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: la, Ib, lc, 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.

Functional Block Diagram

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 offers 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

ANSI Device Numbers & Functions

<table>
<thead>
<tr>
<th>DEVICE NUMBER</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Synchroncheck</td>
</tr>
<tr>
<td>27/7/A</td>
<td>Structure Undervoltage</td>
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<tr>
<td>27</td>
<td>Sensitive Directional Power</td>
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<td>25/29</td>
<td>Forward Power</td>
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<td>73/7/49</td>
<td>Breaker Failure</td>
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<td>73/7/29/25</td>
<td>Phase Instantaneous Overcurrent (High/Low)</td>
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<td>73/7/100</td>
<td>Neutral Instantaneous Overcurrent</td>
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</table>

<table>
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<tr>
<th>DEVICE NUMBER</th>
<th>FUNCTION</th>
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<tbody>
<tr>
<td>50G</td>
<td>Ground Instantaneous Overcurrent</td>
</tr>
<tr>
<td>50GK</td>
<td>Isolated Ground Instantaneous Overcurrent</td>
</tr>
<tr>
<td>50S</td>
<td>Sensitive Ground Instantaneous Overcurrent</td>
</tr>
<tr>
<td>51</td>
<td>Neutral Time Overcurrent</td>
</tr>
<tr>
<td>51G</td>
<td>Ground Time Overcurrent</td>
</tr>
<tr>
<td>51SG</td>
<td>Sensitive Ground Time Overcurrent</td>
</tr>
<tr>
<td>51PH/V</td>
<td>Voltage Restraint Phase Time Overcurrent</td>
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<tr>
<td>67/67N/NL</td>
<td>Neutral Overvoltage</td>
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<tr>
<td>67/67G</td>
<td>Ground Overvoltage</td>
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<tr>
<td>67/67SG</td>
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<td>Bus/Line Overvoltage</td>
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<td>59NH/NL</td>
<td>Neutral Overvoltage</td>
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<td>CT Supervision</td>
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<td>67/67N</td>
<td>Neutral Directional Overcurrent</td>
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<tr>
<td>67/67G</td>
<td>Ground Directional Overcurrent</td>
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<td>67/67N</td>
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<td>Under/Over Frequency Broken Conductor Detection</td>
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<td>97F</td>
<td>VT Fused Failure Detection</td>
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<tr>
<td>97F</td>
<td>VT Fused Failure Detection</td>
</tr>
<tr>
<td>97F</td>
<td>Load Identification</td>
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</table>
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, 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 \(|\Delta V|\), phase angles \(|\Delta \phi|\), and frequencies \(|\Delta f|\) 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, 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 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. EnertVista™ 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: Ia, Ib, Ic, Ig, Isg
- Phase-to-phase and phase-to-ground voltages for bus and line: Vab, Vbc, Vca, Vbb, Vba, Vac
- Active power (per-phase and total): Wa, Wb, Wc
- Reactive power (per-phase and total): Var, Varb, Varc, Var
- Total active and reactive energy: MWh, Mvarh
- Power factor (per-phase and total)
- Frequency
- Demand
- Ia, Ib, Ic, Ig, Isg, Va, Vb, Vc, and Vx 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)
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. Fail-safe 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 F65 relay. The EnerVista suite provides all the tools to monitor the status of your protected asset, maintain the relay, and integrate information measured by the 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

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 to a Graphical display with IEC Symbols.

Dimensions

NOTE: All dimensions are shown in mm (inches)
PHASE/NEUTRAL AND GROUND TIMED OVERCURRENT (351PH/351SN/351SG)

<table>
<thead>
<tr>
<th>Current</th>
<th>Rated current</th>
<th>Reset dropout level</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>150A</td>
<td>0.05 to 160.0 A in steps of 0.01 A</td>
<td>97% to 98% of the pickup level</td>
<td>±1.5% of the reading ≤30 mA from 0.005 to 10 A, ±15% of the reading for higher values</td>
</tr>
</tbody>
</table>

RECOVERY VOLTAGE: 0.00 to 900.00 s. in steps of 0.01 s. Trip delay: 0.00 to 900.00 s. in steps of 0.01 s. Accuracy: ±3.5% of operation time or 50 ms. (whichever is greater)
**Technical Specifications**

### F650 Feeder Protection & Bay Controller

#### Activation by V2/V1 ratio

- **Snapshots Events**: Selectable by setting

#### Snapshot Events

- **Angle accuracy**: 10 to 5000 mHz in steps of 10 mHz
- **Maximum voltage difference**: 300 V
- **Hold time**: 0.00 to 900.00 s in steps of 0.01 s
- **Condition permission**: Reclaim time: 0.00 to 900.00 s in steps of 0.01 s each shot adjustable between 0 and 900 s before lockout
- **Schemes**: Three-phase pole tripping schemes
- **Autoreclose**: (79)

#### FREQUENCY RATE OF CHANGE

- **df/dt trend**: Increasing, decreasing, bi-directional
- **df/dt level accuracy**: 80 mHz or 3.5%, whichever is greater
- **Overvoltage supervision**: 0.00 to 110.00 % in steps of 0.1%
- **95% settling time for df/dt**: < 24 cycles
- **Operate time**: 0 to 40000 s in steps of 1 s
- **Angle**: ±50 mHz
- **Frequency**: 50 Hz
- **Accuracy**: ±1.5% of the reading ± 1 mA from 0.1 to 10 A (for phases and ground)
- **Current**: 100 ms
- **Accuracy**: ±2.5% of the reading from power factor ±0.2 to 0
- **LoadRelay Burden**: 500 A during 1 second
- **Maximum angle difference**: 25º to 80º in steps of 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**: ±2º
- **Dead Source Function**: None

#### BREAKER FAILURE (50BF)

- **Current**: Fundamental phase (without harmonic)
- **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
- **Accuracy**: ±0.5% of the reading a 10 mA from 0.05 to 10 A

#### BREAKER MAINTENANCE

- **K/BKR Ph A, B, Cнт**:
  - 0.00 to 9999.99 in steps of 0.01 (KA's)
  - 0.00 to 9999 in steps of 1
  - 0 to 9999 in steps of 1

#### SWITCHGEAR

- **Switchgear number**: 1 to 16
  - 100 ms
  - 98% of pickup
  - ±1% of the reading for higher values

#### CURRENT AND POWER METHOD

- **Thermal Exponential, block interval, Rolling demand**
- **Sampling**: 30, 60, 90, 120, 180, 240, 300, 600, 1200 seconds
- **Accuracy**: ±2.5%

#### DATA LOGGER

- **Channels**: 1 to 16
- **Parameters**: Any of the analog Metering actual values
- **Capacity**: Fixed, 32768 measures

#### MONITORING

**TRIP/CLOSE COIL MONITORS**

- **Detect open trip and close circuits**

**OSCILLOGRAPHY**

- **Records**: Up to 20 oscillograph records.
  - Programmable via programmable logic
  - Up to 20 oscillograph records.
  - Parameters: 1 to 32, 64, 128, 256, 512, 1024, 2048 cycles
  - Sampling: 100 ms
  - Resolution: 1 ms
  - Accuracy: ±1%

#### FUSE FAILURE

- **Activation**: By Algorithm based on instantaneous sequence of voltage and current
- **Activation by V2/V1 ratio**

#### ACCURACY

- **Events**: 5.12 scrolling events for models with rear ethernet communication board 2 options; G,H,J,K,L,M,N
- **Events for models with rear ethernet communication board 2 options**: C,D,E,U
- **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 (IN ordering code)
- **Storage**: Permanent in non volatile memory (Flash without battery)

#### Current and Power Method

- **Thermal Exponential, block interval, Rolling demand**
- **Sampling**: 30, 60, 90, 120, 180, 300, 600, 1200 seconds
- **Accuracy**: ±2.5%

#### Voltage

- **Accuracy**: ±1% reading, from 10 to 208 V
- **Power Active**: ±2.5% of the reading from power factor ±0.2 to 1
- **Reactive**: ±2.5% of the reading from power factor ±0.2 to 1
- **Apparent**: ±2.5% of the reading

#### ENERGY

- **Watts-hour (positive and negative)**
  - Range: ± to 2147 MWh
  - Updating Time: 100 ms
  - Accuracy: ±2.5%
  - Range: ± to 2147 MWh
  - Updating Time: 100 ms

#### POWER FACTOR

- **Accuracy**: ±0.5 %

#### FREQUENCY

- **Accuracy**: ±0.2 Hz

#### INPUTS

- **Current inputs**: Appropriate for 1 or 5 A
- **Overload**: 20 A permanent
- **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 Rating: 5 A @ 120 Vac (50 or 60 Hz)
- Voltage withstand: 260 Vac permanent
- Continuous at 275 V to neutral
- 120 Vac during 1 min/hr at 420 to neutral

**DIGITAL INPUTS**
- Voltage Threshold: Programmable from 20 up to 230V in steps of 1 V
- Impedance: > 100 KΩm
- Load for voltage supervision inputs: 2 mA + V/100 KΩm
- Maximum error: ≤ 10% setting or ± 5 V
- Acknowledge 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 branches
- No of remote devices: 16
- Default states on loss of comm.: Off, Off, Lates, Off

**ANALOG INPUTS (dcmA)**
- Current inputs: 0 to 1; 0 to +1; 0 to 5; 0 to 10; 0 to 20; 0 to 40
- Conversion range: 0 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
- Impedance: > 100 KΩm

**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
  - DC: 130 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 voltage range
- DC: 24 to 48 V
- AC: 120 to 230 V
- Low Range (LO): 50 ms at 125 Vdc
- 0.3 A with L/R = 40 ms at 125 Vdc

**OUTPUTS**
- Tripping Contacts/Output Relays
  - Permanent current Carry continuous: 16 A
  - Closing current Hike and Carry for 1 second: 60 A
- Opening current: 0.3 A with L/R = 40 ms at 125 Vdc
- 0.25 A with L/R = 40 ms at 250 Vac

**REMOTE OUTPUTS**
- Standard output points: 32
- User output points: 32

**COMMUNICATIONS**
- FRONT PORT (COM2)
  - Type: RS232
  - Baud Rate: 300, 600, 1200, 2400, 4800, 9600, 38400, 57600 and 115200 bauds
  - Default baud rate: Modem4 RTU / DNP 3.0

**ASYMLECTRONIC 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 and COM2
    - Modbus on COM1 and COM2

**CAN PORT**
- Type: Cable or multimode glass F.O. port with ST connectors
- Isolation: 2kV

**ETHETNET PORT**
- Type:
  - Model B: 10/100BaseTX self-negotiable
  - Model C: 10/100BaseTX + 10/100BaseFX with ST connectors
  - Model D: 10/100BaseTX + Double 100BaseFX with ST connectors
  - Model E: IEC 60870-5-103 on COM1
  - Model G: IEC 60870-5-103 on COM1
  - Model H: IEC 60870-5-103 on COM1
- Voltage loss hold-up time:
  - AC: 120 to 230 V
  - DC: 110 to 250 V
- Options:
  - High Range (HI): 200 ms typical, worst voltage range
  - Voltage Threshold:
    - LO, LOR: 0.25 A with L/R = 40 ms at 125 Vdc
    - HI, HIR: 0.3 A with L/R = 40 ms at 250 Vac
- COMMUNICATIONS
  - User output points
  - Standard output points
- REMOTE OUTPUTS
  - 0.25 A with L/R = 40 ms at 250 Vdc
  - Opening current
  - Closing current
- PROTOCOLS:
  - ModBus TCP/IP
  - DNP over TCP/IP and UDP/IP
  - IEC 60870-5-104

**SAFETY**
- IEC 60825-17: 2 kV 2.3 kV
- Impulse voltage withstand:
  - IEC 60825-27: 5 kV
- Insulation resistance:
  - IEC 60825-27: 500 V (test level)
- Radiated Emission:
  - IEC 60825-28: 500 V (test level)
- Emission levels:
  - IEC 60825-28: 500 V (test level)
  - IEC 60825-28: 1000 V (test level)
- Surge Immunity:
  - IEC 60825-28: 5000 V (test level)
- Surge Immunity:
  - IEC 60825-28: 5000 V (test level)
  - IEC 60825-28: 10000 V (test level)
  - IEC 60825-28: 10000 V (test level)
- Conducted RFI Immunity:
  - IEC 60825-28: 5000 V (test level)
  - IEC 60825-28: 10000 V (test level)
- Conducted EMI Immunity:
  - IEC 60825-28: 5000 V (test level)
  - IEC 60825-28: 10000 V (test level)
- Radiated Immunity:
  - IEC 60825-28: 5000 V (test level)
  - IEC 60825-28: 10000 V (test level)
- Radiated Immunity:
  - IEC 60825-28: 5000 V (test level)
  - IEC 60825-28: 10000 V (test level)

**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:
  - Model B: 11 lbs (5 kg)
  - Model C: 13.2 lbs (6 kg)

**ENVIRONMENTAL**
- Temperature:
  - Storage: -40 to +80°C
  - Operation: -10 to +60 degrees C
- Humidity:
  - Up to 95% without condensing

**APPROVALS**
- CE: Conforms to EN/IEC 60255, 61010
- UL: UL508 Certified under E234810
- KEMA: 61850 edition 2 certificate
- EAC: Machines and Equipment TR CU 010/2011

*Specifications subject to change without notice.*
### Ordering

<table>
<thead>
<tr>
<th>F650</th>
<th><strong>Display</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Basic Display (see note 2)</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Graphic Display with Standard Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Graphic Display with IEC Symbols (see note 2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Rear Serial Communications Board 1</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Redundant RS485</td>
</tr>
<tr>
<td>A</td>
<td>Redundant plastic fiber optic</td>
</tr>
<tr>
<td>P</td>
<td>Redundant glass fiber optic</td>
</tr>
<tr>
<td>G</td>
<td>Redundant RS485 + fiber remote CAN bus I/O</td>
</tr>
<tr>
<td>X</td>
<td>Redundant glass fiber optic + fiber remote CAN bus I/O</td>
</tr>
<tr>
<td>Y</td>
<td>Cable remote CAN bus I/O</td>
</tr>
<tr>
<td>Z</td>
<td>RS485 + cable remote CAN bus I/O</td>
</tr>
<tr>
<td>M</td>
<td>None</td>
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</tbody>
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<table>
<thead>
<tr>
<th><strong>Rear Ethernet Communications Board 2</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>10/100 Base TX</td>
</tr>
<tr>
<td>C</td>
<td>10/100 Base TX + 100 Base FX</td>
</tr>
<tr>
<td>D</td>
<td>10/100 Base TX + Redundant 100 Base FX</td>
</tr>
<tr>
<td>E</td>
<td>Redundant 10/100 Base TX</td>
</tr>
<tr>
<td>G</td>
<td>1588, 10/100 Base TX + 100 Base TX</td>
</tr>
<tr>
<td>H</td>
<td>1588, 10/100 Base TX + 100 Base TX</td>
</tr>
<tr>
<td>J</td>
<td>PRP, 1588, 10/100 Base TX + Redundant 100 Base FX (see note 3)</td>
</tr>
<tr>
<td>K</td>
<td>PRP, HSR, RSTP, 1588, 10/100 Base TX + Redundant 100 Base FX (see note 3)</td>
</tr>
<tr>
<td>L</td>
<td>PRP, HSR, RSTP, 1588, 10/100 Base TX + Redundant 100 Base TX (see note 3)</td>
</tr>
<tr>
<td>M</td>
<td>PRP, HSR, RSTP, 1588, 10/100 Base TX + Redundant 100 Base TX (see note 3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>I/O Board in Slot F</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16 Digital Inputs + 8 Outputs</td>
</tr>
<tr>
<td>2</td>
<td>8 Digital Inputs + 8 Outputs + 2 Trip / Close circuit supervision circuits</td>
</tr>
<tr>
<td>3</td>
<td>32 Digital Inputs</td>
</tr>
<tr>
<td>4</td>
<td>16 Digital Inputs + 8 Analog Inputs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>I/O Board in Slot G</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>16 Digital Inputs + 8 Outputs</td>
</tr>
<tr>
<td>2</td>
<td>8 Digital Inputs + 8 Outputs + 2 Trip / Close circuit supervision circuits</td>
</tr>
<tr>
<td>3</td>
<td>32 Digital Inputs (See Note 1)</td>
</tr>
<tr>
<td>4</td>
<td>16 Digital Inputs + 8 Analog Inputs (See Note 1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Auxiliary Voltage</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO</td>
<td>24-48 Vdc (range 19.2 - 57.6)</td>
</tr>
<tr>
<td>HI</td>
<td>110-250 Vdc (range 88 - 300, 120-230 Vac (range 96 - 250)</td>
</tr>
<tr>
<td>LOR</td>
<td>Redundant L</td>
</tr>
<tr>
<td>HR</td>
<td>Redundant H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Language</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Chinese/English (See Note 2, 4)</td>
</tr>
<tr>
<td>F</td>
<td>French/English</td>
</tr>
<tr>
<td>P</td>
<td>Russian/English (See Note 2)</td>
</tr>
<tr>
<td>S</td>
<td>Spanish/English</td>
</tr>
<tr>
<td>T</td>
<td>Turkish/English</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Protocol</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60870-5-104</td>
<td>Modbus RTU, TCP/IP, DNP 3.0 Level 2, IEC 60870-5-104</td>
</tr>
<tr>
<td>IEC 60870-5-103</td>
<td>Modbus RTU, TCP/IP</td>
</tr>
<tr>
<td>IEC 61850-6-84</td>
<td>MultiSync IS, CIO Remote CAN Bus I/O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Enhanced Display</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Enhanced Display with Front USB port</td>
</tr>
</tbody>
</table>

**Notes:**
1. 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.
2. 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.
3. Basic display (B): available for English, French, Spanish and Chinese languages. For Chinese only IEC symbols option is available (N in ordering code).
4. Display options with language selection:
   - Basic display (B): available for English, French, Spanish and Chinese languages.
   - 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.
   - Graphic display (M & N): available for English, French, Spanish, Russian, Turkish and Chinese languages. For Chinese only IEC symbols option is available (N in ordering code).
5. Advanced features require new CPU:
   - For order codes with options G, H, J, K, L and M for the rear Ethernet communication board, Chinese language is not available.

**Related Products / Accessories**
- Multisync 100 - GPS Clock
- CIO Remote CAN Bus I/O Module
- Related Products / Accessories

**GE Grid Solutions**
- Toll Free: +1 877-605-6777
- Direct: +1 678-844-6777

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