F650

FEEDER PROTECTION AND BAY CONTROLLER SYSTEM

Cost effective solution for protection, automation and control of distribution feeders

KEY BENEFITS

- Flexible protection and control device for distribution feeder applications
- Advanced automation capabilities for providing customized protection and control solutions
- Human machine interface (HMI) - graphical LCD, programmable buttons, and easy keys for selecting setting menus, and submenus.
- Minimize replacement time - Modular with card draw-out construction
- Reduce troubleshooting time and maintenance costs - IRIG-B and SNTP time synchronization, event reports, waveform capture, data logger
- Advanced automation capabilities for providing customized protection and control solutions
- Voltage and frequency based load shedding and transfer schemes to increase system uptime and improve system stability
- Reduced relay to relay wiring and associated installation costs through high-speed inter-relay communications
- Simplified system integration with communications supporting serial and Ethernet interfaces and multiple protocols
- Reduced relay to relay wiring and associated installation costs through high-speed inter-relay communications
- Embedded IEC61850 Protocol (optional), IEC 60870-5-103 (optional)

APPLICATIONS

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

FEATURES

Protection and Control

- Time, instantaneous & directional phase, neutral, ground and sensitive ground overcurrent
- Manual close with cold load pickup control via PLC, 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
- Breaker control and breaker failure
- Abnormal frequency protection (Rate of change, under and over frequency)
- Broken conductor and locked rotor
- Synchrocheck - V, , & Hz
- Up to 64 Programmable digital inputs and up to 16 digital outputs
- Trip Circuit Supervision

Monitoring & Metering

- Fault locator, record of last 10 faults -metering - current, voltage, power, energy, frequency and harmonics
- Breaker operation & trip failure
- Total breaker arcing current
- Event recorder - 479 Events
- 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
- Configurable graphical HMI interface
- Alarm Panel

EnerVista™ Software

- Sophisticated software for configuration and commissioning
- Document and software archiving
- EnerVista™ Integrator providing easy integration of data in the F650 into new or existing monitoring and control systems

Digital Energy
Multilin

Protection and Control

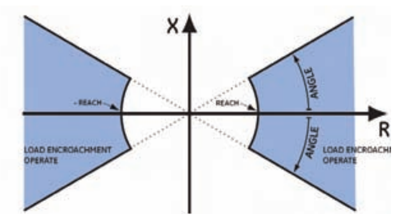
The F650 provides high speed protection and control for feeder management and bay control applications, including:

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, I^2t, definite time, rectifier curve and four user-programmable curves.

Directional Elements

Directional supervision are 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.



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

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/overvoltageelement
- 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 offers 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 to provide protection against system disturbances through load shedding.

Wattmetric Zero-sequence Directional

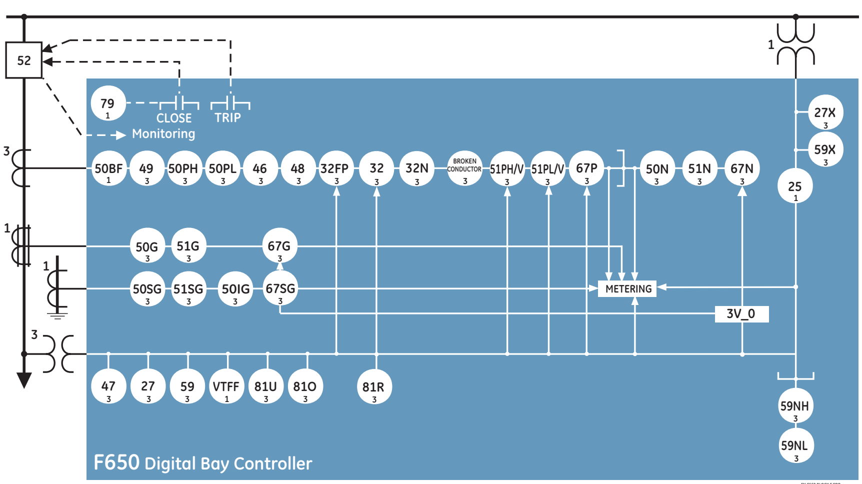
Applications include ground fault protection in solidly grounded transmission networks, grounded/ungrounded/resistor-grounded/resonant-grounded distribution networks. The wattmetric zero-sequence directional element responds to power derived from zero-sequence voltage and current in a direction specified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

Use the breaker failure function to determine when 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",

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
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	
59/59X	Bus/Line Overvoltage
59NH/NL	Neutral Overvoltage - High/Low
67P	Phase Directional Overcurrent
67N	Neutral Directional Overcurrent
67G	Ground Directional Overcurrent
67SG	Sensitive Ground Directional Overcurrent
79	Autorecloser
81 U/O	Under/Over Frequency Broken Conductor Detection
N/A	Load Encroachment
81R	Frequency Rate of Change
VTFF	VT Fuse Failure Detection

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

Autoreclosurer

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 ($\Delta\varphi$), and frequencies
(Δf) as well as the dead source condition.

Multiple Settings Groups

Three 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, I2, and the positive sequence current I1. 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 (I2/I1) 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 GE 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), loadshedding based on frequency, voltage and communication, loop restoration schemes, other remedial action schemes and dynamic setting group changes.

Inputs and Outputs

A choice of 16 to 64 inputs and 0 to 16 outputs are available. 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 IEC61850 compliant IEDs or controllers. The remote outputs interface seamlessly to the remote inputs of other F650 devices via the IEC61850 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:

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, reactive and apparent energy: MWh, MVArh, MVah
- 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.

Event Recording and Oscillography

The F650 is capable of storing 479 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.

Communications

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.

Protocols supported by the F650 include IEC61850, DNP 3.0, Modbus RTU, ModBus TCP/IP and IEC 60870-5-104. These protocols make it easy to connect to a Utility automation system and are integrated into the F650, eliminating the need for external protocol converter devices.

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.

Interoperability With Embedded IEC61850 Protocol

IEC61850 is the new international standard for information exchange and interoperability between intelligent devices within a substation. Use the F650 with IEC61850 to lower the costs and simplify the engineering, commissioning, operating, and maintenance associated with substation protection and control applications. IEC61850 is built on over 7 years of GE leadership in UCA 2.0 implementation.

IEC61850 allows for the seamless connection of IEDs from multiple vendors. 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 F65 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 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
- 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

Display
- Graphic 16x40 or text 4x20 LCD display
- Fluorescent backlight to improve visibility

LEDs
- Multicolor programmable LEDs with label panel
- Local/Remote/Off pushbutton with LEDs

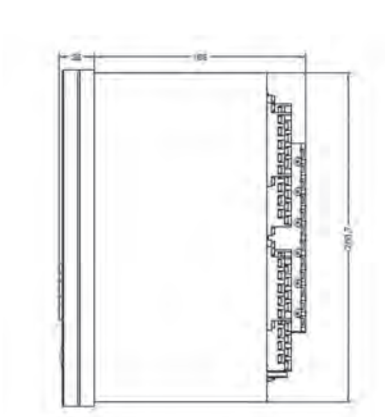
Keypad & Shuttle
- Local/Remote/Off pushbutton withLEDs
- Key control for easy navigation
- Ergonomic programmable keys

Front Port
- Electrically isolated front USB communication port

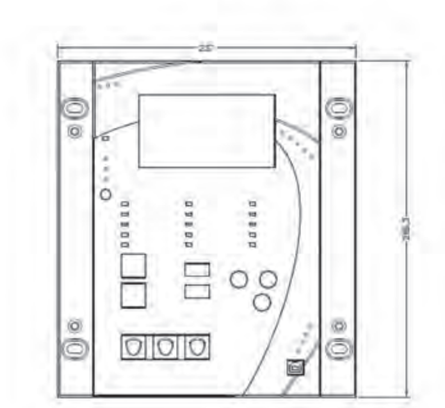
The F650 uses a "shuttle" control for ease of use. A choice of text or graphic display, and up to five configurable keys are available for frequently performed control functions. Up to 15 programmable LEDs are available. The F650 can incorporate (option "N" for the second position of the ordering code)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

Dimensions

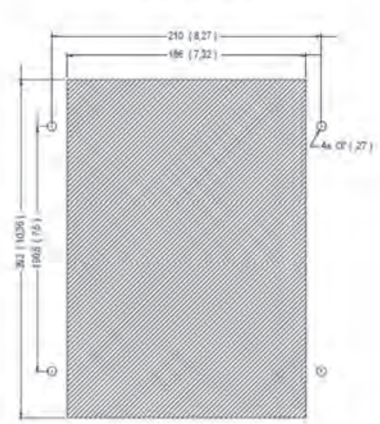
SIDE VIEW



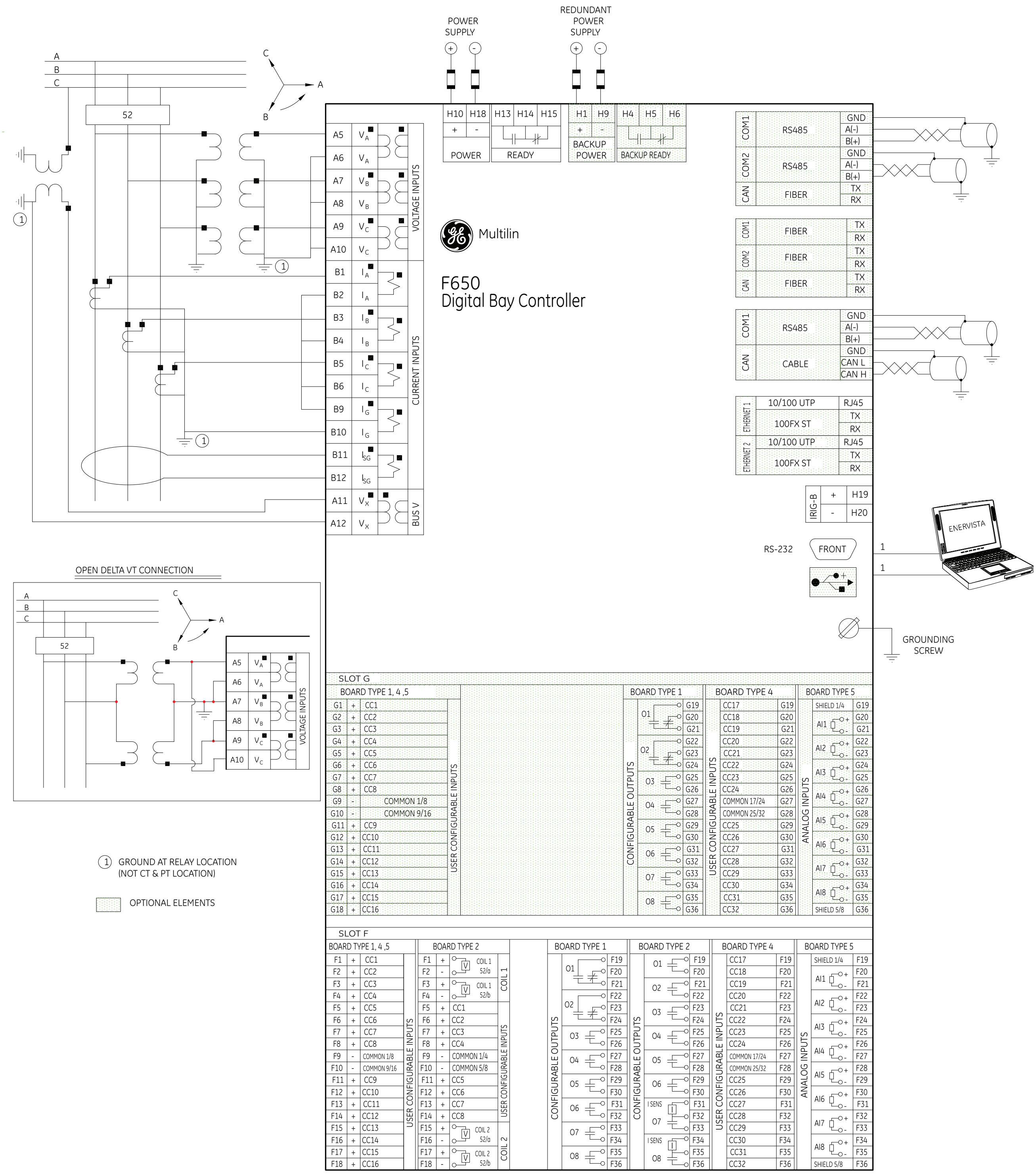
FRONT VIEW



CUTOUT



Typical Wiring Diagram



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: ±0.5% of the reading ±10 mA from 0.05 to10A
±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 inverseI^2t
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, ±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: ±0.5% of the reading ±10 mA from 0.05 to 10A
±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
I^2t
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 ±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: ±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 I^2t
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 ±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 dropuout level: 97% to 98% of the pickup level
Accuracy: ±0.5% of the reading ±10mA from 0.05 to 10A
±1.5% of the reading for higher values
Overreach < 2%
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: ± 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: ±1.5% of the reading 1 mA from 0.005 to 16 A
Overreach: < 2%
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: ± 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: ±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:** ±3% of operate time or 50 ms (which ever 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° in steps of 1°
Block Logic: Permission or Block selectable by setting
Angle accuracy: ±2° for I>0.1 A and V>5 Vac
Operate time: <30ms, 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: Isg (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° in steps of 1°
Block Logic: Permission or Block selectable by setting
Angle accuracy: ±2° for I>0.1 A and V>5 Vac
Operate time: <30ms, 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° in steps of 1°
Angle accuracy: ±3° from 0.1 A and 5 Vac
Response time: <30ms 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
Accuracy: ±0.5% of the reading ±10 mA from 0.05 to 10 A
±1.5% of the reading for higher values
Timer accuracy: ±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
Accuracy: ±0.5% of the reading ±10 mA from 0.05 to 10A
±1.5% of the reading for higher values
Timer accuracy : ±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
Pickup level: 3 to 300 in steps of 1 V
Reset dropout level: 97% to 98% of the pickup level
Accuracy: ±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: ±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: ±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: ±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: ±1% of the reading, from 10 to 208 V
Timing accuracy: ±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: ±1% of the reading, from 10 to 208 V
Operation curves:
Fixed time or inverse curve
Timing accuracy: ±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: ±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: ±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: ±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: ±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: ±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
±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: ±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:
±3% of complete range
Trip delay (two steps):
0.00 to 900.00s in steps of 0.01s
Timing accuracy: ±3.5% of operation time or 50ms (whichever is greater)

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

Distribution Feeder Protection

Technical Specifications *(cont'd)*

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 onpositive 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

KI^2t 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 to16
Maximum KI^2t: 0.00 to 9999.99 in steps of 0.01 $(KA)^2s$
KI^2t integ. Time: 0.03 : 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 to16
Switchgear: 1 to16 (configurable).

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
Up to 16 digital channels selectable from the available internal states programmable through PLC
Storage: Permanent in non volatile memory (flash) without battery 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: 479 scrolling events
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: Ia(kA RMS), Ib(kA RMS), Ic(kA RMS), Ig(kA RMS), Isg(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
LoadRelay 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

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
LoadRelay 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
Impedance: > 100 kOhm
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

Technical Specifications *(cont'd)*

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:
200 ms typical, worst case 100 ms without unit reset

OUTPUTS

TRIPPING CONTACTS/OUTPUT RELAYS

Permanent current Carry continous 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:
Model B: 10/100BaseTX self-negotiable
Model C: 10/100BaseTX + 100Base FX with ST connectors
Model D: 10/100BaseTX + Double 100BaseFX with ST connectors (physical media redundancy)
Model E: Redundant 10/100BaseTX
Protocols: ModBus® TCP/IP
DNP over TCP/IP and UDP/IP
IEC 60870-5-104
IEC61850
Http, ftp, tftp (allow the use of a standard Internet browser)

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

TYPE TESTS

CATEGORY	STANDARD	CLASS	TEST
EMC	IEC 61000-4-1 IEC 60255-22-1	III	Oscillatory waves immunity
	IEC 61000-4-2 IEC 60255-22-2	IV	Electrostatic discharge immunity test
	IEC 61000-4-3 IEC 60255-22-3	III	Radiated electromagnetic field disturbance test
	IEC 61000-4-4 IEC 60255-22-4	IV	Electrical fast transient
	IEC 61000-4-5 IEC 60255-22-5	IVA	Surge immunity test
	IEC 61000-4-6 IEC 60255-22-6	III	Conducted electromagnetic field disturbance test
	IEC 61000-4-8 EN 61000-4-8	IV	Power frequency magnetic field immunity
	ENV50204	III	Radiated electromagnetic field disturbance test - 1890 MHz.

TYPE TESTS

CATEGORY	STANDARD	CLASS	TEST
EMC Emisivity	IEC 60255-25 EN 61000-6-4	A	Conducted and radiated emissions
Product	IEC 60255-5	2 kV	Insulation resistance - dielectric test
	IEC 60255-5	6kV .5J	Impulse test
	IEC 60255-11	100ms	Power supply Voltagedips/interruptions/variations:
Mechanical	IEC 60255-21-1	I	Vibration test (sinusoidal)
	IEC 60255-21-2	I	Shock and bump
	IEC 60255-21-2	II	Seismic

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 Cyrilic

PACKAGING

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

ENVIRONMENTAL

Temperature:
Storage: -40 to +80° C
Operation: -20 to +60° C
Humidity: Up to 95% without condensing

APPROVALS

CE: Conforms to EN/IEC 60255, 61010
UL: UL508 Certicfied under E234610

*Specifications subject to change without notice.

Distribution Feeder Protection

Ordering

F650	* * * F * G * * * * * *	DESCRIPTION
DISPLAY	B	Basic alfanumeric Text Display
	M	Graphic Display (without IEC symbols)
	N	Graphic Display with IEC symbols
REAR SERIAL COMMUNICATIONS BOARD 1	F	None
	A	Redundant RS485
	P	Redundant plasticfiber 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
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 Digital Inputs + 8 Outputs
	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 LO
	HIR	Redundant HI
LANGUAGE	-	English/English
	C	Chinese/English (See Note 2)
	F	French/English
	P	Russian/English (See Note 2)
	S	Spanish/English
COMMUNICATION PROTOCOL	-	Modbus ® RTU, TCP/IP, DNP 3.0 Level 2, IEC 60870-5-104
	3	IEC 60870-5-103, Modbus ® RTU, TCP/IP
	6	IEC61850, Modbus ® RTU and TCP/IP, DNP 3.0 Level 2, IEC 60870-5-104
ENVIRONMENTAL PROTECTION	-	Without Harsh (Chemical) Environment Conformal Coating
	H	Harsh (Chemical) Environment Conformal Coating
ENHANCED DISPLAY	-	Display with RS232
	E	Enhanced Display with Front USB port

SPECIAL MODELS:
MOD001: 6A output contacts instead of 16A..

(*) Notes:

(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 and Chinese languages

Accessories for the F650

Feeder Protection with the F650	TRCD-F650-C-S-1
Multilink Ethernet Switch	ML2400-F-HI-HI-A2-A2-A6-G1
Viewpoint Maintenance	VPM-1
Viewpoint Monitoring IEC61850	VP-1-61850

Visit www.GEMultilin.com/F650 to:

- View Guideform specifications
- Download the instruction manual
- Review applications notes and support documents
- Buy a F650 online
- View the 650 Family brochure

Ordering Note: This order code is valid for the latest version of F650 hardware and firmware version. The older hardware and previous firmware versions are still available and may be ordered through the usual channels.