GE
Digital Energy

Multilin™ C90Plus

Automation Control System

The Multilin™ C90Plus is a powerful automation controller that eliminates the need for several external devices, such as substation programmable logic controllers and disturbance recorders. Highly customizable and scalable, C90Plus is designed for blackout and emergency events in transmission and industrial power systems.

The C90Plus features intelligent high-end and fast load shedding, bay protection and control, and comprehensive communications.

Key Benefits

- Powerful automation controller eliminates the need for separate substation PLCs
- High-end load shedding with multiple stages of frequency and voltage retains system stability after disturbances
- Fast optimal load shedding executed within 20ms minimizing process outages and costs associated with system downtime
- Intelligently sheds loads to maintain system / process integrity
- Highly customizable and scalable, integrating easily into most industrial facilities with new or existing EMS/SCADA systems
- Configurable annunciator panel capable of handling up to 288 alarms, eliminating the need for a separate panel
- Embedded Synchrophasor measurement capabilities (per IEEE® C37.118), eliminating the need for dedicated PMUs and support for synchrophasor multi-cast (per IEC® 61850-90-5) reducing bandwidth and communications infrastructure costs
- Increased network availability via failover time reduced to zero through IEC® 62439-3 "PRP" support
- Advanced fault and disturbance recording, including internal relay operating signals, eliminating the need for external recording devices
- HMI with pre-configured and customizable displays including real-time bay control, metering, fast load shed reports, equipment status, fault and event recording

Applications

- Advanced bay control / monitoring (6 breakers and 30 disconnects)
- Fast, power-balance load shed
- Frequency and voltage load shed
- Substation alarm concentrator, annunciator, and controller
- Advanced automation schemes such as bus transfer
- Stand-alone breaker protection and monitoring

Bay Protection & Control

- Dedicated automation controller with 4000 lines of logic
- 10 stages of under/over frequency protection, 4 stages of rate-of-change-of frequency, 6 stages of undervoltage elements
- Protection logic at 1 msec execution rate
- HMI for breaker and disconnect control
- Dual breaker failure protection
- Direct and tele-protection elements using inter-relay comms

Monitoring & Metering

- Advanced recording capabilities with high-capacity event recorder, transient & disturbance recording, configurable and extended waveform capture and data logger
- Current, voltage, frequency, power, energy and synchrophsors (per IEEE C37.118) measurement

Fast Load Shed

- Intelligently shed necessary loads per customized priorities
- Highly customizable and scalable for simplified integration into new or existing EMS/SCADA systems
- Suitable for small or large industrial systems without re-design

Communications

- Supported industry protocols: IEC 61850, DNP 3.0, Modbus Serial/TCP, IEC 60870-5-104 and 103, PRP
- Up to 3 independent IP addresses with failover features & standards based inter relay comms

imagination at work

Advanced Bay Control

The C90Plus bay control or monitoring functionality is intended for high-end bay control applications typically used in transmission installations, where a larger quantity of I/O, advanced protection and control functionality and an advanced HMI is desired.

Bay Control Protection Functions

Overcurrent

The C90Plus provides multiple stages of overcurrent functions for phase, neutral and ground. Overcurrent functions include:

- Instantaneous and timed overcurrent elements for phase, neutral, ground and negative sequence protection
- Directional supervision is available for phase neutral and negative sequence elements
- Time O/C elements can individually be set to use IEEE, IEC or custom FlexCurves™

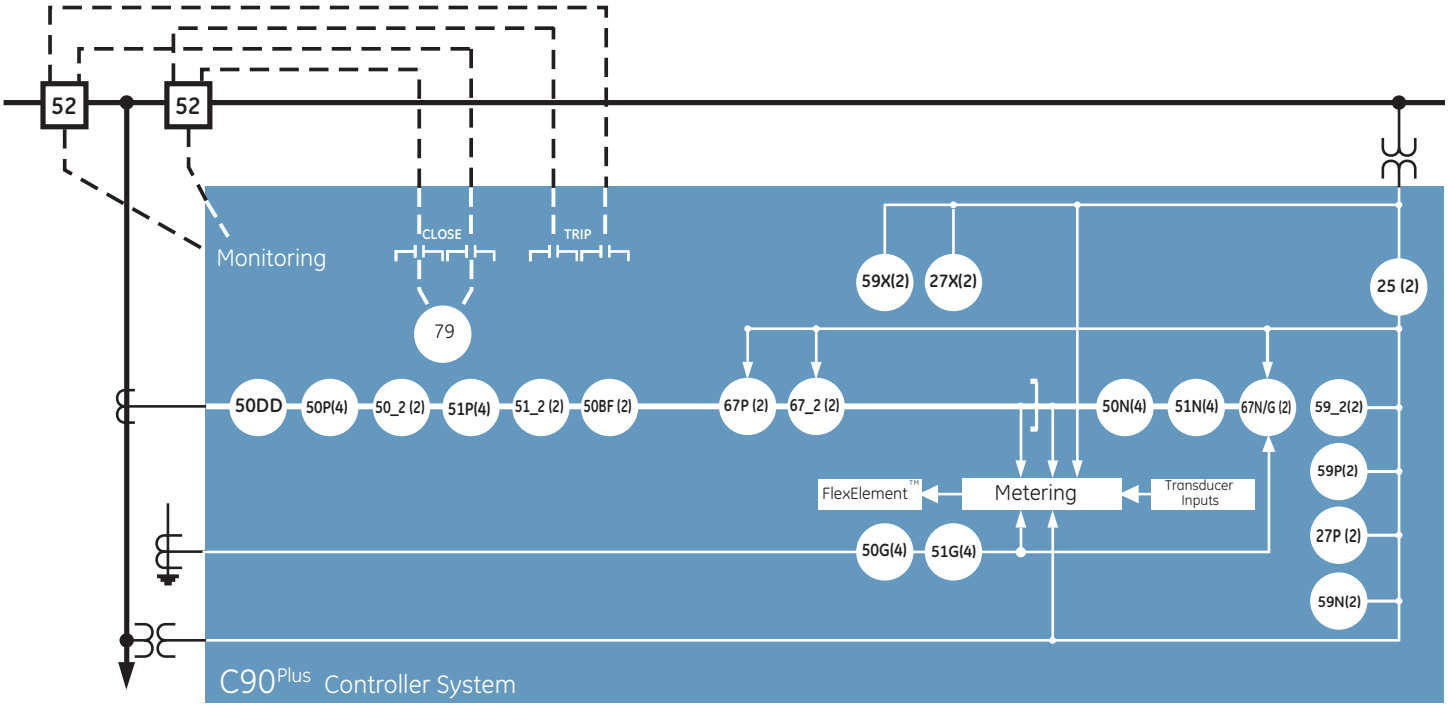
Over and Under Voltage Protection

Long lines under lightly loaded conditions or no-load or sudden loss of power may experience voltages exceeding the rated per unit voltage level of the line. Use the phase overvoltage element of the C90Plus to initiate a local trip as well as a remote trip using direct transfer trip. The C90Plus also provides additional voltage functions including neutral overvoltage, negative sequence overvoltage and phase undervoltage. The phase undervoltage can be programmed as definite time or inverse time.

Over and Under Frequency Protection

The multiple stages of under and over frequency elements can be used to initiate load shedding or remedial action schemes or frequency-based load restoration schemes during lack of generation in the network or due to sudden load drops. Combined with the advanced automation capabilities of the C90Plus, flexible, special protection schemes, advanced load shedding and load restoration schemes can be built.

Functional Block Diagram



ANSI® Device Numbers & Functions

DEVICE NUMBER	FUNCTION
25	Synchronism Check
27P	Phase Undervoltage
27X	Auxiliary Undervoltage
50BF	Breaker Failure
50DD	Current Disturbance Detector
50G	Ground Instantaneous Overcurrent
50N	Neutral Instantaneous Overcurrent
50P	Phase Instantaneous Overcurrent

DEVICE NUMBER	FUNCTION
50_2	Negative Sequence Instantaneous Overcurrent
51G	Ground Time Overcurrent
51N	Neutral Time Overcurrent
51P	Phase Time Overcurrent
51_2	Negative Sequence Time Overcurrent
52	AC Circuit Breaker
59N	Neutral Overvoltage
59P	Phase Overvoltage

DEVICE NUMBER	FUNCTION
59X	Auxiliary Overvoltage
59_2	Negative Sequence Overvoltage
67N	Neutral Directional Overcurrent
67P	Phase Directional Overcurrent
67_2	Negative Sequence Directional Overcurrent
79	Automatic Recloser
81 U/O	Under and Over Frequency

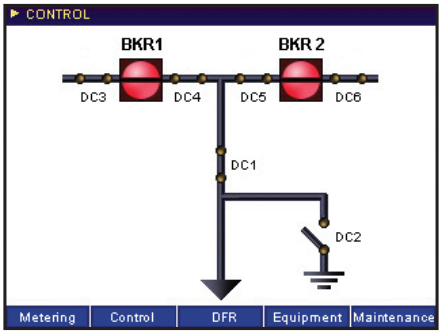
Small Signal Oscillation Functionality

A new protection element called the small signal oscillation detection is added to the product. Modern power systems are becoming increasingly interconnected to each other for the benefits of increased reliability, reduced operation cost, improved power quality and reduced necessary spinning reserve. With the increasingly large interconnected power systems some technical challenges also become apparent. One of these challenges is the inter-area low frequency oscillations that are a major threat to reliable operations of large-scale power systems. Inter-area oscillations not only limit the amount of power transfer, but also threaten the system security and equilibrium, as they may lead to system instability and cascading outages.

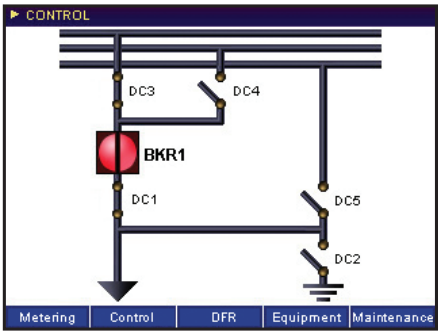
Therefore, it is essential to identify the characteristics of the inter-area oscillations, including oscillation frequency and damping ratio, so that proper actions can be taken based on the results. This is required to improve the system damping and maintain stability in the power system. The C90Plus can detect these inter-area oscillations and provide an alarm or even a trip signal to prevent a large-scale system disturbance.

Bay Configurations

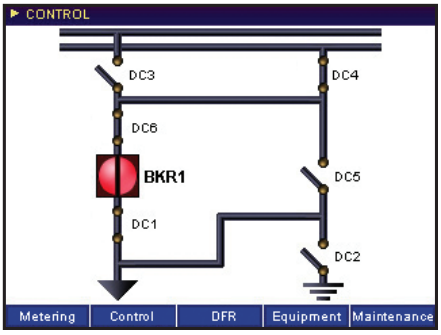
The C90Plus has 12 pre-configured bay single line diagrams and corresponding controls for each of the bay equipment. Users can also program their own single line diagrams using the ANSI/IEC library symbols provided in the EnerVista setup program.



Breaker-and-Half Configuration.



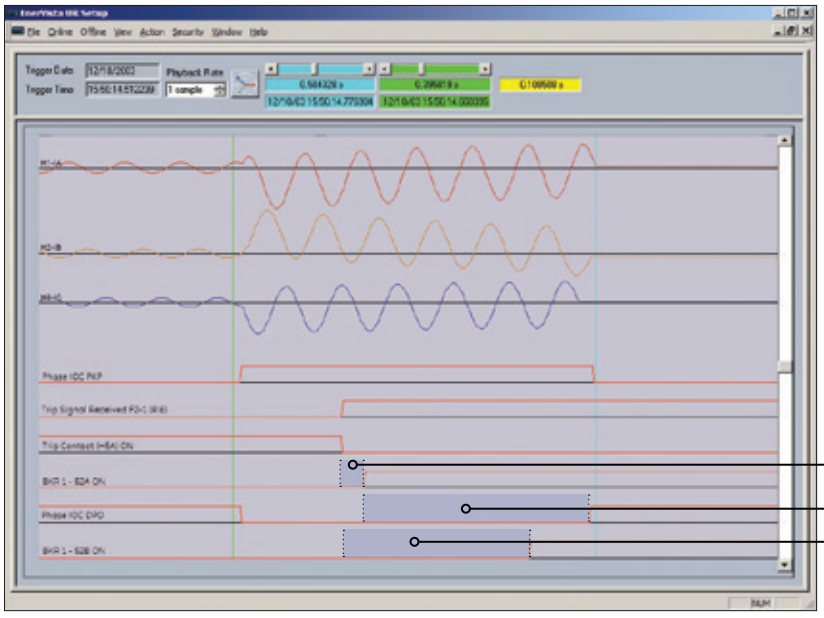
Two-Main and Transfer Bus Configuration.



Double Bus Configuration.

Power System Troubleshooting

The C90Plus contains tools that allow for the early detection of impending breaker problems and allow for maintenance to be performed before serious damage occurs.



Breaker Latch Release Time:

Indicates how long it took for the breaker latch to release from the time the trip coil was energized by the relay

Arc Extinguish Time:

Indicates the length of time that was required for the breaker to extinguish the arc and finally clear the fault

Breaker Mechanism Travel Time:

Indicates time interval required for the breaker mechanism to travel to its rest position

Triggering a waveform on each breaker operation can identify changes in the length of time each part or mechanism in the breaker takes to perform its function.

Fast Load Shed

Why Fast Load Shed?

Conventional frequency and voltage load shedding schemes operate typically in 250 ms to seconds.

Contingency based load shedding schemes are typically faster at 160 – 400 ms depending on both system architecture and communications employed.

Both these scheme types are too slow for industrial cogeneration applications, such as oil and gas or manufacturing, where very fast load shedding is required to ensure power system and critical processes integrity.

What is Fast Load Shed?

Fast load shed is a system consisting of one or more C90Plus, IEC 61850-Ethernet network, UR, URPlus or IEC 61850-8-1 capable end devices that provides fast load shedding, to re-establish power balance when source/loads balance is disrupted. End devices are of UR, URPlus, SR or IED's with IEC 61850-8-1 support (other vendor IED interoperability not proven/tested). It is possible to use existing devices which do not support IEC 61850. In those cases the D25 RTU can be used to communicate between those existing devices and the fast load shed controller (FLSC), however this will slow the scheme down. The C90Plus FLSC checks if generation lost exceeds remaining generation reserve per:

$$\Delta(\text{Pgen}) + \text{Preserve} \geq 0$$

In case of generation loss or power unbalance GOOSE messages are sent to shed enough load per pre-defined priorities above available generation reserve (Adaptive Mode). Load priorities can be changed/updated via HMI within a second. Alternatively, a pre-defined shedding scenario can be executed upon each defined contingency (Static Mode).

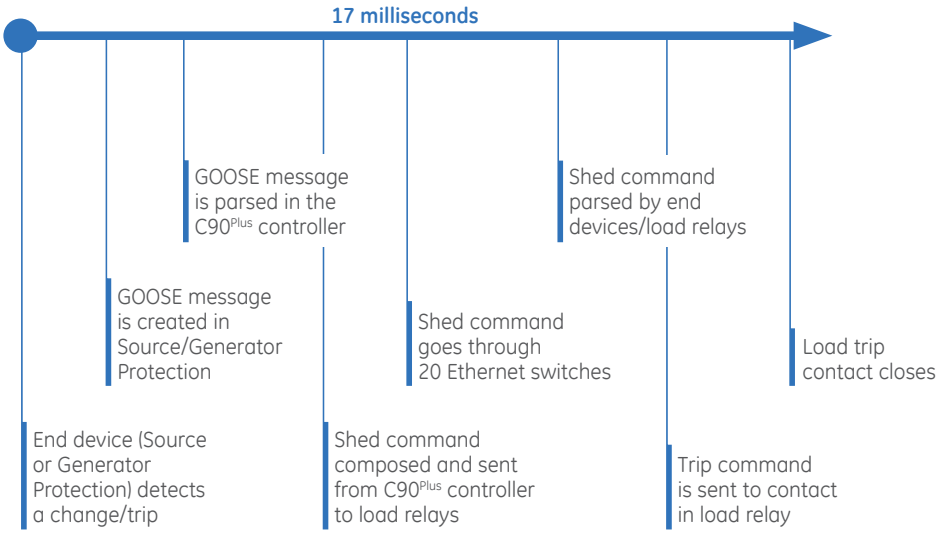
Up to 16 automatic reports are generated for any scheme operation containing Fast Load Shed Controller (FLSC) relay name, firmware revision, contingency date/time and duration, steady-state power flows, infeeds lost, scenarios encountered, load groups shed, settings last changed date.

Speed of Fast Load Shed Scheme:

The speed of Fast Load Shedding including internal processing is as follows:

Origin	UR end device detects trip/breaker operation
3000 µs	UR GOOSE message with change of online state
200 µs	Message passed through multiple LAN switches
3000 µs	FLSC processing and calculations
1000 µs	Shed command GOOSE message composed
500 µs	FLSC GOOSE message is sent through LAN switches
3000 µs	Shed command GOOSE message parsed by load URs
4000 µs	UR end device calculations and processing
2000 µs	Trip contact output closes
16.7 ms	Total

End-to-end execution made under 20 ms



C90Plus Load Shed Scheme Devices

C90Plus Fast Load Shed Controller (FLSC)

The controller is the main decision point of the system where all the calculations and intelligent commands are sent. It is a substation hardened device with a real-time operating system that is highly reliable and accurate. It is also equipped with a local annunciator panel and HMI screen (optional) for ease-of-use for maintenance and operation. The controller receives source data from end devices, load data from end devices or aggregators via analog GOOSE. It handles up to 64 loads or infeeds as well as 6 local infeeds, and makes the final decision to shed load. The load shed commands are issued via GOOSE to end devices.

C90Plus Fast Load Shed Aggregator (FLSA)

This is an extension of the system allowing for aggregation of load data and is a load shed data concentrator, combining load data from end devices and sending as analog GOOSE to the FLSC. It does not make load shed decisions. It allows the controller to handle more than 64 loads. By connecting the aggregators in a tree-like matrix, the number of loads controlled with this scheme can reach over 2500.

Load Shed Controller Design

The FLSC can interface or aggregate measurements into 32 sources/infeeds and 32 loads/load groups (many loads/group).

User-defined shed priorities of the load groups are fixed or user-selectable through an HMI. Loads can be taken out of scan if it is determined that shedding is not required. The FLSC has an auto-compute solution option (Adaptive Mode) where loads to be shed are calculated based on priorities, generation lost and generation reserve, and a manual scenario execution option (Static Mode) where load shedding is pre-determined for each power loss contingency.

Scalability of the Fast Load Shed Scheme

The controller can handle up to 64 infeeds/loads or aggregators plus 6 local devices (infeeds or loads).

Adding another C90Plus as an aggregator extends the system by an additional 70 loads. With 12 infeeds, 18 loads & 40 aggregators (64 loads each), the system can support 12 infeeds and 2578 sheddable loads. Minimal re-configuration is required in the case of system expansion.

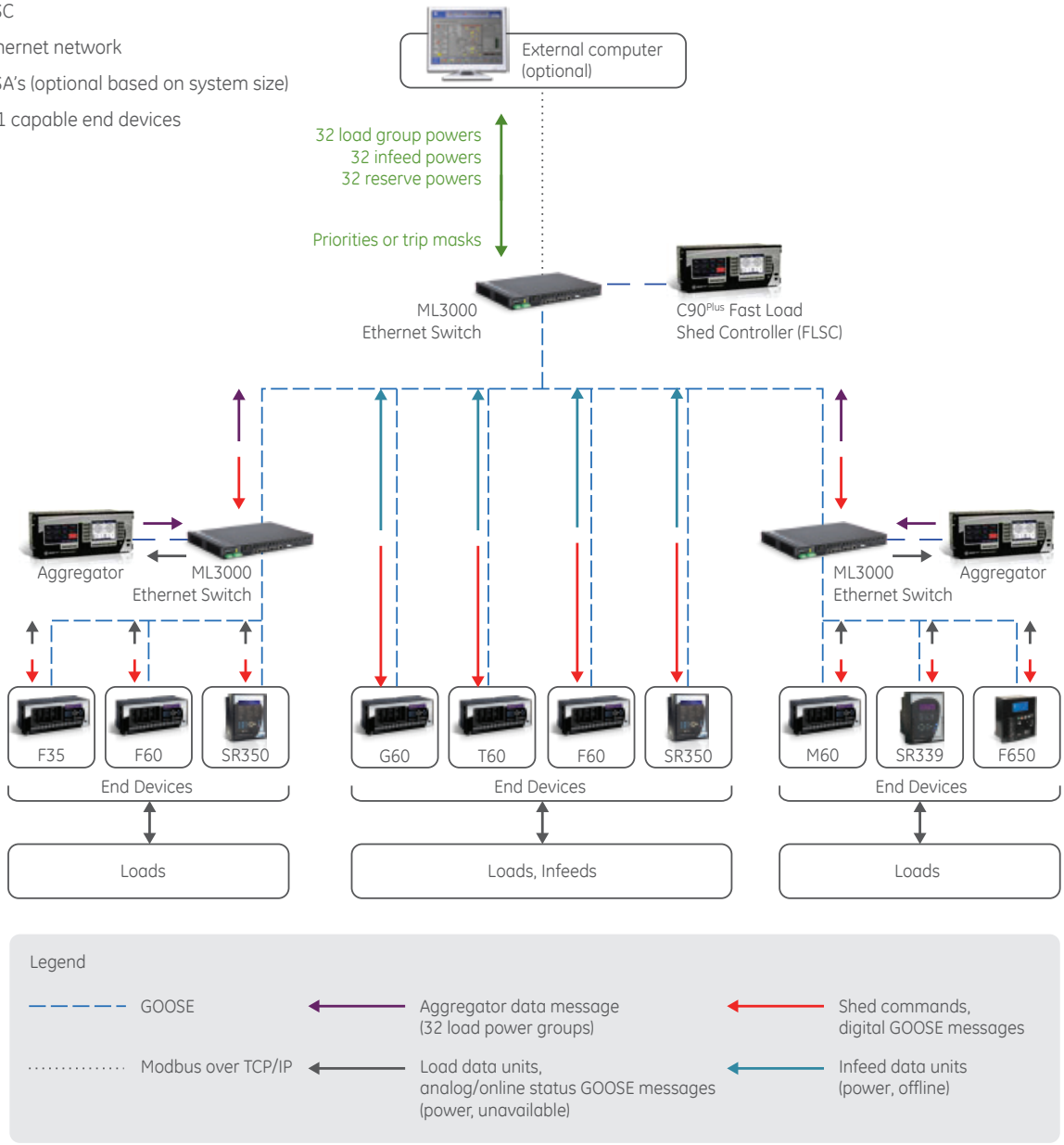
Interoperability

All communications are based on GOOSE and IEC 61850-8-1.

The System Overview and Architecture

Below is a typical Fast Load Shed scheme, consisting of:

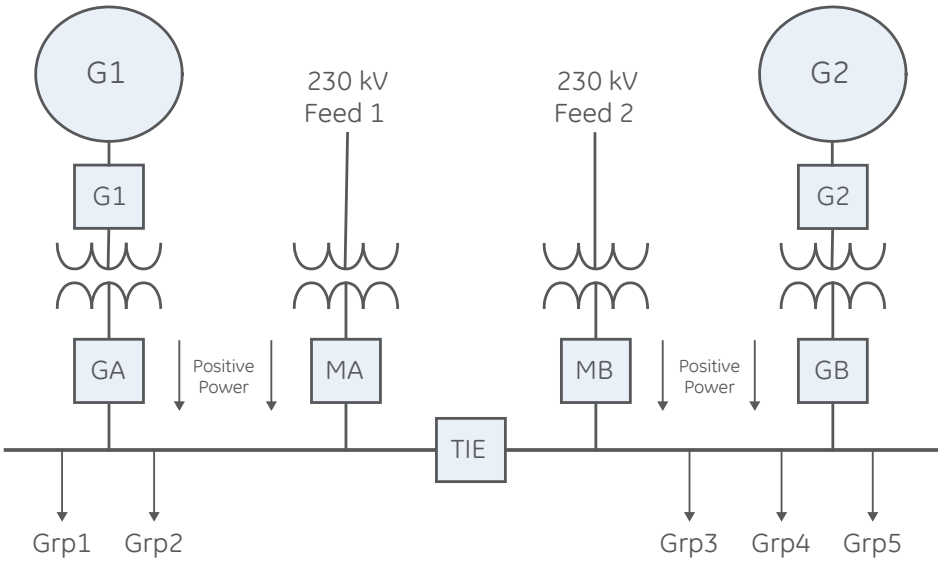
- 1 x C90Plus FLSC
- IEC 61850-Ethernet network
- 2 x C90Plus FLSA's (optional based on system size)
- IEC 61850-8-1 capable end devices



The above system architecture can be expanded to cater for non-IEC 61850 end devices by adding a D25 Substation Controller.

Simplified Source-Load Example

Below is a simplified system illustrating the load shed priorities and how shedding is determined:



The Total System Load = PGrp1 + PGrp2 + PGrp3 + PGrp4 + PGrp5
Total Source/Generation = PG1 + PG2 + PMA + PMB
The C90Plus calculates: Δ(Pgen)+ Preserve ≥ 0

LOAD PRIORITIZATION: (AS SET BY END-USER)		
Asset	**Value**	**Priority/Status (User set)**
Group 1	10MW	5
Group 2	10 MW	0 (Don't Shed)
Group 3	5 MW	1
Group 4	20MW	4
Group 5	5 MW	2

Example: For a loss of 9MW of Generation with no generation reserve, the scheme will trip Load Groups 3 and 5 for a total of 10MW.

Actual Load Shed Performance Results (System Islanded)

Below are some test results from a C90Plus fast load shed scheme operation in conjunction with backup df/dt and under frequency load shedding, illustrating operating speed of each system at a petrochemical facility that got islanded as a 4.5MW underpowered island. In this case the scheme operated in 13 ms, including trip command to shedding load breakers.

TIME(MS)	EVENT
0	Breaker MB Opened Manually
8	Breaker Open De-bounced Island Detected Priorities 1, 2 and, 3 Load Shed Sent
10	Shed Message Received at Load Relays
13	Trip Coils Energized
50	Shed Breaker Open – Load Shed
64	ROCOF(df/dt) Trigger
106	Under Frequency Load Shed Trigger

C90Plus Automation Control System

The C90Plus is a powerful logic controller and protection product designed for the requirements of industrial and utility power systems. Its unparalleled list of features make the C90Plus one of the most agile and advanced products, allowing it to perform several functions and be used in many scenarios based on the needs of each customer. The C90Plus provides unmatched logic processing ability combined with a powerful math engine with deterministic execution of logic equations, regardless of the configuration of the number of lines of logic.

The C90Plus provides the tools and functionality necessary for creating customized automation and control schemes that include:

- Advanced bay control and interlocking
- Breaker monitoring and control
- Automatic bus transfer schemes
- Load shedding and load restoration schemes
- Ultra fast load shedding in industrial plants

Automation Logic

The C90Plus incorporates advanced automation features including powerful FlexLogic™ (user programmable logic) for its protection and advanced automation schemes. Combined with the communication capabilities, C90Plus automation features far surpass what is found in average relays with programmable logic. The C90Plus integrates seamlessly with UR and URPlus relays for complete system protection, including interlocking and special protection schemes.

FlexLogic

FlexLogic is the powerful user programmable logic engine that provides the ability to create customized protection and control schemes thereby minimizing the need, and the associated costs, of auxiliary components and wiring. The independent automation FlexLogic features math, Boolean and control functions, which can be used for advanced load shedding, load restoration and dynamic Volt/VAR control schemes. More than 4000 lines of logic are provided with a deterministic execution rate of 50 msec, irrespective of the number of lines of logic.

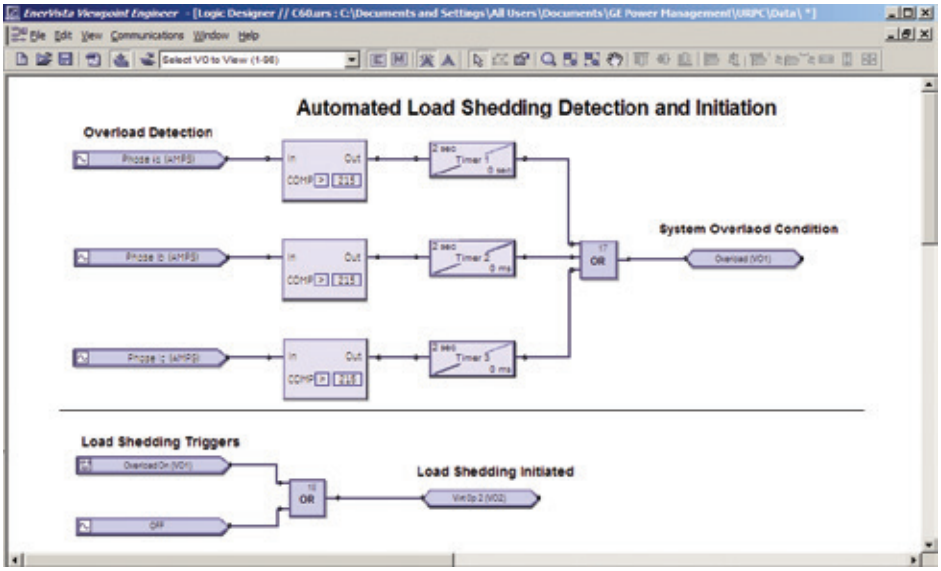
Automation FlexLogic operators include:

- Math: EXP, ACOS, ATAN2, ATAN, ASIN, FLOOR, CEIL, LOG, LOG10, POW, SIN, COS, TAN, NEG, ABS, SQRT, ADD, SUB, MUL, DIV, CONSTANT
- Boolean: AND, NAND, NOR, NOT, OR, XOR
- Control: =, <=, !=, >=, <, >, Latch, Positive/Negative/Dual one shot, Timers, Counters

Deterministic Automation

A power system is a real-time system in which time and accuracy of every control should be considered critical. The C90Plus operating system ensures that every action and control is scheduled properly and beforehand to guarantee that nothing is missed nor delayed. This intelligence inside the C90Plus handles both protection trip commands as well as any other logic written for execution as per its programmed timeline. No more delays or missed timelines when it comes to control because the processor is 'busy' or otherwise.

Custom Programmable Logic Designer



The C90Plus supports an advanced automation logic engine that supports Boolean operators, analog comparisons, and advanced mathematical operations.

Communications

The C90Plus supports the most popular industry standard protocols enabling easy, direct integration into DCS and SCADA systems including:

- IEC 61850
- DNP3
- Ethernet Global Data (EGD)
- IEC 60870-5-104
- Modbus RTU, Modbus TCP/IP
- PRP as per IEC 62439-3
- Three independently configurable IP's with failover features
- Inter-relay communication card to enable implementation of pilot schemes based on standard communication protocols
- Front USB for maintenance and downloading records and events

Interoperability with Embedded IEC 61850

Use the C90Plus with integrated IEC 61850 to lower costs associated with protection, control and automation. GE Multilin's leadership in IEC 61850 comes from thousands of installed devices and follows on many years of development and operational experience with UCA 2.0.

- Replace expensive copper wiring between devices with direct transfer of data using GOOSE messaging
- Configure systems based on IEC 61850 and also monitor and troubleshoot them in real-time with EnerVista Viewpoint Engineer
- Integrate GE Multilin IEDs and generic IEC 61850-compliant devices seamlessly in EnerVista Viewpoint Monitoring

Extreme Communication

- High reliable communication card with automatic failover and extremely fast redundant schemes
- Inter-relay communication card to enable implementation of pilot schemes that are based on standard communication protocols, and both "Direct" and "Tele-Protection" input and output elements available

Ease-of-use, security ease-of-use and quick setups are considered throughout every application and configuration parameter requiring virtually no training for those working in the power industry. The EnerVista suite is an industry-leading set of software programs that simplifies every aspect of using the C90Plus relay. The EnerVista suite provides all the tools to monitor the status of the protected asset, maintain the relay, and integrate information measured by the C90Plus into DCS or SCADA monitoring systems. Convenient COMTRADE and Sequence of Events viewers are an integral part of the URPlus Setup software included with every URPlus relay, to carry out postmortem event analysis to ensure proper protection system operation.

Security and NERC® CIP

- Audit Trail
- Password protection and authentication
- Support for alphanumeric passwords
- Role-based access control to manage multiple personnel rights as per ANSI INCITS 359-2004

LAN Redundancy

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

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's Multilin products. The setup software within Launchpad allows for the configuration of devices in real-time by communicating using serial, Ethernet, or

modem connections, or offline by creating setting files to be sent to devices at a later time. Included in Launchpad is a document archiving and management system that ensures critical documentation is up-to-date and available when needed. Documents made available include:

- Manuals
- Application Notes
- Guideform Specifications
- Brochures
- Wiring Diagrams
- FAQ's
- Service Bulletins

Viewpoint Engineer

Viewpoint Engineer is a set of powerful tools that will allow you to configure and test your relays at a system level in an easy-to- use, graphical drag-and-drop environment. Viewpoint Engineer provides the following configuration and commissioning utilities:

- Graphical Logic Designer
- Graphical System Designer
- Graphical Logic Monitor
- Graphical System Monitor

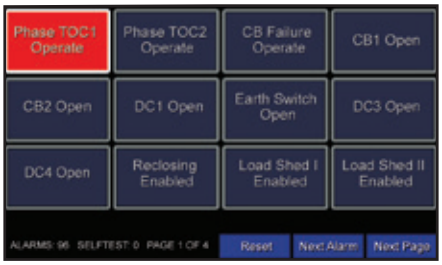
User Interface and HMI

The C90Plus provides extensive local HMI capability through two dedicated display panels. One serves as a digital annunciator and the other optional HMI is for display and control functions.

Annunciator

Enhanced HMI and Annouciator panels on the front of the C90Plus make it one of the most powerful human machine interfaces on local units. The C90Plus provides an embedded, configurable color LCD annunciator on the front panel of the device, eliminating the need for LED labels and separate annunciators in the relay panel.

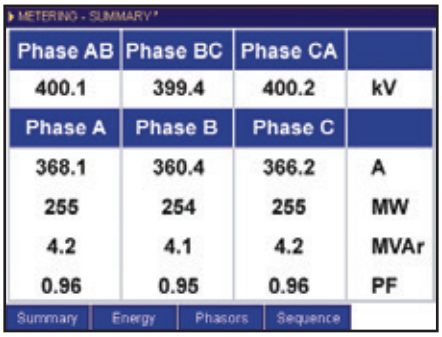
- Any contact/direct/remote input or internally generated FlexLogic operand can be assigned to be displayed on the annunciator.
- Up to 288 targets may be assigned. The display can be configured for 12/24/48 alarms per page to a maximum of 24 pages using a 16-color pallet for better visualization and customization.
- A separate self-test message page on the annunciator panel shows clear error messages about the device health, greatly assisting in identifying, and correcting device related issues.
- For easy maintenance and asset management, product information, such as IP addresses and serial numbers of each module, are also accessible without the need to connect to the unit.



12 to 48 user-configurable alarms per page eliminate the need for a separate annunciator.

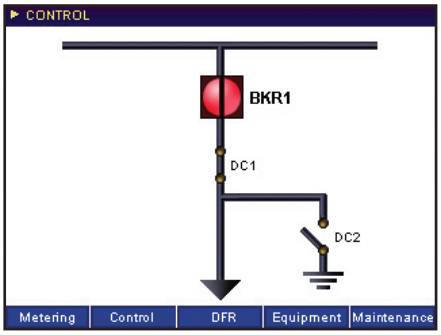
HMI

- Comprehensive data visualization.



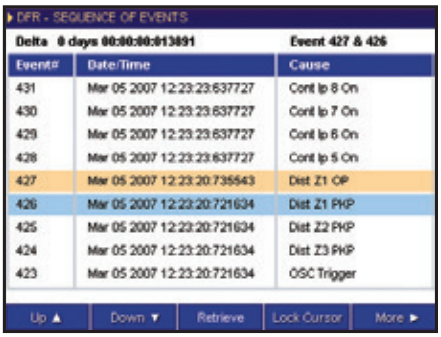
Easy-to-read large display of metering values.

- User-programmable single line diagram supported by ANSI/IEC symbols. Pre-programmed single line diagrams for bay monitoring and control for common bus configurations, including ring-bus, double breaker and breaker-and-half configurations.



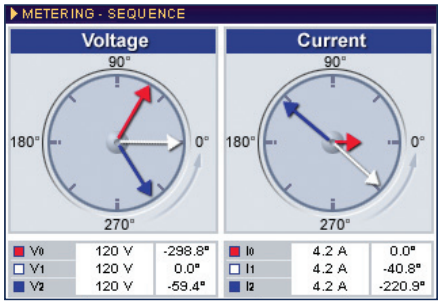
Single Bus Configuration.

- Multiple programmable control pushbuttons, ten pushbuttons per page with multiple levels of control.
- Local/remote control.



Sequence of event records provide the ability to view the time difference between two events for troubleshooting and analysis.

- Pre-programmed comprehensive displays for:
  - Metering
  - Bay Control
  - Fault Reports
  - Sequence of Event Reports
  - Fault Records
  - Device Diagnostics
  - Equipment Manager
  - Fast Load Shed Status and Reports
  - Real-Time Phasor Displays of Voltage, Current and Sequence Components



Phasor display of sequence components showing the standing unbalance in the line.

Front Panel USB

The front panel of the C90Plus provides a USB 2.0 host for field laptop connections for high-speed data transfers, making downloading and uploading faster than a conventional RS232 connection.

C90Plus Automation Control System

Digital Alarm Annunciator

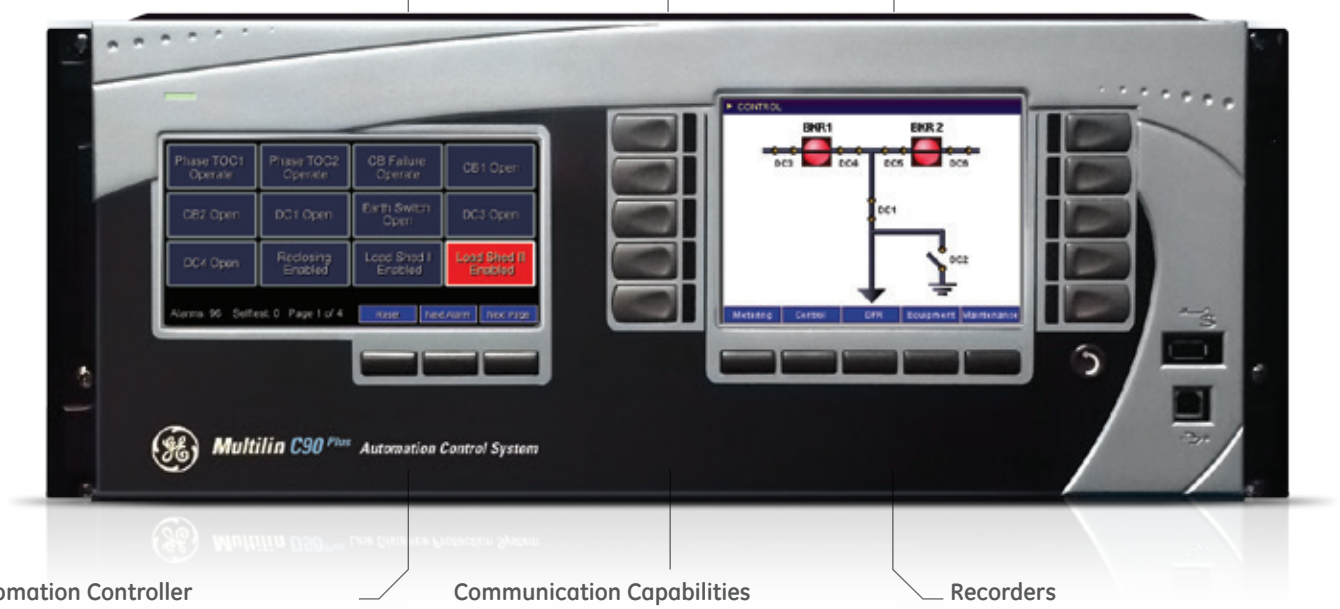
- 288 customizable alarms in multiple pages using a pallet of 16 colors
- Eliminates the need for separate annunciator
- Descriptive self-test messages

Intuitive HMI

- User-configurable single line diagrams using IEC/ANSI library symbols
- Local control and status indication of breakers & disconnect switches, 20 user-programmable pushbuttons
- Local/remote control
- Fault, event, disturbance and transient reports

Bay Protection

- Overcurrent, over/under voltage, over/under frequency
- Breaker failure, autoreclose, synch check
- 512 lines of Protection FlexLogic @ 1 msec execution



Automation Controller

- Built-in industry hardened logic controller
- 4096 lines of independent user-programmable logic, 50 msec execution rate
- Advanced math, Boolean and control operations

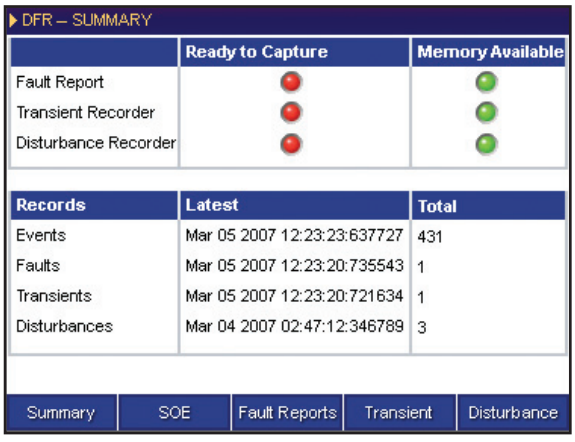
Communication Capabilities

- Up to three independent Ethernet ports with redundant fast-over
- IEC 61850, DNP3, MODBUS TCP/IP, IEC 60870-5-104 protocols
- Front USB port for high speed data transfer

Recorders

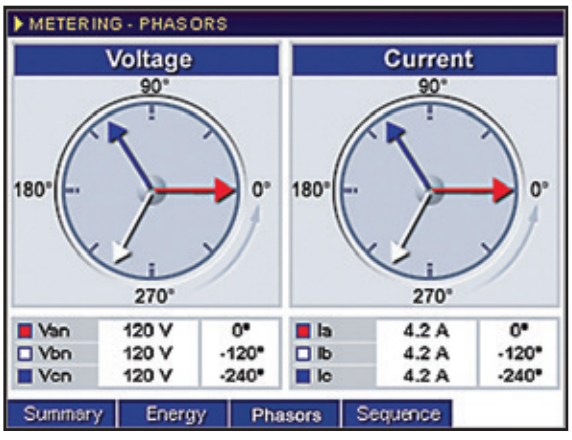
- Eliminates the need for stand-alone disturbance recorders
- Configurable and up to 256 samples/cycle, 1 min duration recorder
- Dedicated disturbance recorder for recording long term events
- Synchrophasors over Ethernet

Disturbance Recorder Eliminates Stand-Alone DFR and Phasor Measurement Unit



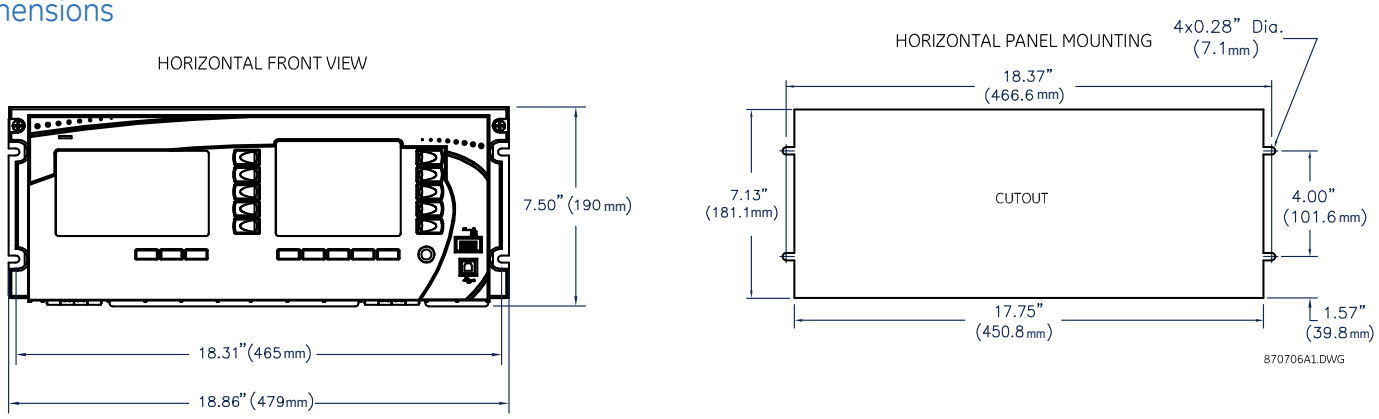
Digital fault recorder summary with the latest information on events, faults, transients and disturbances.

Real-Time Phasor Information of Fundamental and Sequence Components

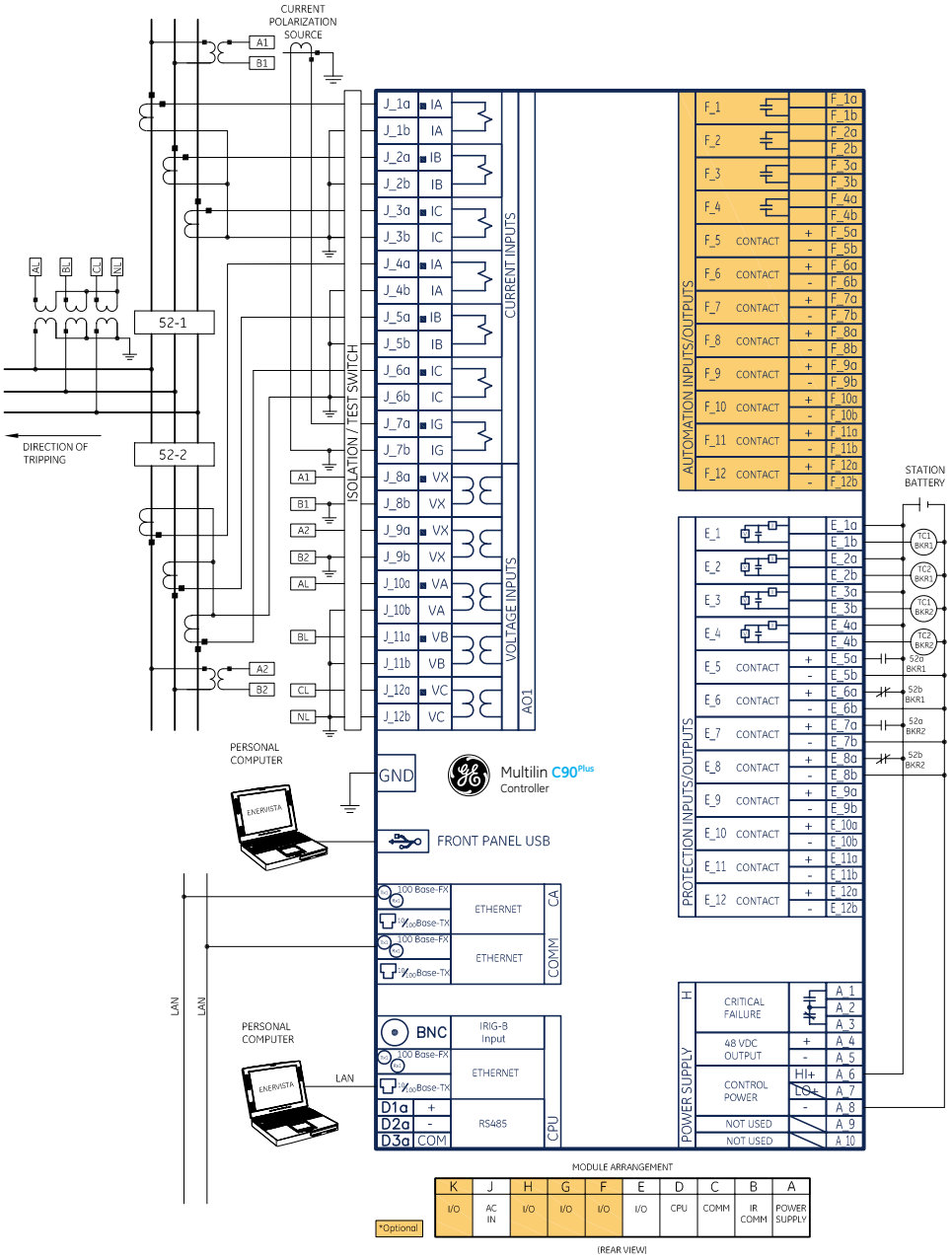


Real-time display of the fundamental phasors of voltage and current in the front panel HMI.

Dimensions



Typical Wiring Diagram



Technical Specifications

AUTORECLOSURE

Applications:	two breakers
Tripping schemes:	single-pole and three-pole
Reclose attempts:	up to 4 before lockout
Reclosing mode:	selectable
Breaker sequence:	selectable

AUXILIARY OVERVOLTAGE

Pickup level:	0.000 to 1.100 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Timing accuracy:	±3% of operate time or ±4 ms (whichever is greater)
Operate time:	<2 cycles at 1.10 × pickup at 60 Hz

AUXILIARY UNDERVOLTAGE

Pickup level:	0.000 to 1.100 pu in steps of 0.001
Dropout level:	>102% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Curve shapes:	GE IAV inverse, definite time
Curve multiplier:	0.00 to 600.00 in steps of 0.01
Timing accuracy:	±3% of operate time or ±4 ms (whichever is greater)

BREAKER FAILURE

Mode:	single-pole, three-pole
Current supervision:	phase current, neutral current
Supervision pickup:	0.001 to 30.000 pu in steps of 0.001
Supervision dropout:	<98% of pickup
Supervision accuracy at 0.1 to 2.0 × CT:	±2% of rated
Supervision accuracy at >2.0 × CT:	±2.5% of reading
Time accuracy:	±3% or 4 ms (whichever is greater)

BREAKER FLASHOVER

Operating quantity:	phase current, voltage, and voltage difference
Pickup level voltage:	0.000 to 1.500 pu in steps of 0.001
Dropout level voltage:	97 to 98% of pickup
Pickup level current:	0.000 to 1.500 pu in steps of 0.001
Dropout level current:	97 to 98% of pickup
Level accuracy:	±0.5% or ±0.1% of rated (whichever is greater)
Pickup delay:	0.000 to 65.535 seconds in steps of 0.001
Time accuracy:	±3% or ±42 ms (whichever is greater)
Operate time:	<42 ms at 1.10 × pickup at 60 Hz

CONTACT INPUTS

Input rating:	300 V DC maximum
On threshold:	70% of nominal voltage setting or 20 V (whichever is greater)
Off threshold:	30% of nominal voltage setting or 15 V (whichever is greater)
Bounce threshold:	50% of nominal voltage setting or 20 V (whichever is greater)
AZ threshold:	80% of nominal voltage setting
Overvoltage threshold:	130% of nominal voltage setting or 285 V maximum
Maximum current:	10 mA during turn on, 0.5 mA steady-state
Nominal voltage:	24 to 250 V
Input impedance:	active
Recognition time:	<1 ms
Debounce timer:	1.50 to 16.00 ms in steps of 0.25
Chatter detection timer:	1 to 100 seconds
Chatter state changes:	10 to 100

DISTURBANCE DETECTOR (50DD)

Type:	sensitive current disturbance detector
Range:	0.004 to 0.04 pu (twice the current cut-off level threshold)

FLEXCURVES

Number:	4 (A through D)
Reset points:	40 (0 through 1 of pickup)
Operate points:	80 (1 through 20 of pickup)
Time delay:	0 to 65535 ms in steps of 1

FLEXELEMENTS

Elements:	8
Operating signal:	any analog actual value, or two values in differential mode
Operating signal mode:	signed or absolute value
Operating mode:	level, delta
Comparator detection:	over, under
Pickup level:	–90.000 to 90.000 pu in steps of 0.001
Hysteresis:	0.1 to 50.0% in steps of 0.1
Delta dt:	20 ms to 60 days
Pickup delay:	0.000 to 65.535 seconds in steps of 0.001
Dropout delay:	0.000 to 65.535 seconds in steps of 0.001

FLEXMATRIX

Principle:	aggregates and conditions signals for tripping and auxiliary functions
Timing accuracy:	±1 ms

FLEX STATES

Number:	up to 256 logical variables grouped under 16 Modbus addresses
Programmability:	any logical variable, contact, or virtual input

GROUND INSTANTANEOUS OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Overreach:	<2%
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Operate time:	<16 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup:	±3% or ±4 ms (whichever is greater)

GROUND TIME OVERCURRENT

Current:	phasor or RMS
Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Curve shapes:	IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I2t, FlexCurves™ (programmable), definite time (0.01second base curve)
Curve multiplier:	0.01 to 600.00 in steps of 0.01
Reset type:	instantaneous/timed (per IEEE)
Timing accuracy for 1.03 to 20 × pickup:	±3.5% of operating time or ±1 cycle (whichever is greater)

NEGATIVE-SEQUENCE DIRECTIONAL OVERCURRENT

Directionality:	co-existing forward and reverse
Polarizing:	voltage
Polarizing voltage:	V_2
Operating current:	I_2
Level sensing (zero-sequence):	|I_0| – K × |I_1|
Level sensing (negative-sequence):	|I_2| – K × |I_1|
Restraint, K:	0.000 to 0.500 in steps of 0.001
Characteristic angle:	0 to 90° in steps of 1
Limit angle:	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy:	±2°
Offset impedance:	0.00 to 250.00 ohms in steps of 0.01
Pickup level:	0.05 to 30.00 pu in steps of 0.01
Dropout level:	<98%
Operation time:	<16 ms at 3 × pickup at 60 Hz

NEGATIVE-SEQUENCE INSTANTANEOUS OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Overreach:	<2%
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Operate time:	<20 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup:	±3% or ±4 ms (whichever is greater)

NEGATIVE-SEQUENCE OVERVOLTAGE

Pickup level:	0.000 to 1.250 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Timing accuracy:	±3% or ±20 ms (whichever is greater)
Operate time:	< 30 ms at 1.10 × pickup at 60 Hz

NEGATIVE-SEQUENCE TIME OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Curve shapes:	IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier:	0.01 to 600.00 in steps of 0.01
Reset type:	instantaneous/timed (per IEEE) and linear
Timing accuracy for 1.03 to 20 × pickup:	±3.5% of operating time or ±1 cycle (whichever is greater)

NEUTRAL DIRECTIONAL OVERCURRENT

Directionality:	co-existing forward and reverse
Polarizing:	voltage, current, dual
Polarizing voltage:	V_0 or VX
Polarizing current:	IG
Operating current:	I_0
Level sensing:	3 × (|I_0| – K × |I_1|), IG; independent for forward and reverse
Restraint (K):	0.000 to 0.500 in steps of 0.001
Characteristic angle:	–90 to 90° in steps of 1
Limit angle:	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy:	±2°
Offset impedance:	0.00 to 250.00 ohms in steps of 0.01
Pickup level:	0.002 to 30.000 pu in steps of 0.01
Dropout level:	<98%
Operation time:	<16 ms at 3 × pickup at 60 Hz

NEUTRAL INSTANTANEOUS OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Overreach:	<2%

Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Operate time:	<20 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup:	±3% or ±4 ms (whichever is greater)

NEUTRAL OVERVOLTAGE

Pickup level:	0.000 to 1.250 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01 (definite time) or user-defined curve
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Timing accuracy:	±3% or ±20 ms (whichever is greater)
Operate time:	<3 cycles at 1.10 × pickup

NEUTRAL TIME OVERCURRENT

Current:	phasor or RMS
Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Curve shapes:	IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier:	0.01 to 600.00 in steps of 0.01
Reset type:	instantaneous/timed (per IEEE)
Timing accuracy at 1.03 to 20 × pickup:	±3.5% of operating time or ±1 cycle (whichever is greater)

NON-VOLATILE LATCHES

Type:	set-dominant or reset-dominant
Number:	16 (individually programmed)
Output:	stored in non-volatile memory
Execution sequence:	as input prior to protection, control, and FlexLogic

PHASE DIRECTIONAL OVERCURRENT

Relay connection:	90° (quadrature)
Quadrature voltage:	phase A (VBC), phase B (VCA), phase C (VAB) for ABC phase sequence; phase A (VCB), phase B (VAC), phase C (VBA) for ACB phase sequence
Polarizing voltage threshold:	0.000 to 3.000 pu in steps of 0.001
Current sensitivity threshold:	0.05 pu
Characteristic angle:	0 to 359° in steps of 1
Angle accuracy:	±2°
Tripping operation time:	<12 ms, typically (reverse load, forward fault)
Blocking operation time:	<8 ms, typically (forward load, reverse fault)

PHASE INSTANTANEOUS OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Overreach:	<2%
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Reset delay:	0.00 to 600.00 seconds in steps of 0.01
Operate time:	<16 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup:	±3% or ±4 ms (whichever is greater)

PHASE OVERVOLTAGE

Voltage:	phasor only
Pickup level:	0.000 to 3.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Operate time:	<3 cycles at 1.10 × pickup
Timing accuracy:	±3% or ±4 ms (whichever is greater)

PHASE TIME OVERCURRENT

Current:	phasor or RMS
Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	<98% of pickup
Level accuracy at 0.1 to 2.0 × CT:	±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT:	±1.5% of reading
Curve shapes:	IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier:	0.01 to 600.00 in steps of 0.01
Reset type:	instantaneous/timed (per IEEE)
Timing accuracy at 1.03 to 20 × pickup:	±3.5% of operating time or ±1 cycle (whichever is greater)

PHASE UNDERVOLTAGE

Pickup level:	0.000 to 1.100 pu in steps of 0.001
Dropout level:	>102% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Curve shapes:	GE IAV Inverse; Definite Time (0.1 second base curve)
Curve multiplier:	0.00 to 600.00 in steps of 0.01
Timing accuracy for operation at <0.90 × pickup:	±3.5% of operate time or ±4 ms (whichever is greater)

PROTECTION FLEXLOGIC

Programming:	Reverse Polish Notation with graphical visualization (keypad programmable)
Lines of code:	512
Internal variables:	64
Supported operations:	NOT, XOR, OR (2 to 16 inputs), AND (2 to 16 inputs), NOR (2 to 16 inputs), NAND (2 to 16 inputs), latch (reset-dominant), edge detectors, timers
Inputs:	any logical variable, contact, or virtual input
Number of timers:	32
Pickup delay:	0 to 60000 (ms, seconds, or minutes) in steps of 1
Dropout delay:	0 to 60000 (ms, seconds, or minutes) in steps of 1

PROTECTION VIRTUAL INPUTS

Input points:	64
Programmability:	self-reset or latched
Output points:	96
Programmability:	output of a protection FlexLogic equation or input to a protection FlexLogic equation

REMOTE INPUTS (IEC 61850 GSSE/GOOSE)

Input points:	64
Remote devices:	32
Default states on loss of communications:	on, off, latest/off, latest/on
Remote double-points status inputs:	16

REMOTE OUTPUTS (IEC 61850 GSSE/GOOSE)

Standard output points:	32
User output points:	32

SENSITIVE DIRECTIONAL POWER

Measured power:	three-phase, true RMS
Stages:	2
Characteristic angle:	0 to 359° in steps of 1
Calibration angle:	0.00 to 0.95° in steps of 0.05
Minimum power:	–1.200 to 1.200 pu in steps of 0.001
Pickup level accuracy:	±1% or ±0.001 pu (whichever is greater)
Hysteresis:	2% or 0.001 pu (whichever is greater)
Pickup delay:	0.00 to 600.00 seconds in steps of 0.01
Time accuracy:	±3% or ±4 ms (whichever is greater)
Operate time:	50 ms

SMALL SIGNAL OSCILLATION DETECTOR

Measured value:	any analog value
Elements:	2
Inputs:	6
Minimum pickup:	0.02 to 10.00 pu in steps of 0.01 for alarm; 0.05 to 10.00 pu in steps of 0.01 for trip
Pickup level accuracy:	±5% or ±0.1 pu (whichever is greater)
Pickup delay:	definite time, 0.00 to 600.00 seconds in steps of 0.01
Time accuracy:	±3% or ± 20 ms (whichever is greater)
Operate time:	3 / (4 × fs) to 1 / fs, where fs is the signal frequency

VT FUSE FAILURE SUPERVISION

Elements:	1 per source
Monitored parameters:	V_2, V_1, I_1

Automation

AUTOMATION LOGIC

Number of lines of logic:	4096
Number of blocks:	1
Edit and view capability:	yes
Logic type:	cyclic
Programming language:	proprietary
Execution rate:	50 ms
Variable types:	Boolean, IEEE floating point
Boolean operations:	NOT, XOR, OR, AND, NOR, NAND, any contact input, any direct input, any teleprotection input, any remote input, any virtual input, any automation logic operand
Arithmetic operations:	add, subtract, multiply, divide, negation, absolute value, square root, exponent, logarithm, sine, cosine, tangent, arcsine, arccosine, arctangent, natural logarithm, base 10 algorithm, modulo, ceiling, floor
Control operations:	latch, timer, comparator, absolute timer functions
Boolean inputs:	any contact input, direct input, teleprotection input, remote input, virtual input, or automation logic operand
Analog inputs:	any FlexAnalog™ quantity
Virtual inputs:	128
Virtual outputs:	255
Remote inputs:	64
Remote outputs:	64
Remote devices:	32

AUTOMATION VIRTUAL INPUTS

Input points:	128
Programmability:	self-reset or latched

AUTOMATION VIRTUAL OUTPUTS

Output points:	255
Programmability:	output of an automation logic equation or input to an automation logic equation

BREAKER CONTROL

Mode:	single-pole, three-pole
Control:	open/close, local/SCADA
Control seal-in:	0 to 2000 ms in steps of 1

BREAKER INTERLOCKING

Interlocking inputs:	6

DISCONNECT CONTROL

Mode:	single-pole, three-pole
Control:	open/close, local/SCADA
Control seal-in:	0 to 2000 ms in steps of 1

DISCONNECT INTERLOCKING

Interlocking inputs:	3

FAST LOAD SHEDDING (FLS)

Elements:	1
Algorithm:	adaptive (using priorities) or static (using trip masks)
Static mode scenarios:	up to 32
Adaptive mode priorities:	up to 128
Total of infeeds, loads, and aggregators monitored per C90Plus:	up to 64 via communications plus 6 local infeeds or loads
Infeeds:	up to 32
Loads per end device:	up to 6 per GOOSE data message
Loads per C90Plus:	up to 70 (up to 64 from end device, plus up to 6 from local contact input/output cards)
Load groups:	up to 32
Operate time:	1/8 power system cycle (exclusive of communications and end device delays)
Power measurement updating:	250 ms

FREQUENCY RATE OF CHANGE LOAD SHEDDING

Elements:	4
Minimum voltage:	0.10 to 1.25 pu in steps of 0.01
Pickup level:	0.10 to 15.00 Hz/s in steps of 0.01
Dropout level:	pickup – 0.02 Hz/s
Pickup delay:	0.00 to 99.99 seconds in steps of 0.001
Dropout delay:	0.00 to 99.99 seconds in steps of 0.001
Level accuracy:	30 mHz/s or 3.5% (whichever is greater)
Time accuracy:	±3% or ±4 ms (whichever is greater)
95% settling time for df/dt:	<24 cycles
Operate time (typical):	6 cycles at 2 × pickup; 5 cycles at 3 × pickup; 4 cycles at 5 × pickup

LOAD SHEDDING SOURCE

Minimum voltage pickup:	0.00 to 1.25 pu in steps of 0.01
Minimum voltage dropout:	pickup + 0.20 pu
Maximum negative-sequence voltage pickup:	0.00 to 1.25 pu in steps of 0.01
Maximum negative-sequence voltage dropout:	pickup – 0.20 pu

SELECTOR SWITCH

Upper position limit:	1 to 7 in steps of 1
Selecting mode:	time-out or acknowledge
Time-out timer:	3.0 to 60.0 seconds in steps of 0.1
Control inputs:	step-up and three-bit
Power-up mode:	restore from non-volatile memory or synchronize to a three bit control input or synchronize/restore mode

SYNCHROCHECK

Elements:	2
Maximum voltage difference:	0 to 100000 volts in steps of 1
Maximum angle difference:	0 to 100° in steps of 1
Maximum frequency difference:	0.00 to 2.00 Hz in steps of 0.01
Hysteresis for maximum frequency difference:	0.00 to 0.10 Hz in steps of 0.01
Dead source function:	none, LV1 & DV2, DV1 & LV2, DV1 or DV2, DV1 xor DV2, DV1 & DV2 (L = live, D = dead)

UNDERFREQUENCY LOAD SHEDDING

Elements:	10
Pickup level:	45.00 to 65.00 Hz in steps of 0.01
Dropout level:	pickup level + 0.03 Hz
Pickup delay:	0.00 to 99.99 seconds in steps of 0.01
Dropout delay:	0.00 to 99.99 seconds in steps of 0.01
Level accuracy:	±0.01 Hz
Time accuracy:	±3% or 4 ms (whichever is greater)
Operate time (typical):	4 cycles at –0.1 Hz/s change; 3.5 cycles at –0.3 Hz/s change; 3 cycles at –0.5 Hz/s change

UNDERVOLTAGE LOAD SHEDDING

Elements:	6
Pickup level:	0.10 to 1.25 pu in steps of 0.01
Dropout level:	pickup level + 0.20 pu
Pickup delay:	0.00 to 99.99 seconds in steps of 0.01
Dropout delay:	0.00 to 99.99 seconds in steps of 0.01
Level accuracy:	±0.5% of reading from 10 to 208 volts
Time accuracy:	±3% or 4 ms (whichever is greater)
Operate time (typical):	2 cycles at 0.90 × pickup

Equipment Manager

BATTERY MONITOR

Principle:	monitors battery voltage and auxiliary alarms
Hysteresis:	5%
Timing accuracy:	1 cycle

BREAKER ARCING CURRENT

Elements:	1 per breaker (to a maximum of 2)
Principle:	accumulates contact wear (Ixt), measures fault magnitude and duration
Auxiliary contact compensation:	0 to 50 ms in steps of 1
Alarm threshold:	0 to 50000 kA2-cycle in steps of 1
Fault duration accuracy:	0.25 of power cycle

Metering

CURRENT METERING

Type:	phase and ground RMS current
Accuracy at 0.1 to 2.0 × CT:	±0.25% of reading or ±0.1% of rated (whichever is greater) at 50/60 Hz nominal frequency
Accuracy at >2.0 × CT:	±1.0% of reading, at 50/60 Hz nominal frequency

DATA LOGGER

Channels:	1 to 16
Parameters:	any FlexAnalog value
Statistics:	maximum and time of maximum, minimum and time of minimum, average
Alarms:	high, high-high, low, low-low

ENERGY METERING

Type:	positive and negative watt-hours and var-hours
Accuracy:	±2.0% of reading
Range:	–2.0 × 109 to 2.0 × 109 MWh/Mvarh
Parameters:	three-phase only
Update rate:	50 ms

FREQUENCY METERING

Accuracy at V = 0.8 to 1.2 pu:	±0.001 Hz (when voltage signal is used for frequency measurement)
Accuracy at I = 0.1 to 0.25 pu:	±0.05 Hz (when current signal is used for frequency measurement)
Accuracy at I > 0.25 pu:	±0.001 Hz (when current signal is used for frequency measurement)

PHASOR MEASUREMENT UNIT

Output format:	per IEEE C37.118 standard
Channels:	14 synchrophasors, 8 analogs, 16 digitals
TVE (total vector error):	<1%
Triggering:	frequency, voltage, current, power, rate of change of frequency, user-defined
Reporting rate:	1, 2, 5, 10, 12, 15, 20, 25, 30, 50, or 60 times per second
Number of clients:	One over TCP/IP port, two over UDP/IP ports
AC ranges:	as indicated in appropriate specifications sections
Network reporting format:	16-bit integer or 32-bit IEEE floating point numbers
Network reporting style:	rectangular (real and imaginary) or polar (magnitude and angle) coordinates
Post-filtering:	none, 3-point, 5-point, 7-point
Calibration:	±5°

POWER METERING

Real power accuracy:	±1.0% of reading at –1.0 ≤ PF < 0.8 and 0.8 < PF ≤ 1.0
Reactive power accuracy:	±1.0% of reading at –0.2 ≤ PF ≤ 0.2
Apparent power accuracy:	±1.0% of reading

VOLTAGE METERING

Type:	RMS voltage
Accuracy:	±0.5% of reading from 30 to 208 volts at 50/60 Hz nominal frequency

Digital Fault Recorder

DISTURBANCE RECORDER

Storage capacity:	one record with all available channels at 60 samples per second for 40 seconds
Maximum records:	64
Sampling rate:	1 sample per cycle
Sampling accuracy:	<1 ms per second of recording
Analog channels:	64
Analog channel data:	any FlexAnalog™ quantity
Digital channels:	32
Digital channel data:	any contact input, direct input, remote input, virtual input, automation logic operand, or FlexLogic operand
Triggers:	any digital change of state (user-programmable), undervoltage, overvoltage, undercurrent, overcurrent, underfrequency, overfrequency, rate of change of frequency, 1 user-programmable trigger, 1 lock
Storage modes:	automatic overwrite, protected
Triggering modes:	time window from rising edge of trigger, continuous recording as long as trigger is active
Pre-trigger window:	0 to 100%
Data storage:	non-volatile memory

EVENT RECORDER

Storage capacity:	8192 events
Time tag:	to 1 ms
Triggers:	any contact input, direct input, remote input, virtual input, logic operand, or self-test event
Data storage:	non-volatile memory

FAULT REPORT

Records:	5
Data:	station and circuit ID, date and time of trip, fault type, active setting group at time of trigger, pre-fault current and voltage phasors (2 cycles before 50DD associated with fault report source), fault current and voltage phasors (1 cycle after trigger), protection elements operated at time of trigger, firmware revision
Triggers:	user-selected operand
Data storage:	non-volatile memory

FAULT LOCATOR

Method:	single-ended
Accuracy:	2% of line length
Units:	miles or kilometers
Trigger:	from fault report
Data storage:	non-volatile memory

FAST LOAD SHED REPORT

Records:	16
Data:	FLSC relay name, firmware revision, contingency date/time and duration, steady-state power flows, infeeds lost, scenarios encountered, load groups shed, settings last change date
Triggers:	any FLS contingency
Data storage:	non-volatile memory

TRANSIENT RECORDER

Storage capacity:	one record with all available channels at 32 samples per cycle for 1 minute
Number of records:	1 to 64
Sampling rate:	16 to 256 samples per power cycle
Timestamp accuracy:	<10 µs per second of recording
Analog channels:	up to twelve 16-bit, unprocessed, AC input channels
Analog channel data:	any FlexAnalog quantity
Digital channels:	up to 128
Digital channel data:	any contact input, direct input, remote input, virtual input, automation logic operand, or FlexLogic operand
Sampled channels:	up to 24
Sampled channel data:	16-bit, unprocessed sampled channels
Triggers:	any digital channel change of state, undervoltage, overvoltage, undercurrent, overcurrent, underfrequency, overfrequency, rate of change of frequency, one userprogrammable, one block
Storage modes:	automatic overwrite, protected
Triggering modes:	time window from rising edge of trigger, continuous recording as long as trigger is active
Pre-trigger window:	0 to 100%
Data storage:	non-volatile memory

Front Panel Interface

ANNUNCIATOR

Inputs:	288
Windows per page:	12 to 48
Pages:	up to 24
Sequence:	manual reset, locking
Off indication:	alarm inactive and reset
Flashing indication:	alarm active and not acknowledged, alarm inactive and not acknowledged
On indication:	alarm active and acknowledged, alarm inactive and not reset
Priority:	by active window and page number
Data storage:	non-volatile memory

CONTROL DISPLAY

Devices:	status and control of up to 8 power system devices
Pushbuttons:	30 dedicated user-programmable pushbuttons
Functionality:	supports select-before-operate functionality

DIGITAL FAULT RECORDER DISPLAY

Sequence of events:	displays the stored sequence of events record
Fault reports:	display and retrieval of the critical metrics of a stored fault report
Transient records:	retrieval of a stored transient record
Disturbance records:	retrieval of a stored disturbance record
Fast load shedding (FLS) records:	retrieval of a stored FLS record

EQUIPMENT MANAGER DISPLAY

Battery monitoring:	displays the current battery voltage and alarm states

METERING DISPLAY

Summary:	displays present values of voltage, current, real power, reactive power, power factor, and frequency on a per-phase and total basis
Phasors:	digital and graphical display of present voltage and current magnitudes and angles
Sequence components:	displays present magnitudes and angles of current and voltage sequence components
Energy:	four-quadrant display of accumulated energy
Demand:	present and peak demand values for current and real, reactive, and apparent power

MAINTENANCE DISPLAY

Input and output status:	displays the current status of all contact inputs and outputs

Hardware

AC CURRENT

CT rated primary:	1 to 50000 A
CT rated secondary:	1 A or 5 A
Nominal frequency:	50 or 60 Hz
Relay burden:	<0.2 VA secondary
Conversion range:	0.02 to 46 × CT rating RMS symmetrical
Current withstand:	20 ms at 250 × rated, 1 second at 100 × rated, continuous at 3 × rated

AC VOLTAGE

VT rated secondary:	50.0 to 240.0 V
VT ratio:	1.00 to 24000.0
Nominal frequency:	50 or 60 Hz
Relay burden:	<0.25 VA at 120 V
Conversion range:	1 to 275 V
Voltage withstand:	continuous at 260 V to neutral, 1 minute per hour at 420 V neutral

CONTACT INPUTS

Input rating:	300 V DC maximum
Selectable thresholds:	24 to 250 V
Maximum current:	10 mA during turn on, 0.5 mA steady-state
Recognition time:	<1 ms
Debounce timer:	1.50 to 16.00 ms in steps of 0.25

CONTACT OUTPUTS: CRITICAL FAILURE RELAY

Make and carry for 0.2 s:	10 A
Continuous carry:	6 A
Break at L/R of 40 ms:	0.250 A at 125 V DC; 0.125 A at 250 V DC
Operate time:	<8 ms
Contact material:	silver alloy

FORM-A RELAY

Make and carry for 0.2 s:	30 A per ANSI C37.90
Carry continuous:	6A
Break at L/R of 40 ms:	0.250 A DC at 125 V DC; 0.125 A DC at 250 V DC
Operate time:	<4 ms
Contact material:	silver alloy

CONTACT OUTPUTS: SOLID-STATE RELAY

Make and carry for 0.2 s:	30 A as per ANSI C37.90
Continuous carry:	6:00 AM
Break at L/R of 40 ms:	10 A at 250 V DC
Operate time:	<100 µs
Contact material:	silver alloy

CONTROL POWER EXTERNAL OUTPUT

Capacity:	100 mA DC at 48 V DC
Isolation:	2 kV

CRITICAL FAILURE RELAY

Make and carry for 0.2 s:	30 A as per ANSI C37.90
Carry continuous:	6:00 AM
Break at L/R of 40 ms:	0.250 A DC at 125 V DC; 0.125 A DC at 250 V DC; 0.10 A DC maximum at 125 V
Operate time:	<8 ms
Contact material:	silver alloy

ETHERNET PORTS

Standard:	1 port supporting Modbus TCP
Optional:	2 ports supporting DNP 3.0, IEC 60870-5-104, or IEC 61850 located on communications module
100Base-FX media type:	1300 nm, multi-mode, half/full-duplex, fiber optic with ST connector
10/100Base-TX media type:	RJ45 connector
Power budget:	10 dB
Maximum optical input power:	–14 dBm
Receiver sensitivity:	–30 dBm
Typical distance:	2.0 km
SNTP clock synchronization:	<10 ms typical

IRIG-B INPUT

Amplitude modulation:	1 to 10 V pk-pk
DC shift:	TTL
Input impedance:	50 kΩ
Isolation:	2 kV

POWER SUPPLY

Nominal DC voltage:	125 to 250 V
Minimum DC voltage:	80 V
Maximum DC voltage:	300 V
Nominal AC voltage:	100 to 240 V at 50/60 Hz
Minimum AC voltage:	80 V at 48 to 62 Hz
Maximum AC voltage:	275 V at 48 to 62 Hz
Voltage withstand:	2 × highest nominal voltage for 10 ms
Voltage loss hold-up:	200 ms duration at nominal
Power consumption:	30 VA typical, 65 VA maximum

RS485 PORT

Baud rates:	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
Protocol:	Modbus RTU and DNP 3.0
Distance:	1200 m
Isolation:	2 kV

SOLID-STATE RELAY

Make and carry for 0.2 s:	30 A as per ANSI C37.90
Carry continuous:	6A
Break at L/R of 40 ms:	10.0 A DC at 250 V DC
Operate time:	< 100 µs

USB PORT

Standard:	type B USB connector for EnerVista software

Communications

DIRECT INPUTS	
Input points:	96 per channel
Remote devices:	16
Default states on loss of communications:	On, Off, Latest/On, Latest/Off
Ring configuration:	yes, no
Data rate:	64 or 128 kbps
CRC:	32-bit
CRC alarm:	responding to rate of messages failing the CRC
CRC alarm monitoring message count:	10 to 10000 in steps of 1
CRC alarm threshold:	1 to 1000 in steps of 1
Unreturned messages alarm:	responding to rate of unreturned messages in the ring
Unreturned messages alarm monitoring message count:	10 to 10000 in steps of 1
Unreturned messages alarm threshold:	1 to 1000 in steps of 1

DIRECT OUTPUTS	
Output points:	96 per channel

FAST LOAD SHEDDING (FLS) END DEVICE DATA UNITS (IEC 61850 GOOSE)	
Number:	64

MODBUS USER MAP	
Number:	up to 256 Modbus addresses
Programmability:	any setting or actual value in decimal

REMOTE INPUTS (IEC 61850 GSSE/GOOSE)	
Input points:	64
Remote devices:	32
Default states on loss of communications:	On, Off, Latest/Off, Latest/On
Remote double-point status inputs:	16

REMOTE OUTPUTS (IEC 61850 GSSE/GOOSE)	
Standard output points:	12A
User output points:	32

TELEPROTECTION	
Input points:	16 per channel
Remote devices:	3
Default states on loss of communications:	On, Off, Latest/On, Latest/Off
Ring configuration:	No
Data rate:	64 or 128 kbps
CRC:	32-bit

Inter-Relay Communications

TYPICAL DISTANCE	
RS422 interface:	1200 m (based on transmitter power; does not take into consideration the clock source provided by the user)
G.703 interface:	100 m
850 nm laser (multimode) interface:	2.0 km (50/125 µm cable with ST connector); 2.9 km (62.5/125 µm cable with ST connector)
NOTE:	The typical distances shown are based on the assumptions for system loss shown below. As actual losses vary from one installation to another, the distance covered by your system may vary.

LINK LOSSES (850 NM LASER, MULTIMODE MODULE)	
ST connector losses:	2 dB (total of both ends)
50/125 µm fiber loss:	2.5 dB/km
62.5/125 µm fiber loss:	3.0 dB/km
Splice loss:	one splice every 2 km, at 0.05 dB loss per splice
System margin:	3 dB of additional loss was added to calculations to compensate for all other losses, including age and temperature

LINK POWER BUDGET (850 NM LASER, MULTIMODE MODULE)	
Maximum optical input power:	–9 dBm
Minimum transmit power:	–22 dBm (into 50 µm fiber), –18 dBm (into 62.5 µm fiber)
Maximum receiver sensitivity:	–32 dBm
Power budget:	10 dBm (for 50 µm fiber), 14 dBm (for 62.5 µm fiber)
NOTE:	These power budgets are calculated from the manufacturer's worst-case transmitter power and worst-case receiver sensitivity.

Tests

PRODUCTION TESTS	
Thermal:	products go through a 12 hour burn-in process at 60°C

TYPE TESTS	
Vibration:	IEC 60255-21-1, 1G (class Bm)
Shock / bump:	IEC 60255-21-2, 10G (class Bm)
Seismic (single axis):	IEC 60255-21-3, 1G / 3.5 mm (class 1)
Make and carry (30 A):	IEEE C37.90
Conducted immunity:	IEC 61000-4-6 / IEC 60255-22-6, class 3 (10 V RMS)
Surge:	IEC 61000-4-5 or IEC 60225-22-5, 1.2/50 test up to level 4 (4 kV)
Burst disturbance (1 MHz oscillatory):	IEC 60255-22-1 up to 2.5 kV at 1 MHz damped
Fast transients:	ANSI/IEEE C37.90.1, EC61000-4-4 class 4, (2 kV, 5 kHz / 4 kV, 2.5 kHz, 2 kV on data control ports and inputs/outputs), IEC 60255-22-4
Radiated immunity:	IEC 61000-4-3 / IEC 60255-22-3 class 3 (10 V/m) or IEEE C37.90.2 radiated RFI (35 V/m)
Power frequency disturbance:	IEC 61000-4-8 (30 A/m) class 4
Radiated/conducted emissions:	IEC 60255-25 / CISPR 11/22 class A
Insulation resistance:	IEC 60255-5
Dielectric strength:	IEC 60255-5, ANSI/IEEE C37.90
Dielectric across relay contacts:	IEEE C37.90 (1.6 kV)
Electrostatic discharge:	EN 61000-4-2, IEC 60255-22-2 8 kV C, 15 kV A, L4
Voltage dips/interruptions/variations:	IEC 61000-4-11 (30% 1 cycle), IEC 60255-11
AC ripple:	IEC 61000-4-17 (standard)
Interruptions on DC power:	IEC 61000-4-29
Damped magnetic immunity:	IEC 61000-4-10 (level 5, 100A/m)
Impulse voltage withstand:	EN/IEC 60255-5 (5 kV)
Humidity cyclic:	IEC 60068-2-30, 6 days 55°C, 95%RH (variant 1)

Environmental

OPERATING TEMPERATURE	
Cold:	IEC 60068-2-1, 16 hours at –40°C
Dry heat:	IEC 60068-2-2, 16 hours at 80°C

OTHER ENVIRONMENTAL SPECIFICATIONS	
Altitude:	up to 2000 m
Installation category:	II
IP rating:	IP30 for front, IP10 for back

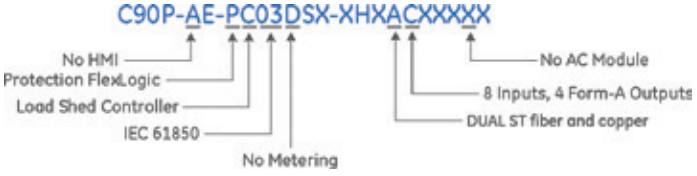
Approvals and Certification

APPROVALS	
UL508 17th edition and C22.2 No.14-05:	UL listed for the USA and Canada

CERTIFICATION	
CE LVD 2006/95/EC:	EN/IEC 61010-1:2001 / EN60255-5:2000
CE EMC 89/336/EEC:	EN 60255-26:2004-08

Typical C90Plus Fast Load Shed Order Codes:

Controller



Aggregator

Ordering

	C90P	*	E	*	*	**	*	*	*	X	H	*	*	*	*	*	*	**	*	Description
Base Unit	C90P																			Base Unit
Front Panel		A																		Annunciator
		H																		Annunciator & HMI
Language			E																	English
Protection				X																None
				P																Basic Protection and Protection FlexLogic
				O																Basic protection, protection FlexLogic, small-signal oscillation detection
Automation					S															Breaker Control & Synchrocheck
					E															Breaker Control, Synchrocheck, & Automation Controller
					L															Breaker Control, Synchrocheck, Automation Controller, & Load Shedding
					C															Fast load shedding (controller)
					A															Fast load shedding (aggregator)
Communications						01														ModBus TCP/IP, DNP 3.0 Serial, and Serial Modbus
						02														ModBus TCP/IP & IEC 61850
						03														ModBus TCP/IP, IEC 61850, & DNP 3.0 TCP/IP
						04														ModBus TCP/IP, IEC 61850, & IEC 60870-5-104
						A2														ModBus TCP/IP, IEC 61850 & PRP
						A3														ModBus TCP/IP, IEC 61850, DNP 3.0 TCP/IP & PRP
						A4														ModBus TCP/IP, IEC 61850, IEC 60870-5-104 & PRP
Metering							D													No AC metering; data logger for non-metering data
							S													Basic Metering
							P													Basic Metering & Synchrophasors
							L													Basic Metering & Data Logger
							U													Basic Metering, Data Logger, & Synchrophasors
Digital Fault Recorder								S												Fault Recorder & Sequence of Events
								D												Fault Recorder, Sequence of Events, & Disturbance Recorder
Equipment Manager									X											No equipment manager features
									S											Circuit breaker, communications statistics, and battery monitor
Harsh Environment Coating										X										None (Standard)
										C										Harsh Environment Conformal Coating
Power Supply											H									High (88-275VAC/80-300VDCI)
Inter-relay Communications												X								Reserved
												B								G.703, 64/128 kbps, two channels
												C								RS422, 64/128 kbps, two channels, two clock inputs
												D								850 nm, 64/128 kbps, ST multi-mode laser, two channels with DDMI
Communications Module													X							None
													A							Dual ST fiber and copper module
I/O Module														X	X	X	X	X		None
														A	A	A	A	A		8 Inputs, 4 Form-A Outputs with Voltage & Current Monitoring
														B	B	B	B	B		8 Inputs, 4 Solid State Outputs with Voltage & Current Monitoring
														C	C	C	C	C		8 Inputs, 4 Form-A Outputs
														D	D	D	D	D		4 Inputs, 8 Form-A Outputs
														E	E	E	E	E		23 Inputs
														F	F	F	F	F		12 Form-A Outputs
AC Module																			X	No AC module
																			01	5 VT & 7 CT (5 Amp current)
																			02	5 VT & 7 CT (1 Amp current)

Notes for Fast Load Shedding:

Front Panel: Can be either A or H (HMI is an option)

Automation: C or A for Controller or Aggregator

Communication Module: Only option A available

AC Module: X – none only option

Accessories for the C90Plus

- MultiLink Ethernet Switch ML3K-F-HX-A-B-E-E-W-W-Y-Y-X-X-X
- Viewpoint Engineer VPE-1
- Viewpoint Maintenance VPM-1
- Viewpoint Monitoring IEC 61850 VP-1-61850
- 350 Feeder Protection 350-E-P5-G5-H-E-S-N-M-3E-D-N
- 339 Motor Protection 339-E-P5-G5-H-E-S-N-M-3E-D-N
- F35 Feeder Protection F35-N03-VKH-F8L-H6P-MXX-PXX
- F60 Feeder Protection F60-N03-VKH-F8L-H6P-MXX-PXX
- F650 Bay Controller F650-B-F-B-F-1-G-0-HI-6E
- 850 Feeder Protection 850-E-P5-NN-G5-H-N-N-A-N-N-G-S-S-B-B-SE-N-N-B-N
- 869 Motor Protection 869-E-P5-NN-G5-H-R-R-A-N-N-G-S-P-B-B-SE-N-N-B-N
- G30 Generator Protection G30-N03-VKH-F8L-H6P-M8L-PXX
- G60 Generator Protection G60-N03-VKH-F8L-H6P-M8L-PXX

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