS485 ports
 Two 1mm-plastic F.O. ports
 Two multimode glass F.O. ports with ST connectors.

PROTOCOLS:

IEC 60870-5-103 on COM1
 DNP on COM1 & COM2
 Serial Modbus on COM1 & COM2

CAN PORT:

Type: Cable or Multimode glass F.O. port with ST connectors
Fiber Wave length: 1300 nm
Isolation: 2kV

ETHERNET PORT:

Type: 10/100BaseTX self-negotiable
Model B: 10/100BaseTX + 100Base FX with ST connectors
Model C: 10/100BaseTX + Double 100BaseFX with ST connectors (physical media redundancy)
Model D: Redundant 10/100BaseTX
Model E: 1588, 10/100 Base TX* + 100 Base TX
Model G: 1588, 10/100 Base TX* + 100 Base FX
Model H: PRP, 1588, 10/100 Base TX* + Redundant 100 Base FX
Model J: PRP, HSR, RSTP, 1588, 10/100 Base TX* + Redundant 100 Base FX
Model K: PRP, HSR, RSTP, 1588, 10/100 Base TX + Redundant 100 Base TX
Model L: PRP, HSR, RSTP, 1588, 10/100 Base TX + Redundant 100 Base TX
Model M: ModBus TCP/IP
 DNP over TCP/IP and UDP/IP
 IEC 60870-5-104
 IEC 61850
 IEEE1588 (PTP)
 IEC 62439-3 Clause 4 (PRP)
 IEC 62439-3 Clause 5 (HSR)
 IEEE 802.1D (RSTP)
 Http, ftp, tftp (allow the use of a standard Internet browser)

PROTOCOLS:

NOTES:
 In Models C and D, the 10/100BaseTX port is selected by an internal switch. Two indicating LEDs for transmission and reception are included.
 Models B, C, D and E supports IEC 61850 Edition 1.
 Models G, H, J, K, L and M supports IEC 61850 Edition 2.

TYPE TESTS			
CATEGORY	TEST	REFERENCE STANDARD	TEST LEVEL
SAFETY	Dielectric voltage withstand	IEC60255-27	2 KV / 2.3 KV
	Impulse voltage withstand	IEC60255-27	5 KV
	Insulation resistance	IEC60255-27	500 V (test level)
EMC	Electrostatic Discharge Immunity	IEC60255-26/ IEC6100-4-2	Level 4
	Radiated RF Electromagnetic Field Immunity	IEC60255-26/ IEC6100-4-3	Level 3
	Electrical Fast Transient Immunity	IEC60255-26/ IEC6100-4-4	Zone A
	Surge Immunity	IEC60255-26/ IEC6100-4-5	Zone A
	Conducted RF Immunity	IEC60255-26/ IEC6100-4-6	Level 3
	Power magnetic Immunity	IEC60255-26/ IEC6100-4-8	Level 5
	Power Frequency Immunity	IEC60255-26/ IEC6100-4-16	Zone A
	Damped Oscillatory Wave Immunity	IEC60255-26/ IEC6100-4-18	2.5 KV Common Mode 1 KV Diff. Mode
	Voltage Dips & Interruptions	IEC60255-26/ IEC61000-4-11/ IEC61000-4-29	Levels based on IEC61000-4-11 & IEC61000-4-29
	Ripple on DC	IEC60255-26/ IEC61000-4-17	15% Rated DC value
MECHANICAL	Radiated & Conducted Emissions	IEC60255-26/ CISPR11/ CISPR22	Class A
	Sinusoidal Vibration	IEC60255-21-1	Class 1
	Shock & Bump	IEC60255-21-2	Class 1
	Seismic	IEC60255-21-3	Class 2
CLIMATIC	Enclosure Protection	IEC60255-26/ IEC6100-4-2	IP52
	Cold test (storage)	IEC60068-2-1	-40°C 16 hrs
	Cold test (operational)	IEC60068-2-1	-20°C 16 hrs
	Dry heat test (storage)	IEC60068-2-2	85°C 16 hrs
	Dry heat test (operational)	IEC60068-2-2	60°C 16 hrs
	Change of Temperature	IEC60068-2-14	5 cycles (3+3) -20°C/60°C
	Damp Heat Humidity Cyclic	IEC60068-2-30	6 cycles (12+12) 55°C @ 93% R.H.
	Damp Heat steady state	IEC60068-2-78	40°C @ 93% R.H.

MECHANICAL CHARACTERISTICS

Metallic package in 1/2 19" rack 6 units high
 Protection class IP52 (according to IEC 529)

CONTROL

Graphical display: English, Spanish, French and Chinese
Basic display: English, Spanish, French, Chinese and Cyrillic

PACKAGING

Approximate weight:
Net: 11 lbs (5 kg)
Ship: 13.2 lbs (6 kg)

ENVIRONMENTAL

Temperature:
Storage: -40 to +80°C
Operation: -10 to +60 degrees C (-20 degrees C for models with copper communication ports)
Humidity: Up to 95% without condensing

APPROVALS

CE: Conforms to EN/IEC 60255, 61010
UL: UL508 Certified under E234610
KEMA: 61850 edition 2 Certified
EAC: Machines and Equipment TR CU 010/2011
Lloyd's Register: Marine certification (Only available for models with Environmental protection option "M")

*Specifications subject to change without notice.

Ordering

	F650	*	*	*	F	*	G	*	*	*	*	*	*	*	Description
DISPLAY	B														Basic Display (see note 2)
	M														Graphic Display with Standard Symbols (see note 2)
	N														Graphic Display with IEC Symbols (see note 2)
REAR SERIAL COMMUNICATIONS BOARD 1	F														None
	A														Redundant RS485
	P														Redundant plastic fiber optic
	G														Redundant glass fiber optic
	X														Redundant RS485 + fiber remote CAN bus I/O
	Y														Redundant plastic fiber optic + fiber remote CAN bus I/O
	Z														Redundant glass fiber optic + fiber remote CAN bus I/O
	C														Cable remote CAN bus I/O
	M														RS485 + cable remote CAN bus I/O
REAR ETHERNET COMMUNICATIONS BOARD 2	B														10/100 Base TX
	C														10/100 Base TX + 100 Base FX
	D														10/100 Base TX + Redundant 100 Base FX
	E														Redundant 10/100 Base TX
	G														1588, 10/100 Base TX* + 100 Base TX
	H														1588, 10/100 Base TX* + 100 Base FX
	J														PRP, 1588, 10/100 Base TX* + Redundant 100 Base FX (See note 3)
	K														PRP, HSR, RSTP, 1588, 10/100 Base TX* + Redundant 100 Base FX (See note 3)
	L														PRP, 1588, 10/100 Base TX* + Redundant 100 Base TX (See note 3)
	M														PRP, HSR, RSTP, 1588, 10/100 Base TX* + Redundant 100 Base TX (See note 3)
I/O BOARD IN SLOT F					1										16 Digital Inputs + 8 Outputs
					2										8 Digital Inputs + 8 Outputs + 2 Trip / Close circuit supervision circuits
					4										32 Digital Inputs
					5										16 Digital Inputs + 8 Analog Inputs
I/O BOARD IN SLOT G						0									None
						1									16 Inputs + 8 Outputs
						2									8 Digital Inputs + 8 Outputs + 2 Trip / Close circuit supervision circuits
						4									32 Digital Inputs (See Note 1)
						5									16 Digital Inputs + 8 Analog Inputs (See Note 1)
AUXILIARY VOLTAGE							LO								24-48 Vdc (range 19.2 – 57.6)
							HI								110-250 Vdc (range 88 – 300), 120-230 Vac (range 96 – 250)
							LOR								Redundant L
							HIR								Redundant H
LANGUAGE									C						Chinese/English (See Note 2, 4)
									E						English/English
									F						French/English
									P						Russian/English (See Note 2)
									S						Spanish/English
									T						Turkish/English
PROTOCOL										None					Modbus® RTU, TCP/IP, DNP 3.0 Level 2, IEC 60870-5-104
										3					IEC 60870-5-103, Modbus RTU, TCP/IP
										6					IEC 61850 Edition 2, Modbus RTU & TCP/IP, DNP 3.0 Level 2, IEC 60870-5-104
ENVIRONMENTAL PROTECTION														H	Without Harsh (Chemical) Environment Conformal Coating
														M	Harsh (Chemical) Environment Conformal Coating
															Marine Range (Lloyd's certification) (See Note 5)
ENHANCED DISPLAY														E	Enhanced Display with Front USB port

(*) Notes:

Communication port marked with "*" is intended only for maintenance purposes in models with Rear Ethernet Communication Board options G,H,J,K,L or M,

1. The number selected for option G must be equal or higher than the number selected for option F for models including boards 4 and 5.

2. Display options with language selection:

Graphic display (M & N): available for English, French, Spanish and Chinese languages. For chinese only IEC symbols option is available (N in ordering code).

Basic display (B): available for English, French, Spanish, Russian, Turkish and Chinese languages

3. Advanced features require new CPU:

- G & H: IEEE 1588 Precision Time Protocol (PTP), 61850 Edition 2.0.

- J & L: Parallel Redundancy Port (PRP) IEEE 1588 Precision Time Protocol (PTP), 61850 Edition 2.0.

- K & M: High-Availability Seamless Redundancy (HSR), Rapid Spanning Tree Protocol (RSTP), Parallel Redundancy Port (PRP), IEEE 1588 Precision Time Protocol (PTP), 61850 Edition 2.0.

4. Chinese language is not available in models with Rear Ethernet communication board options G, H, J, K, L or M.

5. Marine Range option of Environmental Protection section is only available with REAR ETHERNET COMMUNICATIONS BOARD 2 options G,H,J,K,L or M

Related Products / Accessories

MultiSync 100 - GPS Clock
CIO Remote CAN Bus I/O Module

MultiSync100-P
CIO-H-X-J-X-XXX

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Toll Free: +1 877-605-6777
Direct: +1 678-844-6777

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