GE VERNOVA

HardFiber

Process Bus System

Instruction Manual

Product version: 8.7x

Publication code: 1601-0011-AQ2

HardFiber Process Bus System Instruction Manual for version 8.7x.

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Part number: 1601-0011-AQ2 (May 2026)

HardFiber Process Bus System

Chapter 1: Introduction

This chapter introduces the HardFiber system.

1.1 Introduction

The GE Vernova Multilin™ HardFiber™ Process Bus System is a remote input/output (I/O) architecture for protection, control, monitoring, and metering. It replaces copper wiring in electrical substation switchyards with standard fiber-optic communications. The system includes all physical components required for installation: relays, factory pre-terminated fiber cables, fiber cross-connect panels, factory connectorized copper cables, and switchyard I/O interface devices known as Bricks or S-Brick(Simple Brick).

S-Brick implements the concept of an IEC 61850 merging unit, expanded to optically connect relays with all types of input and output signals in the switchyard, not just instrument transformers. The relays are the proven GE VERNOVA Multilin Universal Relays (URs) with long field records. The UR product family incorporates all major applications, from a simple feeder relay to a sophisticated generator-protection package.

The HardFiber system replaces custom copper wiring between power apparatus in the switchyard and protection and control devices in the control house with pre-fabricated off-the-shelf components that use standard physical and logical interfaces. It shortens deployment time, reduces labor requirements, facilitates work transfer, improves quality, simplifies procurement, and improves safety. The engineering, installation, commissioning, and operation of the system are based mostly on existing skill-sets.

The HardFiber system uses the UR devices as they have been used to date and continue to be used outside of the HardFiber system. Simply order the process bus module version of the UR device and the HardFiber S-Brick. For the UR, the current transformer (CT), voltage transformer (VT), and contact input/output plug-in modules are replaced with an IEC 61850 Process Card, so that optical signals rather than copper signals interface with the UR device. The balance of the relay hardware, firmware, functionality, software, and documentation are unchanged. The Process Card and plug-in modules for traditionally hard-wired I/O are logically interchangeable. Personnel trained on UR devices require only a minor update related to the HardFiber system. Settings and application templates developed for UR devices are applicable with minor modifications required to configure the remote I/O from the Bricks. Testing procedures and automated test scripts require only minor adjustments to accommodate the HardFiber system.

The primary role of Bricks is to limit the amount of copper wiring by containing it as close to the power apparatus as possible, and to provide a transparent and unified digital interface to the relays. Bricks are simple signal converters rather than full-featured Intelligent Electronic Devices (IEDs). Bricks do not have separate settings, an elaborate human-machine interface (HMI), or native firmware.

The remote I/O data from/to the Bricks implements the IEC 61850 process bus protocol allowing integration of devices from other vendors as they become available. Details of the implementation are outlined in an appendix of this instruction manual and have been independently verified by a third-party test laboratory. Experience with or knowledge of IEC 61850 is not required to implement a HardFiber system.

The HardFiber system does not require system-level configuration software to organize and use the remote I/O (process bus) data from the Bricks. Configuration of the system is relay-centric as traditionally practiced, with complimentary and well-established EnerVista software capable of fully configuring the system. See the appropriate UR instruction manual for more information on the EnerVista software

The total HardFiber system includes the cables and accessories necessary to connect the UR devices to the S-Bricks and the S-Bricks to the power apparatus. All cables (outdoor fiber, indoor fiber, and copper) are rated for direct use with no extra protective gear. All cables are factory pre-terminated and tested in order to speed deployment, improve quality, and reduce on-site labor requirements. As a result, cable length data is needed when ordering the ruggedized Brick, and cable length estimation becomes a more stringent part of the engineering process. Or, with a few additional tools and skills, users can instead make their own HardFiber cables. The HardFiber system using the S-Brick provides only the UR devices and the S-Brick itself. Users must provide mounting cabinets for the S-Brick (where appropriate), all copper and fiber optic cables, and fiber-optic patch panels necessary to interface the S-Brick to primary apparatus and the S-Brick to UR devices.

The HardFiber process bus is physically and logically unrelated to other integration protocols, such as IEC 61850 station bus, DNP, Modbus, Direct I/O, and Ethernet Global Data (EGD). These continue to be supported by the UR devices independently.

This instruction manual contains the information necessary to design, build, and test the remote I/O (process bus) aspect of the system. It is of interest to protection engineering, installation, commissioning, and testing teams. The SCADA/HMI and communication teams refer primarily to the relay manuals.

This manual is organized into the following chapters:

- The System overview section on page 2-1 presents an overview of the HardFiber system, providing an understanding of design principles and objectives. It summarizes the functionality of each UR device working in a HardFiber system.
- The Component descriptions section on page 3-1 outlines the functionality and intended application of each component of the HardFiber system
- The Installation section on page 4-1 contains mounting, wiring, and cabling information
- The UR settings and actual values section on page 5-1 outlines settings required to configure the remote I/O (process bus) aspect of the UR devices. FlexLogic™ operands and FlexAnalog™ values specific to the HardFiber systems on UR devices are tabulated. See the B95^Plus manual for that product.
- The Diagnostics and troubleshooting section on page 6-1 describes the diagnostic and self-tests performed. Instructions are given on how to troubleshoot HardFiber self-test alarms.
- The Testing and commissioning section on page 7-1 requires no special tools
- The Application examples section on page 8-1 provides examples emphasizing the novel features of the HardFiber system

Appendices are as follows:

- The Message format section on page A-1 is an interoperability document describing IEC 61850 communication between Bricks and relays. All data items are disclosed, including internal diagnostics and items related to the inner workings of the Bricks. Users of systems with UR devices do not need this appendix.
- The Specifications section on page B-1 lists technical specifications for the components of the HardFiber system. For UR specifications, see its instruction manual.

1.2 Safety symbols and definitions

Before attempting to install or use the device, review all safety indicators in this document to help prevent injury, equipment damage, or downtime.

The following safety and equipment symbols are used in this document.

⚠DANGER Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠WARNING Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠CAUTION Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE Indicates practices not related to personal injury.

1.2.1 General cautions and warnings

The following general safety precautions and warnings apply.

⚠DANGER Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example such as can arise from high voltage connected to low voltage terminals.

Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example such as can arise from high voltage connected to low voltage terminals.

Follow the requirements of this manual, including adequate wiring size and type, terminal torque settings, voltage, current magnitudes applied, and adequate isolation/clearance in external wiring from high to low voltage circuits.

Use the device only for its intended purpose and application.

Ensure that all ground paths are uncompromised for safety purposes during device operation and service.

Ensure that the control power applied to the device, the alternating current (AC), and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.

Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations.

Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.

Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device.

For tests with secondary test equipment, ensure that no other sources of voltages or currents are connected to such equipment and that trip and close commands to the circuit breakers or other switching apparatus are isolated, unless this is required by the test procedure and is specified by appropriate utility/plant procedure.

When the device is used to control primary equipment, such as circuit breakers, isolators, and other switching apparatus, all control circuits from the device to the primary equipment must be isolated while personnel are working on or around this primary equipment to prevent any inadvertent command from this device.

Use an external disconnect to isolate the mains voltage supply.

⚠WARNING The S-Brick surface mount option must be installed behind an electrical barrier, that is, in an enclosed rack system, an electrical enclosure, or a panel system, and within an authorized area.

⚠CAUTION LED transmitters are classified as IEC 60825-1 Accessible Emission Limit (AEL) Class 1M. Class 1M devices are considered safe to the unaided eye. Do not view directly with optical instruments.

NOTICE This product is rated to Class A emissions levels and is to be used in Utility, Substation Industrial environments. Not to be used near electronic devices rated for Class B levels.

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1.3 For further assistance

For product support, contact the information and call center as follows:

GE VERNOVA
650 Markland Street
Markham, Ontario
Canada L6C 0M1
Worldwide telephone: +1 905 927 7070
Europe/Middle East/Africa telephone: +34 94 485 88 54
North America toll-free: 1 800 547 8629
Fax: +1 905 927 5098
Worldwide e-mail: multilin.tech@gevernova.com
Website: https://www.gevernova.com/grid-solutions/multilin

HardFiber Process Bus System

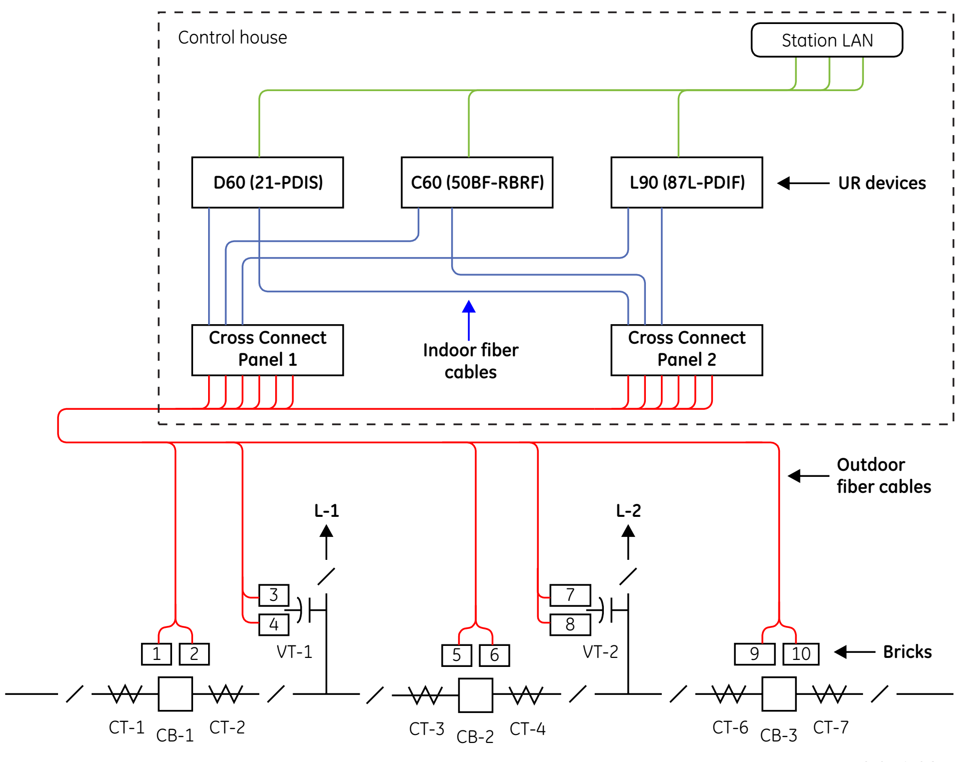
Chapter 2: System overview

This chapter explains the components in a HardFiber system and describes the compatible UR device.

2.1 Architecture

The figure shows the components of a HardFiber system that uses UR devices. In this example, the Bricks are ruggedized and outdoors.

Figure 2-1: Example of a HardFiber system using S-Bricks



These components in the order of signal flow are as follows:

- Copper cables (not shown)
- Bricks
- Outdoor fiber cables
- Cross Connect Panels
- Indoor fiber cables
- Compliant relays (UR with Process Cards)

The *copper cables* make the connections between the copper terminals inside the power equipment to the Bricks mounted in the switchyard, typically on the outside of the equipment.

The *Bricks* convert copper signals to and from digital optical signals. Copper signals include CTs, VTs, contact inputs, and contact outputs.

The *outdoor fiber cables* make the optical connection among the Bricks in the switchyard and the Cross Connect Panels in the control house. They supply power to the Brick via an embedded copper wire pair.

The *Cross Connect Panels* are where individual fibers in the outdoor cables are patch-corded to individual fibers of indoor cables, completing the associations between the relays and the Bricks for a given station topology. Also, the panels distribute direct current (DC) to the Bricks via the outdoor fiber cables.

The *indoor fiber cables* make the optical connection between the process bus ports of the relays and the Cross Connect Panel.

The *Process Cards* in the relays convert Brick digital optical signals for UR device.

The HardFiber system using the S-Brick supplies the two fundamental components of the system: the S-Brick to convert analog signals to digital signals, and the Process Cards in the relays. The S-Brick and the Process Cards perform complementary signal conversion functions. When applying the S-Brick, the user supplies the copper cables to make connections to power equipment, the outdoor fiber cables, DC power to the S-Brick, fiber optic patch panels to connect outdoor fiber cables to indoor fiber cables, and the indoor fiber cables.

NOTE

A HardFiber system includes all required process bus material. No additional items, such as Ethernet switches, clocks, or clock distribution systems, are required.

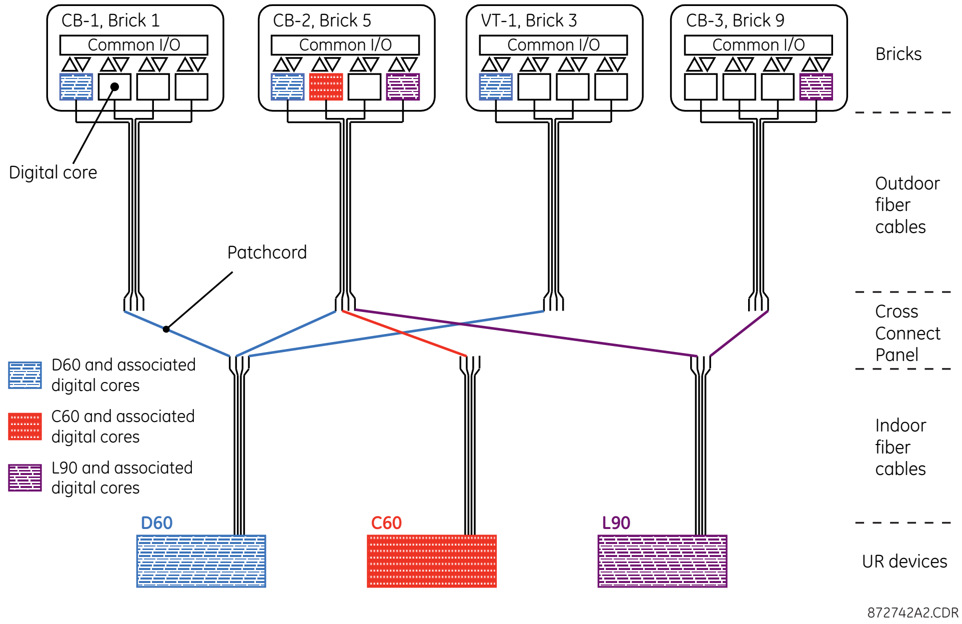
The preceding figure also shows that UR devices interface with several Bricks installed at different locations within the switchyard. For example, the D60s need to communicate with the Bricks on two breakers and one CVT. For this reason, the Process Card has eight optical fiber ports, allowing each UR device to connect to eight Bricks. Conversely, Bricks need to interface with several IEDs. For example, a Brick on the center breaker needs to communicate with the zone protection relay on each side of the breaker and the breaker failure relay. Thus, Bricks have four digital cores, each of which can communicate by fiber exclusively with one relay.

Fiber connections to all the station's Process Card ports and all its Brick cores are brought by indoor and outdoor fiber cables to Cross Connect Panels. Here, each fiber of each cable is broken out to an LC type optical coupler. Patch cords are then plugged into the couplers to interconnect Brick digital cores to Process Card ports according to the functional requirements and configuration of the station's power apparatus. Thus continuous and dedicated point-to-point optical paths are created between relays and Bricks, without switches or other active components.

This patching or "hard fibering" is what gives the HardFiber system its name. This approach takes advantage of the fact that a relay needs to talk to only the few Bricks that have input or outputs related to that relay's function, that only a few relays are interested in any given Brick, and that the relay-Brick connections change rarely, only when the station one-line changes. The number of ports on Process Cards (eight) and the number of digital cores in a Brick (four) have been chosen to meet or exceed the requirements of all typical applications. For those few instances where additional Brick digital cores are required, for instance for VTs on a large bus, additional Bricks can be installed sharing the same copper interface to the primary apparatus.

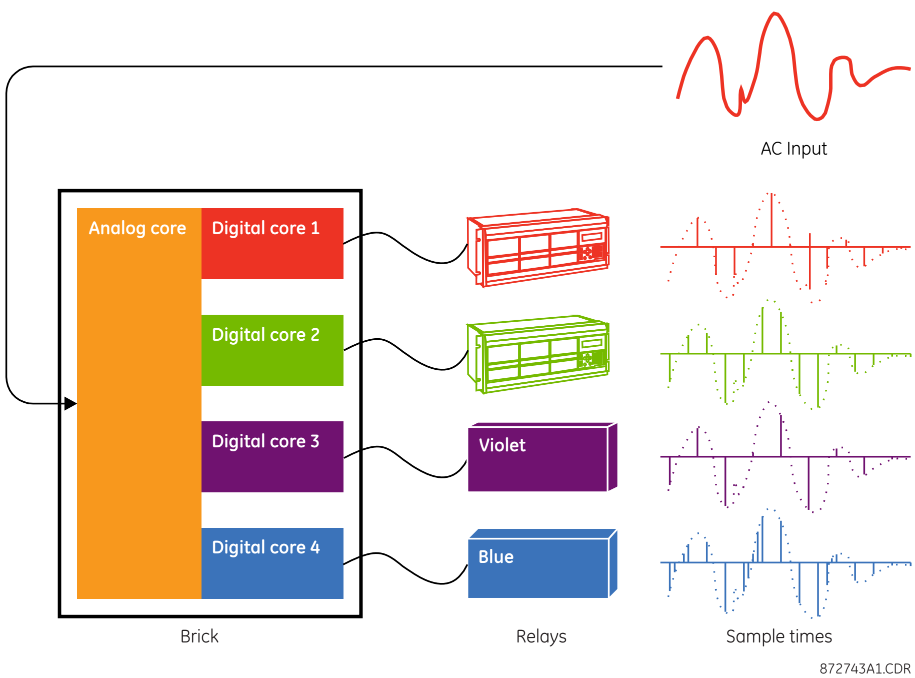
The following figure provides an expanded view of the previous one. Digital cores from Bricks 1, 5, and 3 are cross-connected to the D60. A digital core in Brick 5 is cross-connected to the C60. Digital cores from Bricks 5 and 9 are cross-connected to the L90. Note that the choice of cores and Process Card ports is arbitrary.

Figure 2-2: Cross-connection of Bricks and IEDs



The various relay protection and measuring elements that use AC data from multiple Bricks must have the currents and voltages at various locations sampled at the same instant. The existing UR method for determining the time of the samples is maintained in HardFiber systems. Each relay contains a sample clock that is phase and frequency locked to the power system quantities measured by that relay. At each tick of the sample clock, a GOOSE Ethernet frame is sent by the relay to each connected Brick digital core. Digital cores sample the quantities on receipt of each frame. Different relays can sample at different rates or with different phase, but as each is connected to different and independent cores, there is no conflict. Thus each relay is able to sample in a way optimal for its application, independently from other relays, and no external clocks are required.

Figure 2-3: Brick digital cores sampling asynchronously



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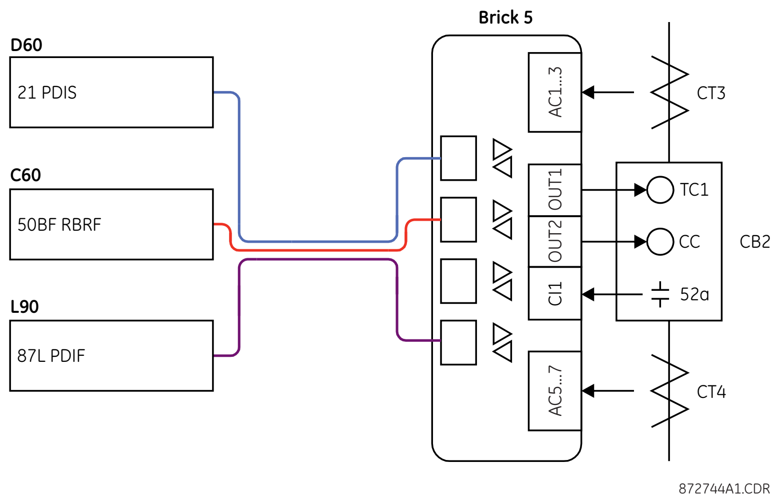
2.2 System setup process

The primary consideration in setting up a HardFiber system is input/output requirements. This task is similar to that performed in a conventional protection application, except that the user considers the inputs and outputs required by all of the relays that can be connected to a given S-Brick.

To illustrate, the following figure further examines the sample system. The D60 needs the current infeed to line L1 through CT4, and it needs to trip CB2. The L90 needs the current infeed to line L2 through CT3, and it needs to trip CB2. The C60 needs the current through CB2 through either CT3 or CT4 and CB2's status (52a), and it needs to trip CB2, all for breaker failure. The C60 also can need to close CB2 if it incorporates reclosing and/or operator control. Therefore, all of these items are connected to Brick 5, making them available to all of the connected relays, although each relay uses only selected items, discarding the rest.

Figure 2-4: Input/output allocation example



Having determined the requirements for Brick inputs/outputs, the next step is to allocate physical positions for the Bricks, Cross Connect Panels, and relays, and to design the routes for the outdoor and indoor fiber cables. With the electrical arrangement complete, the cable lengths are determined and a material list for the process bus is compiled.

The EnerVista Setup software included with the UR device also is used to configure the relays in HardFiber process bus systems. A **Remote Resources** menu item appears in the software, allowing the user to declare the S-Bricks that the relay is to communicate with, and the function of the inputs and outputs on the Brick for relay usage. This process is described in Settings on page 5-1. Afterwards, the UR protection elements, schemes, logic, and other functions are configured as usual.

Users are encouraged to upgrade the UR device to its latest firmware version before use with a HardFiber S-Brick. Firmware upgrades sometimes include fixes for operation with the S-Brick.

2.3 Redundancy

Redundant protection is a common practice within utilities. The HardFiber system supports this philosophy using duplicated Bricks and data cross-checking. Users can apply redundant A and B systems each with its own Bricks, cables, and relays.

A HardFiber system allows a single relay to communicate with duplicated Bricks. Simply setting two Bricks as origins for an AC bank causes the relay to use CT/VT signals from the second Brick when trouble or failure is detected in the first Brick (see Settings on page 5-1).

When two Brick origins have been set for an AC bank, the relay can cross-check the values received against each other. With UR devices, the user can bias the relay either towards security or dependability. When biased towards security, protection is blocked if communication is lost from either Brick or if either Brick asserts a diagnostic flag, or if there is a discrepancy between the analog signals from the two Bricks. When biased towards dependability, protection is blocked if communication is lost from both Bricks, if both Bricks assert a diagnostic flag, or if there is a discrepancy between the analog signals from the two Bricks. If a single Brick is lost, the processing of protection continues with the AC signals from the healthy Brick.

Brick duplication is shown in the Example of a HardFiber system using S-Bricks on page 2-1, where two Bricks are applied (odd and even numbering) at each location in the switchyard. The fiber cabling and Cross Connect Panels are also duplicated but A and B relays are not provided. The scheme can be further enhanced by adding duplicate relays. The duplicate relays utilize spare digital cores in the duplicate Bricks. This scheme provides the high level of availability currently found in conventional redundant schemes, but also provides a high level of security (through signal comparison) not achievable in today's schemes.

2.4 UR devices

The HardFiber system is compatible with the following UR devices when the UR is ordered with a Process Bus Module:

- B30 Bus Differential Protection System
- C30 Controller System
- C60 Breaker Protection System
- C95 Breaker Protection System
- C70 Capacitor Bank Protection and Control System
- D30 Line Distance Protection System
- D60 Line Distance Protection System
- F35 Multiple Feeder Protection System
- F60 Feeder Protection System
- G60 Generator Protection System
- L30 Line Current Differential Protection System
- L90 Line Current Differential Protection System
- M60 Motor Protection System
- N60 Network Stability and Synchrophasor Measurement System
- T35 Transformer Protection System
- T60 Transformer Protection System

Descriptions of these devices follow.

The B90 and L60 products do not support the process bus module.

2.4.1 Features per product

The table lists features per product when using the process bus module/HardFiber.

The number of features available in a UR device can differ from the number given in a UR instruction manual when the device contains a process bus module (Process Card). For example, for many devices, there are six signal sources available when a Process Card is installed, while the instruction manual indicates there is a maximum of two or four.

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Table 2-1: Elements per product with process bus module

Feature	Rule	Max	B30	C30	C60 /95	C70	D30	D60	F35	F60	G60	L30	L90	M60	N60	T35	T60
Automatic Voltage Regulator	# of elements; 0 if Enhanced Capacitor Bank Control software option not ordered	3				3											
Autoreclose 3P	# of elements; 0 for L30 when Three-Pole Auto-Reclose not ordered	6					2		6	4		3					
Autoreclose 1P 3P		1			1			1					1				
Auxiliary Overvoltage	# of elements	3	3		3	3	3	3	3	3	3	3	3	3			3
Auxiliary Undervoltage	#of elements	3	3		3		3	3	3	3	3	3	3	3			3
Breaker Arcing Current (I2t)	# of elements	6			6	3	2	2; 4 with Breaker and Half option	6	4		2	2; 4 with Breaker and Half option	2		6	4; 6 with 6 windings option
Breaker Control	# of elements	6	6	6	6	3	2	2; 4 with Breaker and Half option	6	4	2	2	2; 4 with Breaker and Half option	2	6	6	4; 6 with 6 windings option
Breaker Failure	# of elements; if B30, # of sources	6	6		6	3		2; 4 with Breaker and Half option		4	2	2	2; 4 with Breaker and Half option	2			4; 6 with 6 windings option
Breaker Flashover		6			6	3		2; 4 with Breaker and Half option	6	4			2; 4 with Breaker and Half option	2			4; 6 with 6 windings option
Breaker Restrike	# of elements	6			6	3		2; 4 with Breaker and Half option	6	4			2; 4 with Breaker and Half option	2			4; 6 with 6 windings option
Capacitor Bank Overvoltage	# of elements; 1 per voltage bank	3				3											
Compensated Bank Neutral Unbalance	# of current banks	3				3											
CT Fail	# of current banks	6									4	2	2; 4 with Breaker and Half option	4		6	6
CT Trouble	# of zones from software option; 2 on B30	6	2														

Feature	Rule	Max	B30	C30	C60 /95	C70	D30	D60	F35	F60	G60	L30	L90	M60	N60	T35	T60
Disturbance Detection	# of elements; 1 per source	6	6		4	6	2	2; 4 with Breaker and Half option	6	4	4	2	2; 4 with Breaker and Half option	4	6	6	4; 6 with 6 windings option
Frequency Rate of Change		4						4		4	4		4		4		4
Ground Instantaneous Overcurrent	# of elements	12	12		8	6	4	4; 8 with Breaker and Half option	12	8	4	4	4; 8 with Breaker and Half option	4			8; 12 with 6 windings option
Ground Time Overcurrent	# of elements	6	6		4	3	2	2; 4 with Breaker and Half option	6	4	2	2	2; 4 with Breaker and Half option	2		6	4; 6 with 6 windings option
Incipient Cable Fault	# of elements	6							6	4							
Negative Sequence Directional Overcurrent		2				2	2	2		2	2	2	2	2			2
Negative Sequence Instantaneous Overcurrent		2				2	2	2	2	2	2	2	2	2			2
C70 Negative Sequence OV	# of voltage banks if at least one	3				3											
Negative Sequence Overvoltage		3					3	3		3	3	3	3	3			
Negative Sequence Time Overcurrent		2				2	2	2	2	2	2	2	2	2			2
Neutral Directional OC		6				3	2	2; 4 with Breaker and Half option		4	4	2	2; 4 with Breaker and Half option	2			4
Neutral Instantaneous Overcurrent	# of elements	12	12		8	6	4	2; 4 with Breaker and Half option	12	8	2	4	2; 4 with Breaker and Half option	8			8; 12 with 6 windings option
Neutral Overvoltage	# of elements; if C70 has at least one voltage bank	3	3		3	3	3	3	3	3	3		3	2			3
Neutral Time Overcurrent	# of elements	6	6		4	3	2	2; 4 with Breaker and Half option	6	4	1	2	2; 4 with Breaker and Half option	2			4; 6 with 6 windings option
Neutral Voltage Unbalance	# of voltage banks	3				3											
Non Volatile Latches		48	16	48	48	16	16	16	16	16	16	16	16	16	16	16	16
Overfrequency		4						4		4	4		4	4	4		4
Phase Current Unbalance	# of elements	3				3											

Feature	Rule	Max	B30	C30	C60 /95	C70	D30	D60	F35	F60	G60	L30	L90	M60	N60	T35	T60
Phase Directional		2				2	2	2		4	2	2	2	2			2
Phase Instantaneous Overcurrent	# of elements	12	12		8	6	4	4; 8 with Breaker and Half option	12	8	4	4	4; 8 with Breaker and Half option	8	12		8; 12 with 6 windings option
Phase Overvoltage	# of elements; 0 if no VT banks	3			3	3	3	3		3	3	3	3	3	3		3
Phase Time Overcurrent	# of elements	6	6		4	3	2	2; 4 with Breaker and Half option	6	4	2	2	2; 4 with Breaker and Half option			6	4; 6 with 6 windings option
Phase Undervoltage	# of voltage banks; if C70 has at least one voltage bank	3	3		3	3	3	3	3	3	3	3	3	3	3		3
Restricted Ground Fault	# of elements; 0 if L90 has no inzone transformer	6								4	4		2; 4 with Breaker and Half option				4; 6 with 6 windings option
Sources	# of sources	6	6		4	6	2	2; 4 with Breaker and Half option	6	4	4	2	2; 4 with Breaker and Half option	4	6	6	4; 6 with 6 windings option
Synchrocheck		4			4		4	4		4	4	4	4		4		4
Underfrequency		6						6	6	6	6	6	6	6	6		6
UnderPower		2												2			
VT Fuse Failure	# of sources	6	2		4	6	2	2; 4 with Breaker and Half option		4	4	2	2; 4 with Breaker and Half option	4	6		4; 6 with 6 windings option
Wattmetric Ground Fault	# of elements	10					2	2	10	2			2				2

2.4.2 Overview of UR devices

The Universal Relay (UR) family is a suite of leading-edge protection and control products built on a common modular platform. All UR products feature high-performance protection, expandable input/output options, integrated control and metering, high-speed communications, and extensive programming and configuration capabilities. The modular approach facilitates user acceptance and reduces training time, commissioning, and upgrades.

A UR can be supplied in a variety of configurations and is available as a 19-inch rack horizontal mount unit or a reduced size (¾) vertical mount unit. The UR consists of the following modules: power supply, central processing unit (CPU), CT/VT input or Process Card, digital input/output, transducer input/output, and inter-relay communications.

FlexLogic is the UR family programming logic that provides the ability to create customized protection and control schemes, thereby minimizing the need and associated costs of auxiliary components and wiring.

The UR includes high accuracy metering and recording for AC signals. Voltage, current, and power metering are standard features. Current and voltage parameters are available as total root mean square (RMS) magnitude, and as fundamental frequency magnitude and angle.

The advanced disturbance and event recording features within the UR can significantly reduce the time needed for analysis of power system events and creation of regulatory reports. Recording functions include:

- Event recorder (SOE) with 1024 time-stamped events
- Oscillography with 64 digital channels and up to 40 analog channels
- Data logger process recording with 16 channels up to one sample/cycle/channel
- Fault reports summary of pre-fault and fault values

The UR provides advanced communications technologies for remote data and engineering access, making it easy to use and integrate into new and existing infrastructures. Networking interfaces include 100 Mbps fiber-optic Ethernet, RS485, RS232, RS422, G.703, and IEEE C37.94. The UR supports the following protocols: IEC 61850, DNP 3.0 Level 2, Modbus RTU, Modbus TCP/IP, IEC 60870-5-104, and Ethernet Global Data (EGD).

The UR is available with a multitude of input/output configurations to suit the most demanding application needs. The expandable modular design allows for easy configuration and upgrades. This includes trip-rated form-A, form-C, and solid state contact outputs with or without DC voltage and current monitoring, and isolated contact inputs with or without auto burnishing. Latched outputs can be used to develop secure interlocking applications and replace mechanical switches.

When used as part of a HardFiber system, a UR device is equipped with the IEC 61850 Process Card to receive inputs and exercise outputs. The Process Card and input/output modules for traditionally hard-wired signals are logically interchangeable and supported by single versions of the UR hardware, firmware, configuration software, and product documentation.

Compatible UR products are outlined as follows.

2.4.2.1 B30 Bus Differential Protection System

The B30 provides protection and metering for a busbar with up to six feeders. Protection is provided by a low-impedance percent differential element with features that make it immune to severe CT saturation. The differential function incorporates a CT saturation detection algorithm and uses percent differential and phase comparison principles for security and dependability. The relay responds to internal faults in ¾ of a cycle on average, and is secure during external faults with as little as 2 ms of linear CT performance during the fault.

The B30 is suited for application to small buses, areas between transformer bushing CTs and connecting breakers, and similar situations.

The B30 incorporates a dynamic busbar replica mechanism by associating the breaker and switch status signals with the zone currents, allowing advanced applications, such as in dual-bus single-breaker bus configurations.

The B30 includes a CT failure alarm function that monitors the level of the differential current. When the differential current stays above a pre-defined level for a pre-defined period of time, a CT trouble event is declared, and an alarm is raised. To prevent false tripping due to CT trouble, undervoltage supervision or an external check zone can be used.

For more information, see the B30 instruction manual.

2.4.2.2 C30 Controller System

The C30 is for power substation control and monitoring. It does not provide signal sources like other UR relays, so metering and protection functions are absent. However, with the same flexible and expandable input/outputs as the rest of the UR series, the C30 is suited for bay control, substation automation, and sequence of event recorder replacements.

When ordered with the Process Card, the C30 is expanded to provide high-speed transient recording for up to six sets of three-phase AC inputs plus six auxiliary AC inputs (a total of 24 channels). This allows the C30 to be deployed to replace legacy digital fault recorders (DFRs) as well as part of a HardFiber Process Bus System.

For more information, see the C30 instruction manual.

2.4.2.3 C60/95 Breaker Protection System

The C60/95 provides an integrated package for the protection, monitoring, and control of circuit breakers. It supports dual-breaker configurations, such as breaker-and-a-half or ring bus with two independent breaker failure functions, a dual-breaker autorecloser, and all of the current source inputs, digital inputs and digital outputs necessary to implement these functions. The breaker failure overcurrent elements are optimized for fast resetting to ensure sub-cycle dropout time even with severe CT subsidence current.

Multi-shot autoreclosing is provided for single-pole or three-pole autoreclosing, with independently programmable dead times for each shot and a variety of reclosing modes for the two breakers. This is complemented with synchrocheck elements allowing synchronism checking across each of the breakers.

A suite of protection functions is included in the C60/95, including phase/neutral/negative-sequence instantaneous overcurrent, phase/neutral/negative-sequence time overcurrent, voltage-based functions, and sensitive directional power.

For more information, see the C60/95 instruction manuals.

2.4.2.4 C70 Capacitor Bank Protection and Control System

The C70 is for protection, monitoring, and control of three-phase capacitor banks. It supports a variety of bank configurations, voltage, and current transformer arrangements, and protection techniques.

The key protection functions (voltage differential, neutral voltage unbalance, neutral current unbalance, phase current unbalance, and capacitor bank overvoltage) are designed to cover grounded and ungrounded, single and parallel banks. Sensitive protection functions support compensation for both external (system) unbalance and inherent internal unbalance of the capacitor bank itself. Compensation settings can be calculated automatically following repairs or other alternations of the bank.

The relay incorporates a number of control elements for automatic capacitor bank control. An automatic voltage regulator responding to voltage, reactive power, or power factor is provided, as well as a separate timer function to initiate controls on a predefined time/date basis. A capacitor bank control element provides remote/local and auto/manual control regulation, trip/close interlocking, and seal-in. A user-programmable time delay inhibits closing until after the bank discharges itself to a safe level.

For more information, see the C70 instruction manual.

2.4.2.5 D30 Line Distance Protection System

The D30 is for protection, monitoring, and control of transmission lines of any voltage level, without, with, and in the vicinity of series compensation, in three-pole tripping applications. Its primary function is three-zone phase distance and ground distance protection, either mho or quadrilateral as per user selection.

The distance elements are optimized to provide good measurement accuracy with a fast operating time, including applications with capacitive voltage transformers and with in-zone or adjacent series compensation.

The D30 phase distance zones can be configured to work with voltages and currents fed from VTs and CTs located independently from one another on either side of a three-phase power transformer. This feature allows backup protection for generators and power transformers.

A close-into-fault (or switch-on-to-fault) function is performed by the line pickup element. Out-of-step blocking and tripping, three-pole autoreclosing, synchrocheck, breaker failure, fault location, and current and voltage-based protection elements are available.

For more information, see the D30 instruction manual.

2.4.2.6 D60 Line Distance Protection System

The D60 is for protection, monitoring, and control of high and extra-high voltage transmission, sub-transmission, and distribution lines in three-pole and single-pole tripping applications. Its primary function is five-zone phase distance and ground distance protection, either mho or quadrilateral as per user selection.

The distance elements are optimized to provide good measurement accuracy with a fast operating time, including applications with capacitive voltage transformers and with in-zone or adjacent series compensation.

The D60 protection includes a state-of-the-art single-pole tripping package coupled with single-pole pilot-aided schemes for fast, secure fault clearing. The D60 supports dual CT inputs for dual breaker line terminals, with individual breaker failure and synchrocheck elements per breaker while incorporating a single coordinated dual-breaker autorecloser. The breaker failure elements feature sub-cycle overcurrent supervision dropout times, including instances with severe CT subsidence current.

The D60 can be ordered to provide synchronized phasor measurements per the IEEE C37.118 Standard for Synchrophasors for Power Systems over Ethernet, via a software configuration option. Existing D60 relays can be upgraded to provide synchrophasors through a software upgrade.

The D60 phase distance zones can be configured to work with voltages and currents fed from VTs and CTs located independently from one another on either side of a three-phase power transformer. This feature allows backup protection for generators and power transformers.

For more information, see the D60 instruction manual.

2.4.2.7 F35 Multiple Feeder Protection System

The F35 is for protection, monitoring, and control of up to five feeders with busbar voltage measurement or up to six feeders without busbar voltage. The F35 provides basic non-directional phase/neutral/ground, instantaneous and time overcurrent protection, and undervoltage protection for up to five or six feeders. Breaker control and independent breaker autoreclosing for up to five or six breakers are also provided.

The F35 provides is a cost-effective option to add detailed event recording and diagnostic information in applications where historically this information was not provided. In addition to the UR oscillography, event recording, and up to six fault locators, the F35 provides breaker wear information (I2t interrupted). The F35 also incorporates current-based detection of potential cable failures on underground cables for up to six feeders.

The F35 can be used to implement complex underfrequency or undervoltage automatic load shedding schemes as part of local or wide area remedial action schemes.

Voltage harmonics are measured for each available VT bank (if ordered) for the total harmonic distortion (THD) and 2nd to 25th harmonics per phase.

For more information, see the F35 instruction manual.

2.4.2.8 F60 Feeder Protection System

The F60 Feeder Protection System is for advanced protection, monitoring, and control for a single distribution feeder, or backup protection for transmission and sub-transmission lines.

The F60 provides directional and non-directional phase/neutral/ground, instantaneous and time overcurrent protection, and multiple voltage protection elements including negative sequence overvoltage. Breaker control and multi-shot three-pole autoreclosing are provided, along with breaker failure protection featuring sub-cycle overcurrent supervision dropout times, including instances with severe CT subsidence current.

The F60 provides a way to add detailed event recording and diagnostic information in distribution applications. In addition to the UR oscillography, event recording, and fault locator, the F60 provides a number of breaker monitoring functions, including breaker wear information (I^2t interrupted), breaker flashover, and breaker restrike detection. The F60 also implements a current-based element for the detection of potential cable failures on underground cables.

The F60 can be used to implement complex automatic load shedding schemes as part of local or wide area remedial action schemes based on underfrequency, rate of change of frequency (ROCOF), or undervoltage.

Current and voltage harmonics are measured for each CT/VT bank for the total harmonic distortion (THD) and 2nd to 25th harmonics per phase.

For more information, see the F60 instruction manual.

2.4.2.9 G60 Generator Protection System

The G60 protects, monitors, and controls medium to large power generators typically driven by steam, gas, or hydraulic turbines including pumped storage generators.

Primary generator protection is provided by a stator differential that incorporates an algorithm to detect CT saturation caused by either AC or DC components in the current, and the unit uses percent differential and phase comparison principles for security and dependability. The G60 also provides 100% stator ground, restricted ground fault, split phase protection, loss of excitation, overexcitation, third harmonic neutral undervoltage, generator unbalance, reverse and low forward power, and accidental energization protection elements. In addition, backup distance protection with power swing/out-of-step detection is provided.

Generator frequency protection includes underfrequency, overfrequency, and accumulated operation at off-nominal frequencies.

The G60 can be ordered to provide synchronized phasor measurements per the IEEE C37.118 Standard for Synchrophasors for Power Systems over Ethernet via a software option. Existing G60s can be upgraded to provide synchrophasors through a software upgrade.

Communications protocols include Ethernet Global Data (EGD) to facilitate integration of the G60 with GE generator control systems.

For more information, see the G60 instruction manual.

2.4.2.10 L30 Line Current Differential Protection System

The L30 is for protection, monitoring, and control of sub-transmission and distribution circuits requiring three-pole tripping only. Applications include both two-terminal and three-terminal lines.

The L30 employs a secure phase-segregated differential algorithm operating on a 64 kbps channel over direct fiber or multiplexed channel using G.703, RS422, or IEEE C37.94 media. The L30 differential element provides a restrained differential characteristic with adaptive restraint based on relay measurements. The L30 operating time is typically 1.0 to 1.5 cycles.

The basic current differential element operates on current input only. Additional sensitivity for long overhead lines or underground lines with significant capacitance can be achieved by applying charging current compensation available in the L30, provided terminal voltage measurements are applied to the relay.

The relay achieves a high degree of security by using a 32-bit cyclic redundancy code (CRC) to protect inter-relay communication packets against communications noise. Redundant channels, channel ID check, and channel asymmetry compensation allow secure application of the L30 over multiplexed communication channels.

In addition to line current differential protection, the L30 provides multiple UR standard current and voltage-based backup protection elements for phase and ground faults. Control elements for breaker autoreclosing and synchrocheck are optional.

The L30 can be ordered to provide synchronized phasor measurements per the IEEE C37.118 Standard for Synchrophasors for Power Systems over Ethernet via a software option. Existing L30s can be upgraded to provide synchrophasors through a software upgrade.

For more information, see the L30 instruction manual.

2.4.2.11 L90 Line Current Differential Protection System

The L90 is for protection, monitoring, and control of high and extra-high voltage transmission circuits requiring single-pole or three-pole tripping. Applications include both two-terminal and three-terminal lines.

The L90 employs a secure phase-segregated differential algorithm operating on a 64 kbps channel over direct fiber or multiplexed channel using G.703, RS422, or IEEE C37.94 media. The L90 differential element provides a restrained differential characteristic with adaptive restraint based on relay measurements. Typical L90 operating time is 1.0 to 1.5 cycles.

The basic current differential element operates on current input only. Additional sensitivity for long overhead lines or underground lines with significant capacitance can be achieved by applying charging current compensation available in the L90, provided terminal voltage measurements are applied to the relay.

The relay achieves a high degree of security by using a 32-bit CRC to protect inter-relay communication packets against communications noise. Redundant channels, channel ID check, and channel asymmetry compensation allow secure application of the L90 over multiplexed communications channels.

In addition to line current differential protection, the L90 provides three-zone phase and ground distance elements with power swing detection and load encroachment. The L90 supports multiple CT inputs for dual breaker line terminals, with individual breaker failure and synchrocheck elements per breaker while incorporating a single coordinated dual-breaker autorecloser. The breaker failure elements feature sub-cycle overcurrent supervision dropout times, including instances with severe CT subsidence current.

The L90 can be ordered to provide synchronized phasor measurements per the IEEE C37.118 Standard for Synchrophasors for Power Systems over Ethernet via a software option. Existing L90s can be upgraded to provide synchrophasors through a software upgrade.

For more information, see the L90 instruction manual.

2.4.2.12 M60 Motor Protection System

The M60 is for protection, monitoring, and control of medium and large sized single and two-speed motors. The M60 features an enhanced thermal model with custom curves, current unbalance biasing, and running and stopped exponential cooling curves. Resistance temperature detector (RTD) inputs are available for the thermal model RTD bias function.

Motor start and supervision functions include starts per hour, time between starts, restart time, acceleration time, emergency restart, and start inhibit. Additional protection functions include a percent differential element for stator differential, mechanical jam, current unbalance, reduced voltage starting, undercurrent, and underpower.

For more information, see the M60 instruction manual.

2.4.2.13 N60 Network Stability and Synchrophasor Measurement System

The N60 is for remedial action, special protection schemes, wide-area monitoring and control, and synchrophasor measurements.

Underfrequency, overfrequency, rate of change of frequency (df/dt), out-of-step and power swing detection, synchrocheck, overvoltage, undervoltage, and FlexMath allow automated network control applications, such as automatic load shedding, power balancing, and remedial action schemes.

The N60 meets all and exceeds many requirements of the IEEE C37.118 Synchrophasors for Power Systems standard. The N60 provides six Phasor Measurement Units (PMUs). The measurements from all six PMUs can be streamed simultaneously over different ports to different clients. The N60 can stream synchrophasors over its Ethernet ports at discrete rates from 1 to 60 per second. In addition to streaming synchrophasors, the N60 can be controlled through programmable triggers to store logging records of synchrophasor data in 25 MB of onboard memory.

The N60 provides metering of many power system quantities, including active, reactive, and apparent power on a per-phase and three-phase basis: true RMS values, phasors, and symmetrical components of currents and voltages, as well as power factor and frequency. Frequency can be measured independently and simultaneously from up to six different signals including currents if needed.

The N60 provides two distinct inter-relay communication methods, direct inputs/outputs and IEC 61850 GOOSE, for sharing of analog information about the state of a local station with other local or remote sites to facilitate a required control action.

For more information, see the N60 instruction manual.

2.4.2.14 T35 Transformer Protection System

The T35 is for protection, monitoring, and control of small, medium, and large three-phase power transformers with up to six restraints/windings, allowing inclusion of small buses and dual-breaker connections into the transformer differential zone.

The T35 performs automatic phase shift compensation for all types of power transformer winding connections and provides for automatic or user-definable reference winding selection for CT ratio matching. The percent differential element is complemented with the 2nd harmonic inrush and 5th harmonic overexcitation inhibits. The 2nd harmonic inhibit improves performance by using both the magnitude and phase angle of the 2nd harmonic ratio. In addition, it can be configured to operate on a per-phase or in a cross-phase blocking mode to accommodate transformers with exceptionally low 2nd harmonic content during inrush conditions.

An instantaneous unrestrained differential element provides fast fault clearing for heavy internal faults, and a number of UR standard current-based and voltage-based protection and control functions are provided as well.

For more information, see the T35 instruction manual.

2.4.2.15 T60 Transformer Protection System

2

The T60 is for protection, monitoring, and control of small, medium, and large three-phase power transformers with up to four restraints/windings.

The T60 performs automatic phase shift compensation for all types of power transformer winding connections and provides automatic or user-definable reference winding selection for CT ratio matching. The percent differential element is complemented with the 2^{nd} harmonic inrush and 5^{th} harmonic overexcitation inhibits. The 2^{nd} harmonic inhibit improves performance by using both the magnitude and phase angle of the 2^{nd} harmonic ratio. In addition, it can be configured to operate on a per-phase or in a cross-phase blocking mode to accommodate transformers with exceptionally low 2^{nd} harmonic content during inrush conditions.

Restricted ground/earth fault extends protection coverage to the neutral point of wye-connected windings where fault currents can be below the pickup of the main transformer differential elements.

Transformer monitoring features including volts-per-hertz, loss-of-life, aging factor, and hottest spot are available, and current harmonics are measured for each CT bank for the total harmonic distortion (THD) and 2^{nd} to 25^{th} harmonics per phase.

Three-zone back-up distance protection with power swing detection and load encroachment functions, synchrocheck, breaker failure plus a number of UR standard current-based and voltage-based protection and control functions are provided as well.

For more information, see the T60 instruction manual.

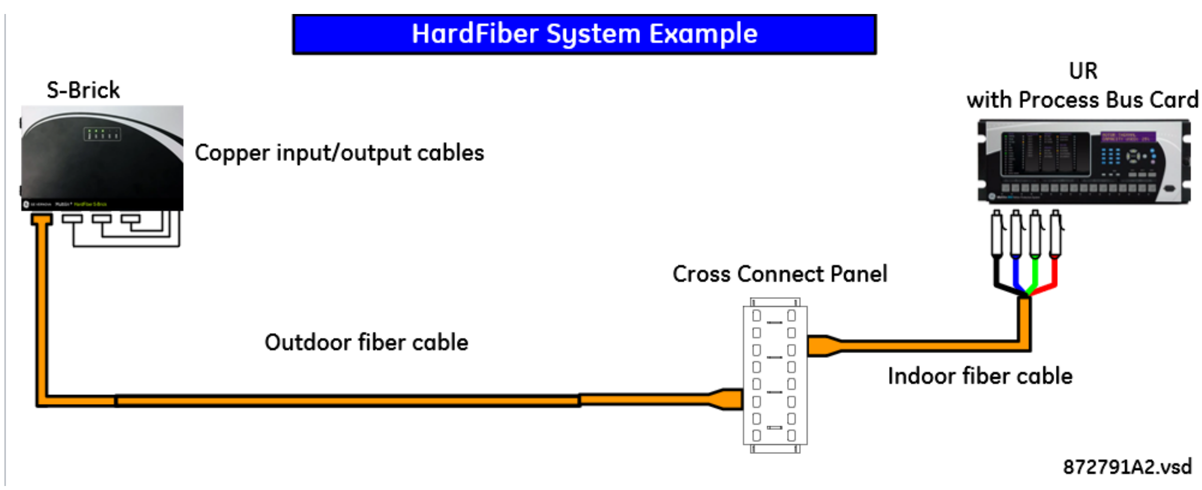
2.5 Order codes

This section lists the order codes for the HardFiber system components.

Order codes are subject to change without notice. See the web page for the latest options.

As an example, the figure shows that three copper cables, a Brick, an outdoor fiber cable, a Cross Connect Panel, and an indoor fiber cable are ordered. The UR already contains the Process Bus Card. Other examples are shown in the Installation chapter.

Figure 2-5: Example for ordering a HardFiber system



2.5.1 Brick order codes

The table shows the order codes for S-Brick and its mounting brackets are included. Brick order codes

	BRICK	– *	– **	– *	– ****	– *	– *	– *	Brick base unit
Base	BRICK								Base unit
Digital cores		4							Four fiber optic, digital cores
Power supply			HI						125/250 V DC power supply
Case				S					Standard kiosk case
CT/VT inputs					CC55				Eight 5 A CT inputs
					CV50				Four 5 A CT inputs and four VT inputs
					CC11				Eight 1 A CT inputs
					CV10				Four 1 A CT inputs and four VT inputs
Mounting						S			Surface mount for S Case only (Case must be S)
						F			Flush mount for S Case only (Case must be S)
						P			19" Rack mount for S Case only (Case must be S)
For future use							X		For future use
For future use								X	For future use

2.5.2 UR family order codes

For the UR family order codes, see the instruction manuals or the GE Vernova web site.

2.5.3 Process bus card order codes

The table shows the order codes for the Process Card for a UR device.

Table 2-2: UR Process Card order code

	UR	– *	
Base	UR		UR series device module
Process Card		81	Eight-port digital Process Card

HardFiber Process Bus System

Chapter 3: Component descriptions

This chapter describes the components of the HardFiber system.

3.1 Overview

An S-Brick HardFiber system has the following components:

- Copper cables, customer-supplied
- S-Bricks, including brackets
- Fiber cables, customer-supplied
- Fiber-optic patch panel, customer-supplied
- Compliant relays, for example UR device with Process Card

The *copper cable* is a short multi-conductor control cable for connecting the analog signals between a Brick and a power system element's CTs, VTs, position sensing contacts, trip circuits, and so on. These cables connect to the Brick at one end. The other end is terminated directly on the power equipment terminals, either on-site or at the power equipment manufacturer facility.

The *Brick* converts analog signals from devices such as CTs, VTs, and status sensing contacts to digital optical signals for transmission to compliant relays. Likewise, it converts digital optical signals originating from the relays to contact output closures for operation of control circuits (for example, trip and close). Bricks are intended to be located physically in, on, or near the power system elements in the switchyard.

The *fiber cable* makes all required connections between the Brick and the control house. In addition to four optical fibers, it contains two copper conductors that supply auxiliary power to the Brick.

A *Process Card* is a module that slides into a standard UR device, making it compliant with the process bus protocol and providing it access to the connected Bricks.

The HardFiber system using the S-Brick provides the S-Brick and Process Card, and the user must provide all interconnections among power system equipment, the S-Brick, and the UR devices.

The following sections describe the components in detail.

3.2 Brick

3.2.1 Overview

Bricks are the input/output interface to the copper environment. Their function is to acquire the AC current and voltage waveforms and contact input status from a primary power system element and transmit this information to the control house via optical fiber. Bricks also apply commands received from the control house to the associated switchyard elements.

Figure 3-1: S-Brick surface mount (order code S)

Figure 3-2: S-Brick flush mount (order code F)

Figure 3-3: S-Brick 19-inch rack mount (order code P)

To facilitate deployment, construction, testing, and maintenance, Bricks are designed to be simple. They have no settings; the system is configured via the relays. All process inputs are always sent to all connected relays and all valid commands are accepted from the connected relays. Bricks have no independent firmware; they inherit whatever firmware is needed from the connected UR devices. No maintenance port is required or provided, and diagnostics are sent to all connected relays. The user interface consists of five light-emitting diode (LED) indicator lights.

The are four Brick hardware options available. Other than mounting, the difference between variants is in the type and rating of the AC inputs, which are used for interfacing with conventional CTs and VTs. The following table lists the number and type of all process input/output points by variant. Most power system elements can be covered by a single Brick. If in a rare case more inputs and outputs are required at a given switchyard location, multiple Bricks can be deployed.

Table 3-1: Brick variants

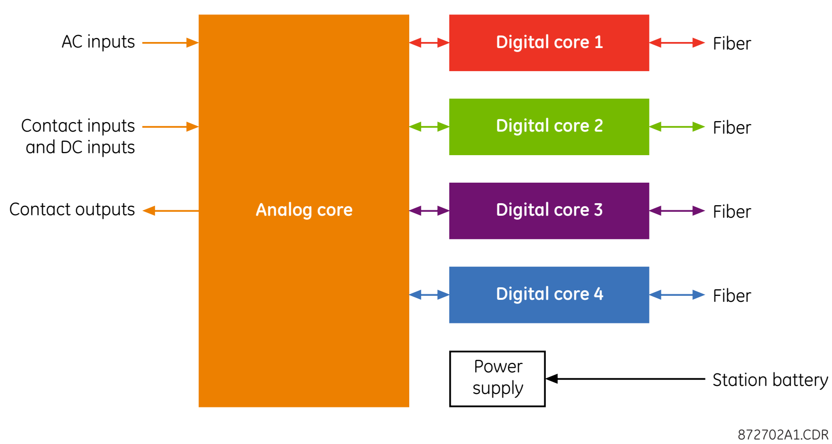
Order code	Brick inputs and outputs							
	Connector D			Connector C		Connector B		
	AC currents		AC voltages	DC inputs	Contact inputs	Contact outputs		
	1 A	5 A				SSR	Latching	Form-C
BRICK-4-HI-*-CC11	8	---	---	3	18	4	1	2
BRICK-4-HI-*-CC55	---	8	---	3	18	4	1	2
BRICK-4-HI-*-CV10	4	---	4	3	18	4	1	2
BRICK-4-HI-*-CV50	---	4	4	3	18	4	1	2

The S-Brick is for mounting inside a cabinet or kiosk and uses standard terminal blocks and fiber-optic connections.

3.2.2 Brick internals

The internal configuration of a Brick and S-Brick is an analog core, four digital cores, and a power supply.

Figure 3-4: Brick internals block diagram



The *analog core* interfaces with the copper input and output signals of the primary equipment, provides proper isolation against noise and other interference, converts analog signals to digital signals, and presents copies of these signals independently to each of the four digital cores using four independent digital data links. The analog core also operates its contact outputs in response to commands received from the digital cores via these four links. The characteristics of each of these copper Brick inputs and outputs are described in the following sections. A programmable logic device (PLD) performs the processing in the analog core; there is no microprocessor. The PLD program is fixed, thus there is no firmware maintenance issue with the analog core.

Each *digital core* transmits the data acquired from the analog core to the control house via an optical fiber Ethernet link. In the control house, each digital core can be cross-connected to a different relay; a single Brick can operate with up to four relays. Each digital core is completely independent from the other digital cores, in order for each of the relays connected to the Brick to be independent. As such, each relay can sample at a different rate, can run different firmware versions, and can even be by a different manufacturer with different process bus implementations.

The *power supply* conditions the DC power received from a Cross Connect Panel via copper conductors imbedded in the outdoor fiber cable, and distributes power at the appropriate internal voltages to the analog and digital cores. The DC power is expected to originate from a 125 or 250 V DC station battery source.

3.2.3 Brick LED indicators

Five LEDs on the top of the S-Brick, they are labeled Status and CH1 to CH4, summarize the state of the Brick. Brick status indicator LEDs

Green indicates that no error is detected. The analog core LED flashes green when the latching contact is open. Depending on the application, the latching contact being open can indicate lockout. A digital core LED flashes green when it is receiving any output "on" command.

When a digital core LED is off and the analog core LED is green, this indicates that no optical signal is being received by that digital core, that it is not connected to an active device in the control house. This can be due to one or more of the following conditions:

- The specific digital core is unused by design
- An interruption in the optical path
- The connected relay being faulty or powered down

Red indicates that an error is detected. For the analog core, it indicates unrecoverable hardware trouble and that factory repair is required. On digital cores, a red LED indicates one or more of the following conditions:

- The digital core is not receiving properly addressed messages, but is receiving an optical signal. Either the relay is not properly configured for the core or the core is connected to other than the intended relay.
- The digital core has suffered an unrecoverable failure and factory repair is needed

The table summarizes LED operation.

Table 3-2: Brick LED status

LED	Analog core condition	Digital core condition
Off	Power off	Power off or no optical signal received
Green	Analog core OK and latching contact closed	Digital core OK and all commands are off
Flashing green	Analog core OK and latching contact opened	Digital core OK and at least one command is on
Red	Analog core error detected; return Brick to factory	Digital core error or carrier healthy but no valid traffic. For the former, return Brick to factory.

3.2.4 Brick AC inputs

The Brick AC inputs sample and digitize conventional instrument transformer secondary signals. Bushing current transformers, free-standing current transformers, wound voltage transformers, capacitive voltage transformers, and bushing potential devices can be used. These are referred to in this document as CTs and VTs, and the associated Brick facilities and functions as CT inputs or VT inputs.

Each Brick provides eight AC inputs, either two banks each of four CT inputs, or one bank of four CT inputs and one bank of four VT inputs. The first bank, with AC inputs named AC1 through AC4, is always CT inputs. The second bank, with inputs named AC5 through AC8, can be either CT inputs or VT inputs, depending on the Brick order code. CT inputs can be ordered with either 1 A or 5 A nominal ratings.

Bricks with two CT banks (similar to the UR series type 8N CT/VT module) are typically installed on circuit breakers, free-standing CTs, and power transformers. Bricks with a CT bank and a VT bank (similar to the UR series type 8L CT/VT module) can be used on a VT and optionally pick up a set of CTs.

As with the UR family CT/VT modules, the first three inputs in each bank are intended for a three-phase set. That is, the first three inputs (the phase inputs, AC1 through AC3 or AC5 through AC7) are intended to be either IA/IB/IC, Vag/Vbg/Vcg, or Vab/Vbc/Vca. The VTs can be in either a wye or delta connection. Normally CTs are in a wye configuration. The fourth input (AC4 or AC8) of each bank is an auxiliary input, Ix or Vx, depending on whether the bank contains CT or VT inputs. Some typical applications for auxiliary AC inputs are ground current, neutral current, neutral voltage, capacitor unbalance current or voltage, and single-phase current or voltage.

Brick AC inputs are isolated from ground and from each other using internal auxiliary instrument transformers.

Figure 3-5: Example of circuit breaker AC input connections (dual Bricks / dual CTs)

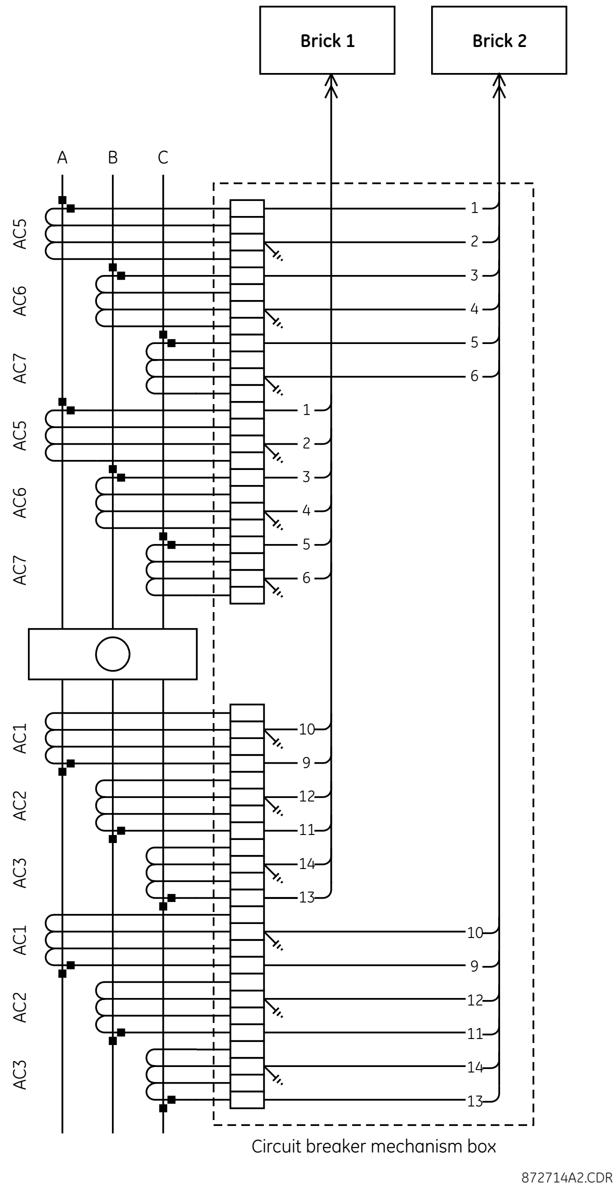


Figure 3-6: Example of circuit breaker AC input connections (dual Bricks with shorting blocks)

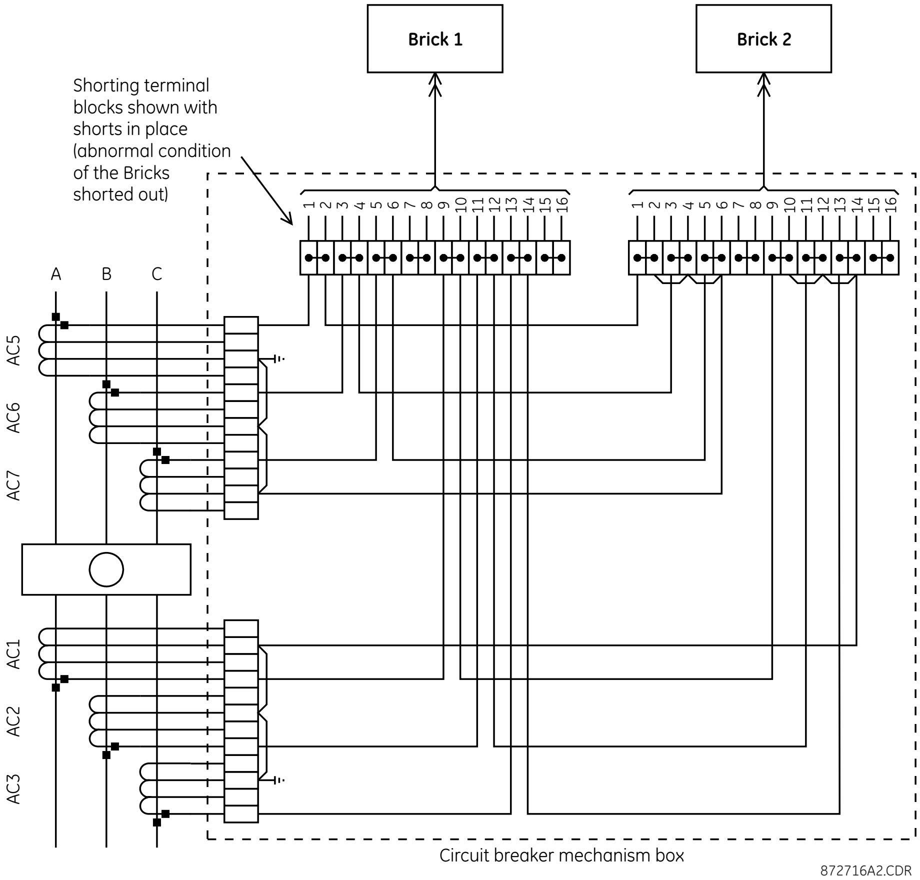


Figure 3-7: Example of voltage transformer wye AC input connections

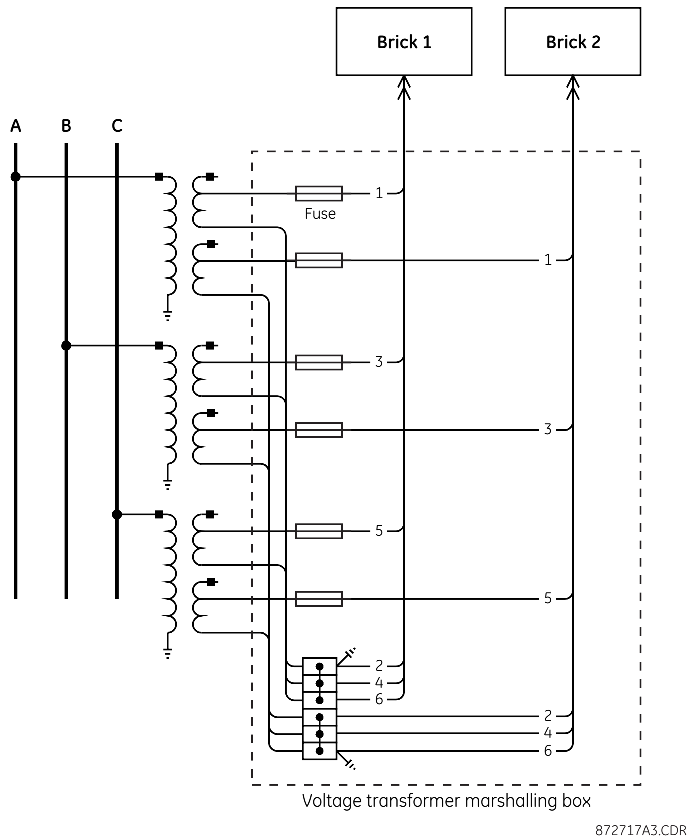
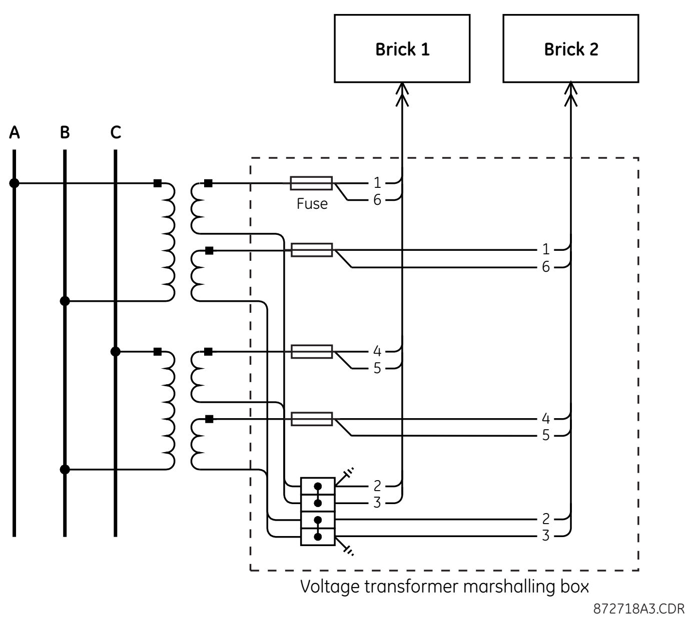


Figure 3-8: Example of voltage transformer delta AC input connections



3.2.5 Brick DC inputs

The Brick DC inputs, in contrast to AC inputs, are for use with low energy analog signals. They are intended for applications, such as measuring the temperature signals from resistance temperature detectors (RTDs), measuring milliampere current loops or millivolt outputs of instrumentation transducers, and measuring the position of potentiometers. DC inputs are sampled at the same rate as AC inputs.

The DC inputs are named DC1 through DC3, and each can be used with any one of the following devices:

- A 100 Ω Nickel, 120 Ω Nickel, or 100 Ω Platinum RTD
- A potentiometer
- A DC loop transducer

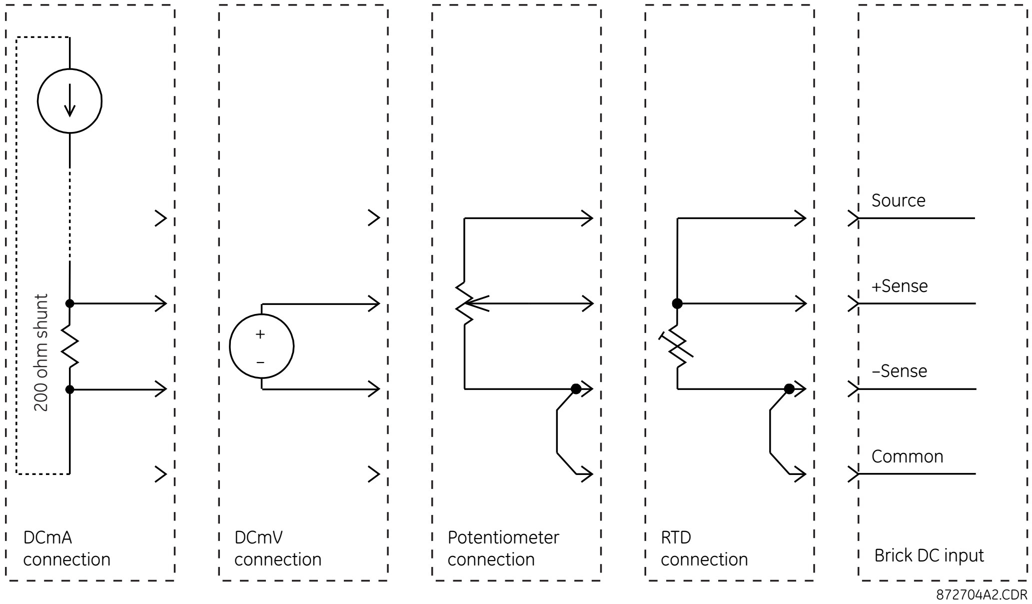
When using a 100 Ω Nickel, 120 Ω Nickel, or 100 Ω Platinum RTD, the DC input supplies a small current and measures the voltage developed by this current passing through the temperature-dependent resistance of the RTD. The effect of lead resistance is automatically compensated for by the Brick hardware.

A potentiometer typically is used to measure equipment position, such as transformer tap position. In this case, the DC input impresses a constant DC voltage across the potentiometer and measures the resulting wiper voltage.

Transducers with a low voltage or milliampere current output signal, such as a gas pressure transducer or a moisture transducer, also can be used. To measure a milliampere current signal, a 200 Ω external shunt is required to convert the current signal to a voltage signal, and to maintain continuity of the current loop if the Brick is unplugged.

The source used to measure potentiometers and RTDs normally operates as a voltage source. However, when the DC input hardware senses an RTD connection, it automatically changes the source characteristics to that of a current source.

Figure 3-9: DC input external connections



3.2.6 Brick contact inputs

Contact inputs are designed to interface to dedicated, isolated, dry contacts, or their electronic equivalents. Examples include breaker/disconnect position switches, temperature switches, pressure switches, and flow switches. In addition to mechanical contacts, Brick contact inputs can be driven by solid-state relays, such as the Brick SSR output contacts.

The contact inputs are named CI1 through CI18.

All contact inputs of a given Brick use a single common return. The Brick does not internally ground the contact input circuit; a single external ground fault is tolerated.

NOTICE Connecting Brick contact inputs to an external power supply can cause permanent damage to the Brick.

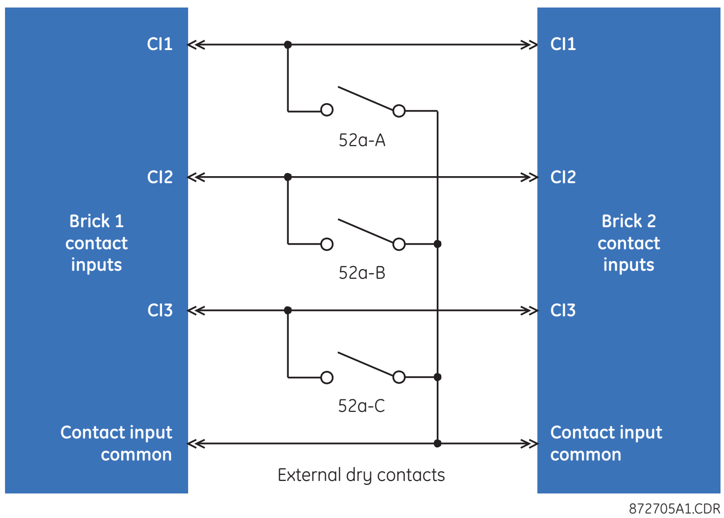
3

External contact status is measured using an internal 24 V DC wetting supply that is derived from the Brick power supply. An external supply is not required or tolerated. This wetting voltage level is more than sufficient to deal with contamination on the external contact surfaces, while allowing spurious energies induced in the external contact input circuit to be clamped at a low level, thus providing reliable performance with short debounce delay.

The Brick does not implement a debounce delay on contact inputs. The contact inputs are sampled at the same rate as the AC inputs. Contact debounce delays can be implemented in the receiving relay as required.

Contact inputs for multiple Bricks can be paralleled and driven by a single contact, as shown in the following figure. However, ensure that no device other than another Brick shares a single contact. Brick contact input circuitry is designed such that when one Brick that shares a contact is powered down, any other Bricks continue to read the contact state correctly.

Figure 3-10: Contact inputs external connections example



3.2.7 Brick SSR contact outputs

Each Brick contains four solid-state relay (SSR) contact outputs designated OUT1 through OUT4. Each SSR contact output is designed to interface directly to a breaker/switch trip or close circuit, or to DC powered conventional protection and control equipment. These outputs feature very short operating times and are capable of interrupting large, highly inductive DC currents.

An SSR contact is closed when any one or more of the four digital cores receives an "on" command for that SSR from the control house. Several security checks are performed by the Brick prior to executing a command. In the event that one of the security tests fails, the command is ignored, and for a time the previous valid command is used. If a Brick digital core receives no valid command in a 10 ms period, then that core defaults the command to off. Off is thus used as the fail-safe state for external circuits. The following security checks are performed:

- Failure of the standard Ethernet 32-bit CRC frame check sequence
- Incorrect composition of the command frame or its dataset
- Mismatch between the Brick actual serial number and/or digital core number and the corresponding fields in the command frame
- Trouble with the digital core, including communications with the analog core
- Trouble with the analog core
- Loss of Brick power

Voltage and current monitoring is provided on each SSR contact output to monitor the contact state and the continuity of the external circuit. The voltage monitoring can be used for instance to alarm on trip circuit troubles, such as loss of trip supply or open circuits anywhere in the trip chain. The current monitoring can be used for example to verify current presence during trip operations and to monitor the opening time of the breaker auxiliary switch typically found in series with trip coils.

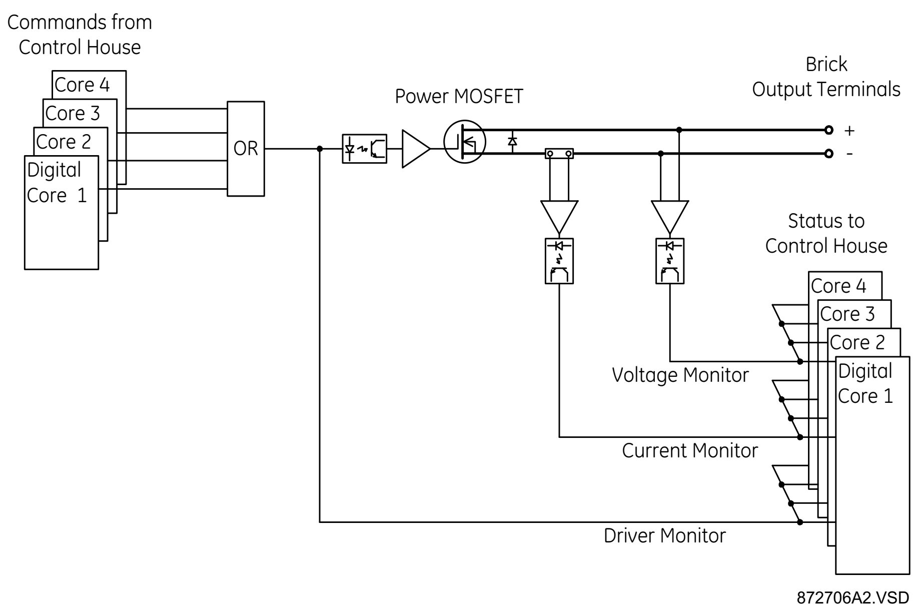
The voltage monitor results in the SSR having an open (off) impedance of approximately 1 MΩ. Take care when using an SSR output to drive a high impedance relay input.

NOTICE Ensure that SSRs are installed with correct polarity in DC circuits. Incorrect polarity results in the SSR behaving as a closed contact. Large or prolonged reverse currents resulting from inverted installation can damage the Brick.

The SSR outputs are polarity sensitive, so external components are needed for applications in control circuits using AC voltage. For this reason, the Brick form-C or latching outputs can be preferred for use in AC control circuits.

The figure shows the Brick SSR contact output logic for OUT1. The logic is analogous for the OUT2 to OUT4 contact outputs.

Figure 3-11: Brick SSR contact output logic



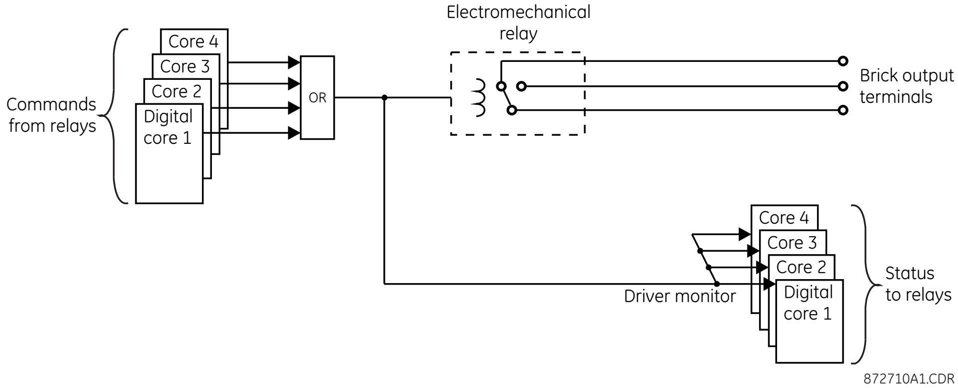
3.2.8 Brick form-C contact outputs

Each Brick provides two form-C contact outputs designated OUT5 and OUT6. Each form-C contact output is for general purpose applications in either AC or DC circuits, such as tap-changer raise/lower control and cooling fan/pump control. The switching element inside the Brick is an electromechanical relay with a single form-C contact.

Form-C relays are energized whenever any one or more of the four digital cores receives an "on" command for that relay from the control house. Control security is the same as for the SSR output contacts.

The figure shows the form-C contact output logic in the Brick for OUT5. The logic is analogous for OUT6.

Figure 3-12: Brick form-C contact output logic



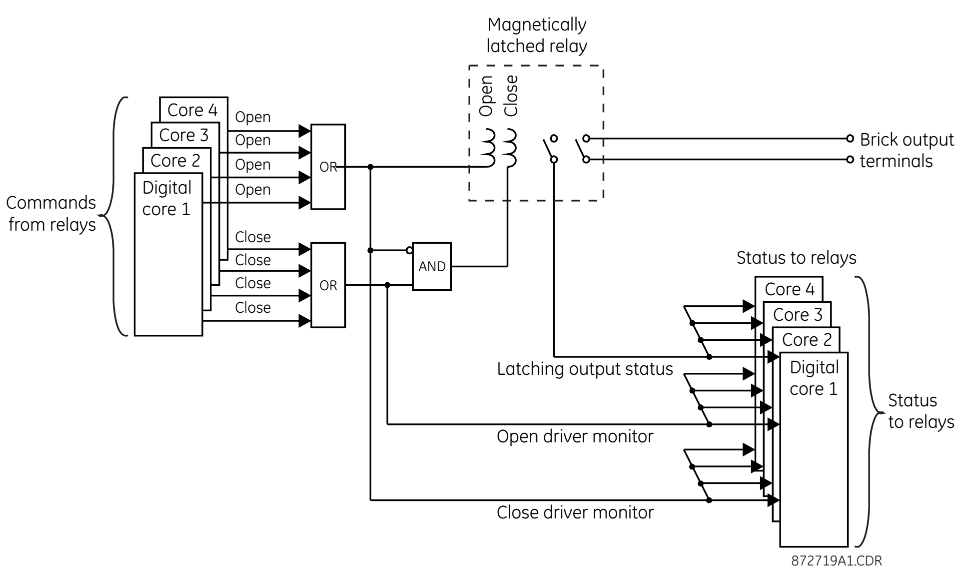
3.2.9 Brick latching output

Each Brick provides a single latching output designated LO. Latching outputs are for applications where the contact state must not change except by explicit command, such as in lockout applications. The switching element inside the Brick is a bi-stable magnetically latched electromechanical relay with a single contact brought out. This contact is suitable for use in either AC or DC circuits. A second contact is used internally to report back to the control house the actual state of the latching output.

The latching output contact opens whenever one or more of the four digital cores receives an open command from the control house. The output contact closes whenever one or more of the four digital cores receives a close command provided that there is no active open command on any core. Otherwise, the contact stays in its previous state. In other words, the latching output is *open-dominant*, as is appropriate for lockout applications. User logic to extend open or close command pulses is not required as the Brick seals-in the open and close commands for a duration sufficient to fully operate the latching relay. Control security is the same as for the SSR output contacts.

Bricks are shipped from the factory with the latching contact closed. It is recommended that the state of this contact be confirmed by continuity test before installing a new or replacement field unit in those applications where the initial state of this contact is important.

Figure 3-13: Brick latching output logic



3.2.10 Brick shared I/O

Shared inputs and outputs (Shared I/O) is a feature that allows IEDs connected to a particular Brick to communicate with each other via the Brick on multiple distinct binary channels. This feature is intended for applications requiring protection quality inter-relay signaling with high speed and deterministic latency. Application possibilities include breaker failure initiation and inter-zone tripping.

Shared I/O points are asserted whenever one or more of the four digital cores receives an "on" signal for that point from the control house. Control security is the same as for the SSR output contacts. Unlike SSRs or other contact outputs, there is no associated output hardware to operate in the analog core. Nevertheless, the commanded output status is sent back through all four digital cores to the control house. Thus, when one relay in the control house sends a shared I/O "on" command, all connected relays in the control house receive the status change. In a sense, these are virtual contact outputs looped back on virtual contact inputs. The overall effect is similar to connecting one or more conventional UR contact outputs with one or more conventional UR contact inputs.

The Settings section on page 5-1 contains more information on shared I/O.

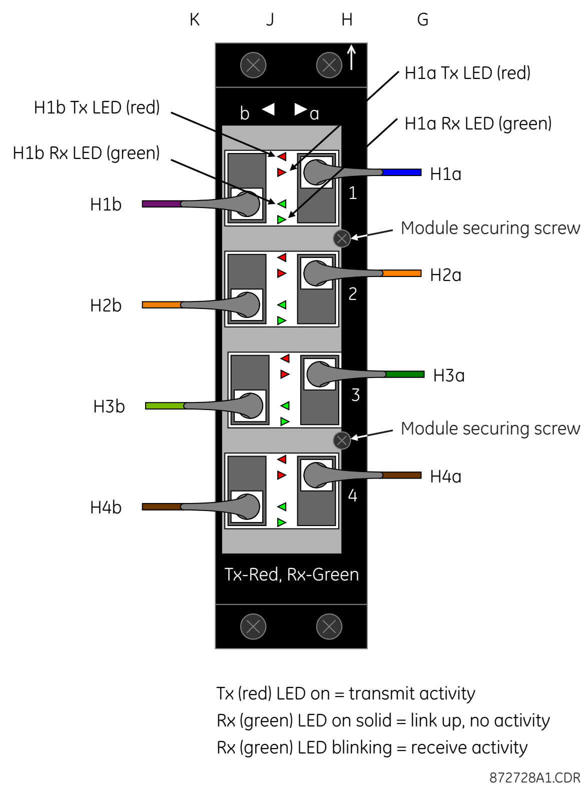
3.3 Cables

The S-Brick is installed indoors and requires the user to supply copper cables and fiber cables. General requirements for these user-supplied cables are described in the Requirements for customer-supplied fiber-optic cables section in Chapter 4.

3

3.4 Process Card

The UR family IEC 61850 process bus module, or Process Card, is a physical module that allows a compatible UR relay to use the input/output hardware of up to eight Bricks in place of conventional input/output hardware inside the UR chassis. The Process Card gives the UR device the input/output equivalent of several CT/VT modules, contact input/output modules, and transducer input modules. UR Process Card



The UR Process Card interfaces to the connected Brick inputs and outputs and allows the UR device to access the following inputs and outputs:

- Up to six AC current/voltage banks, each with four channels (A, B, C, X)
- Up to 40 contact inputs
- Up to 32 SSR outputs
- Up to 16 form-C outputs
- Up to eight latching outputs
- Up to eight RTD inputs
- Up to eight TDR (transducer) inputs
- Up to 16 shared inputs
- Up to 16 shared outputs

See UR settings and actual values on page 5-1 for details on input/output functionality.

The UR Process Card slides into the "H" slot of the UR chassis like other modules. In place of the typical terminal block module mounted at the rear of the UR chassis, there is a black metal cover with a slot for the optical fiber port connectors of the Process Card to project through. The black metal cover is labeled to identify the port designations and their diagnostic LED indicators. To avoid fiber damage through the fibers being inadvertently left connected while the Process Card is withdrawn from the front, two screws secure the Process Card from the rear. These screws must be removed from the rear and the fibers disconnected before the Process Card is removed.

The eight optical fiber ports are the only user connections to the module — there are no copper connections. The ports are intended for operation with 50/125 μm multimode optical fiber, and accept the standard LC connectors used by the indoor fiber cables. The ports are arranged at the rear in a grid with two columns and four rows. Following the UR convention for module terminals, the ports are designated by the slot position letter ("H" in this case), the row number (1 through 4 in this case) and the column letter ("a" or "b"). These designations are shown in the previous figure.

As shown in the figure, each optical port has two diagnostic LED indicators associated with it, in the shape of arrowheads pointing toward the port. The red LEDs light when the transmitter is on. The green LEDs are on solid when receiving carrier, and flash when receiving Ethernet frames.

Table 3-3: Process Card LED status

LED	Description
Red arrow	Transmitter is on. Transmit activity.
Green arrow	Solid when receiving carrier. Link up, no activity. Flashes when receiving Ethernet frames. Link up, receive activity.

As with other fiber connections, cover the ports with the plugs provided when not in use.

3

HardFiber Process Bus System

Chapter 4: Installation

This chapter outlines mechanical and electrical installation of the HardFiber system.

The process for the S-Brick is

- For the 19-inch rack-mount S-Brick, attach it to the mounting bracket
- Mount S-Brick
- Connect cables to S-Brick
- Connect cables to relay Process Card
- Configure software (next chapter)

⚠CAUTION **Install, operate, and use the equipment for its intended function and in the manner specified. Otherwise, any safety protection provided by the equipment can be impaired.**

4.1 Mechanical installation

This section outlines the mechanical installation of the HardFiber system, including dimensions and mounting.

Bricks are intended for mounting on or inside the power system elements in the switchyard. It is suggested that the Bricks be installed, copper wire connections made, and the Bricks fully tested and pre-commissioned at the power equipment factory, preferably with new or factory refurbished switchyard elements. Take care when considering retrofit mounting of an S-Brick inside an existing mechanism cabinet to ensure that the S-Brick and its cables do not interfere either with the operating mechanism itself or encroach on the space required to test and maintain the mechanism.

4.1.1 S-Brick

4.1.1.1 Dimensions

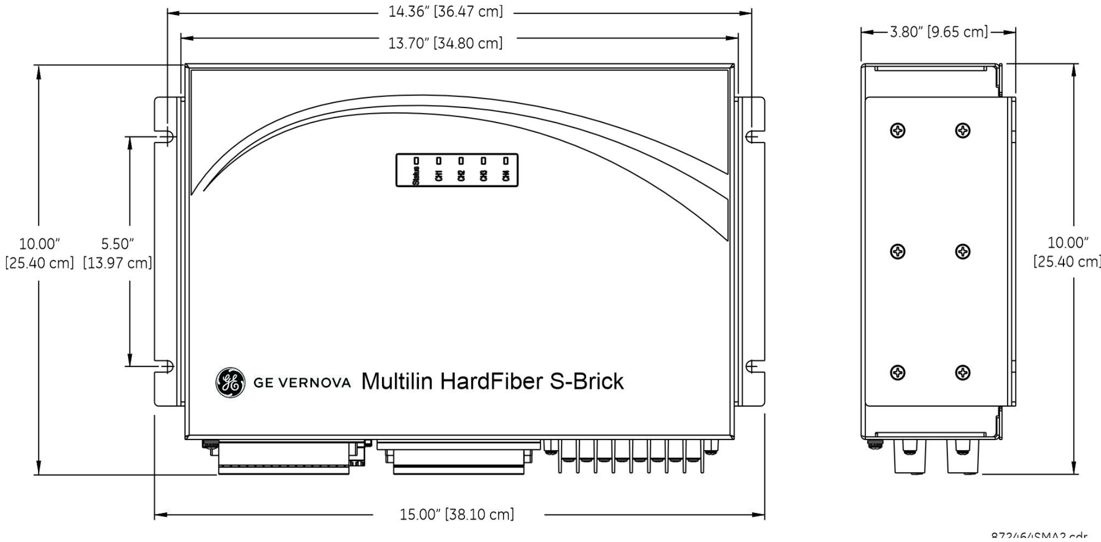
The figures show the dimensions of the S-Brick.

4

Figure 4-1: S-Brick dimensions

⚠WARNING **The S-Brick surface mount option must be installed behind an electrical barrier, that is, in an enclosed rack system, an electrical enclosure, or a panel system, and within an authorized area.**

Figure 4-2: S-Brick surface-mount dimensions (order code S)



4

Figure 4-3: S-Brick flush-mount dimensions (order code F)

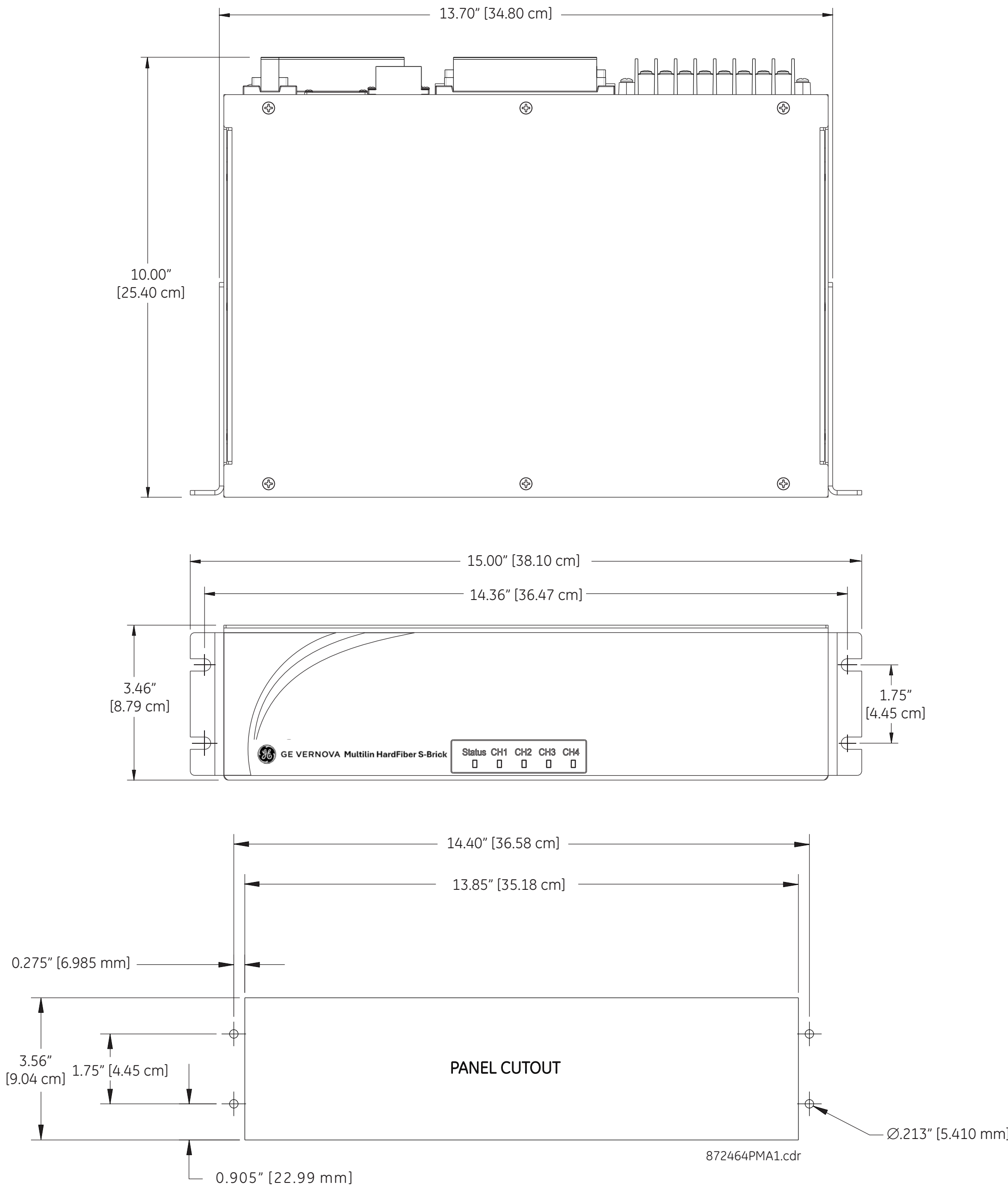


Figure 4-4: S-Brick 19-inch rack-mount dimensions (order code P)

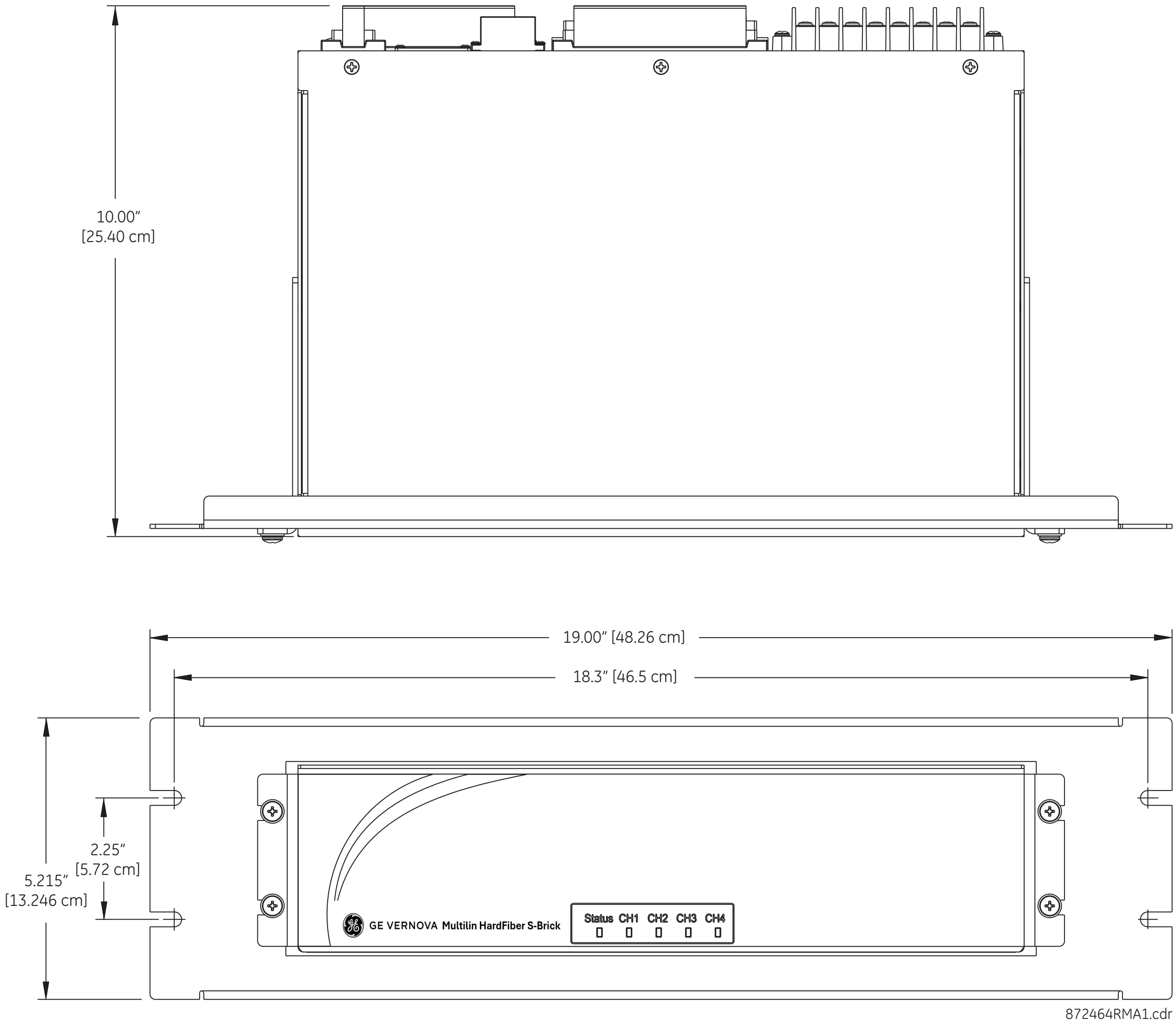
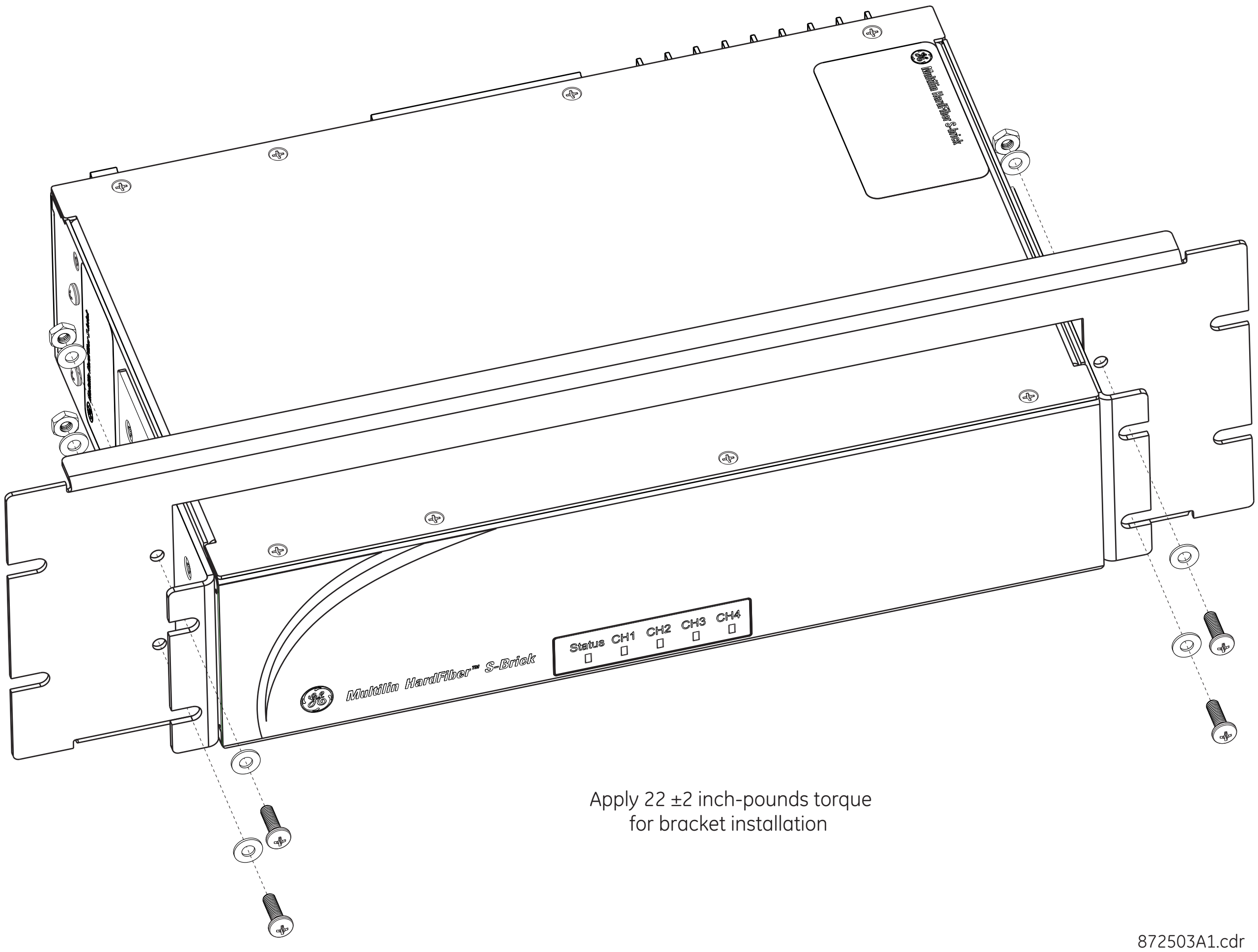


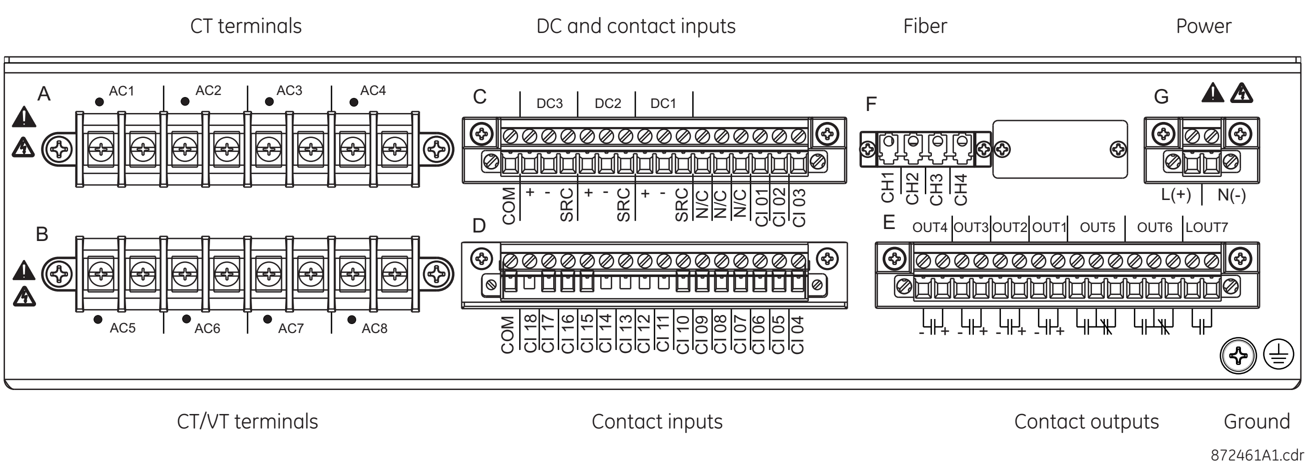
Figure 4-5: S-Brick 19-inch rack-mount bracket attachment (order code P)



4.1.1.2 Rear terminal layout

The figure shows the connections on the back of the S-Brick.

Figure 4-6: S-Brick rear panel



4.1.1.3 Mounting

The process for the S-Brick is

- For the 19-inch rack-mount S-Brick, attach it to the mounting bracket
- Mount S-Brick

The S-Brick is for indoor installation in switchgear, relay panels, and equipment cabinets.

The S-Brick comes in a more typical electronics case, with standard terminal blocks and fiber-optic connectors. Customers supply all cabling, including fiber-optic cables, copper connections to primary equipment, DC power, and DC short circuit protection.

To attach the 19-inch rack-mount bracket:

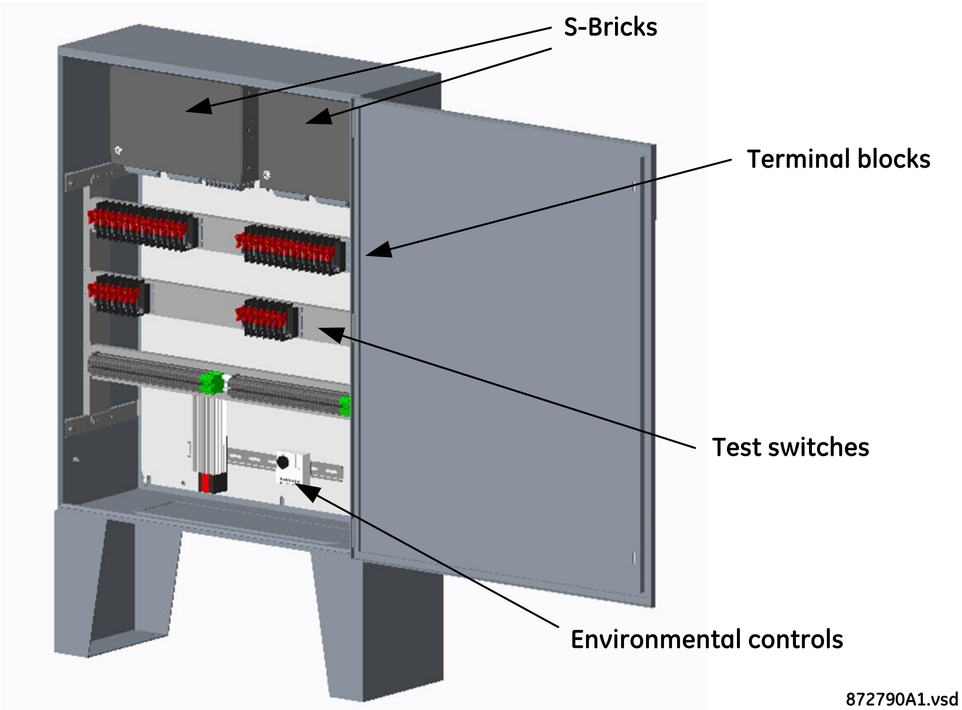
1. Attach the bracket as shown in the S-Brick 19-inch rack-mount bracket attachment (order code P) figure on page 4-6. For maximum stability, be sure to slide the unit through the bracket so that the S-Brick mounting bracket is before the 19-inch rack-mount plate. That is, install the S-Brick in the 19-inch bracket, not behind it. Tighten the screws to torque of 22±2 pounds per inch (inch-pounds).

To mount the S-Brick:

1. Mount the S-Brick in a primary equipment cabinet or kiosk for environmental protection, such as in circuit breaker control cabinets, where space permits. Otherwise, mount the S-Brick inside a marshalling cabinet or kiosk.

   Recommended torque is 22 ± 2 inch-pounds (10-32 screws).

Figure 4-7: Typical S-Brick mounting kiosk



4.2 Electrical installation

⚠WARNING **De-energize all sources coming into a Brick prior to commencing any work on a Brick (mains power, CT, VT and Digital Input and Output signals).**

4.2.1 S-Brick

The process is

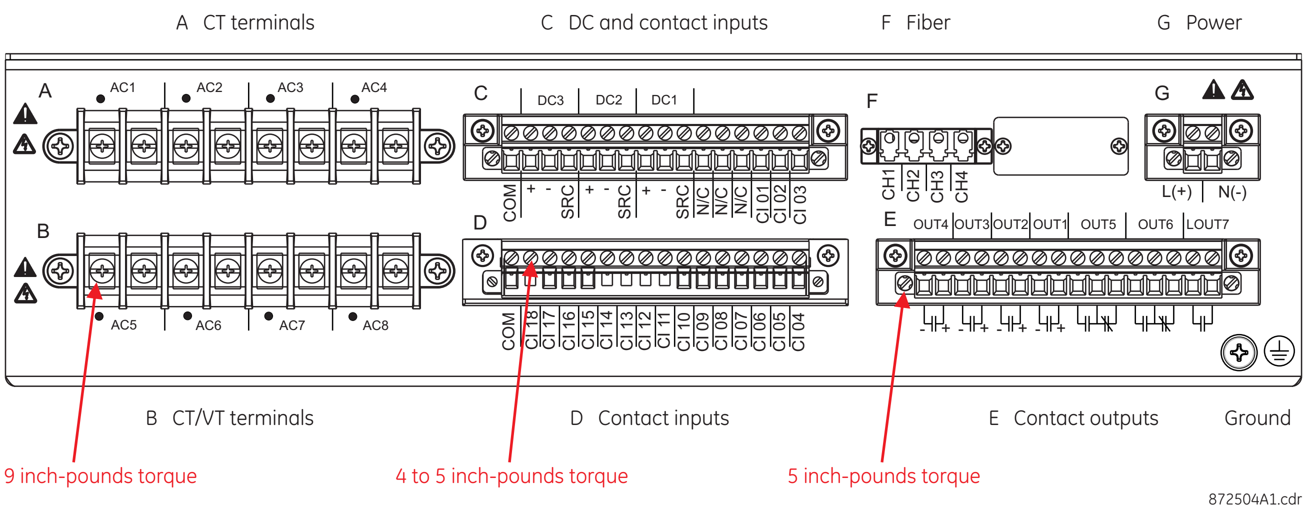
- Check power supply. DC power is expected to originate from a 125 or 250 V DC station battery source. Do not connect the Brick to power or power up until all wiring is complete.
- Connect the S-Brick to ground with a copper wire sized #12 AWG or larger
- Connect the input/output copper cables to the terminals on the back of the S-Brick. The input/output copper cables are external to the HardFiber system.
- Connect indoor fiber cables to the S-Brick terminals and the patch panel
- Connect the patch panel to ground with a copper wire sized #12 AWG or larger, or as per the manufacturer's instructions
- Connect another indoor fiber cable to the back of the patch panel and the UR. Connect it to the back of the UR relay Process Card in the following order from top to bottom for the LC connectors: blue, orange, green, brown. Either column "a" or "b" can be used on the relay.
- Connect the cross-connect patches at the front of the patch panel. That is, complete the optical paths between Bricks and relays with patch cords on the front of the patch panel.
- Power up the unit

Wiring is as follows. The CT and VT terminal blocks accept AWG #10 copper wires and permit the landing of two wires using ring lugs. All other terminal blocks for copper wires accept a maximum of AWG #12 copper wires and permit the landing of two wires using ring lugs. Connect fiber-optic cables using standard LC connectors suitable for use with 100 Mb, 50/125 µm, multimode fiber.

The figure shows recommended torque, as follows:

- 9 inch-pounds for connections to terminal blocks A, B
- 4 to 5 inch-pounds for connections to terminal blocks C, D, E, G
- 5 inch-pounds for connector terminal blocks C, D, E, G (two screws, meaning one on each end)

Figure 4-8: Torque for S-Brick connections



4.2.1.1 Requirements for customer DC supply

The customer must provide a 125 or 250 V DC rated supply to power the S-Brick. The DC circuit must provide short circuit protection for the power supply. The recommended short circuit protection is 1A, fast acting, 10,000 A DC interrupting capacity, Littelfuse KLKD001 or equivalent. The general recommendation is to power the S-Brick separately from the associated primary equipment for good operating and maintenance practices.

NOTE

S-Bricks are rated for operation with a DC supply. However, an AC supply can be used for product evaluation purposes.

4.2.1.2 Copper cables

Standard copper cables can be used for connection to AC measurements, contact inputs, contact outputs, power supply, and case ground. AC measurement (currents and voltages) terminals accept up to 2 #10 ring lugs on one terminal.

All other terminal blocks for copper cables (contact inputs, contact outputs, RTDs/transducers, power supply) accept up to #14 copper cables using ferrule terminations.

WARNING **Hazardous voltage can appear when a cable with energized current transformer circuits is disconnected from the AC measurement terminals.**

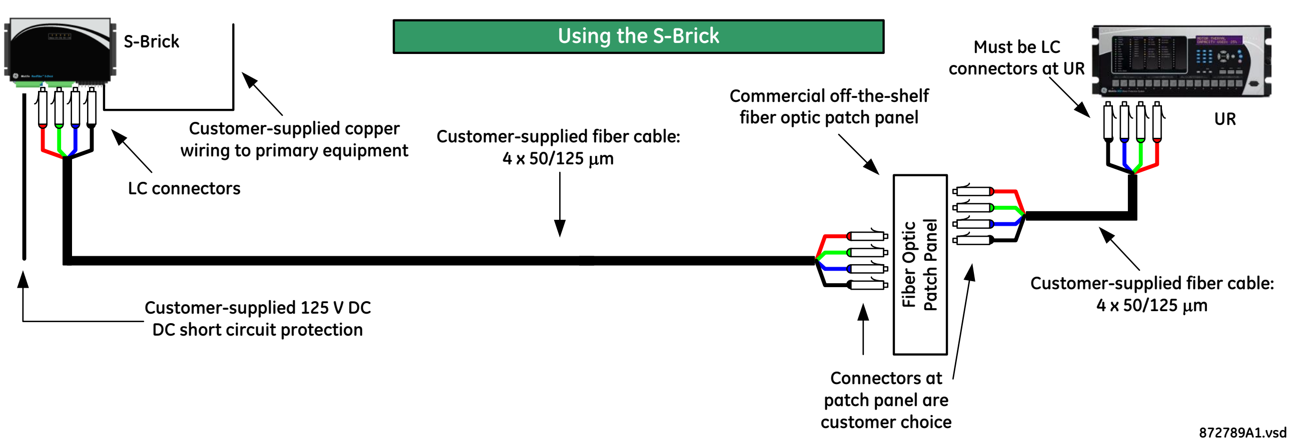
4.2.1.3 Fiber cables

The HardFiber system requires the use of 50/125 mm multimode fiber, that supports 1310 nm and 1550 nm transmission. Class 1 graded index fiber is ideal. In general, OM2 and OM3 rated fibers meet these requirements. Environmental rating of the fiber cables is as per customer application. The S-Brick and URs have female LC connectors, so cables must use male LC connectors at these ends. The S-Brick has four LC connectors, while the URs have eight LC connectors. Any commercially available fiber-optic patch panel can be used for cable management.

4.2.1.4 Using customer-supplied cables

Customers supply all cabling, including fiber-optic cables, copper connections to primary equipment, DC power, and DC short circuit protection. The figure shows a typical installation.

Figure 4-9: Typical S-Brick installation



4.2.1.5 Typical wiring

The following figures are typical wiring diagrams for the four S-Bricks.

Figure 4-10: S-Brick CC11 typical wiring

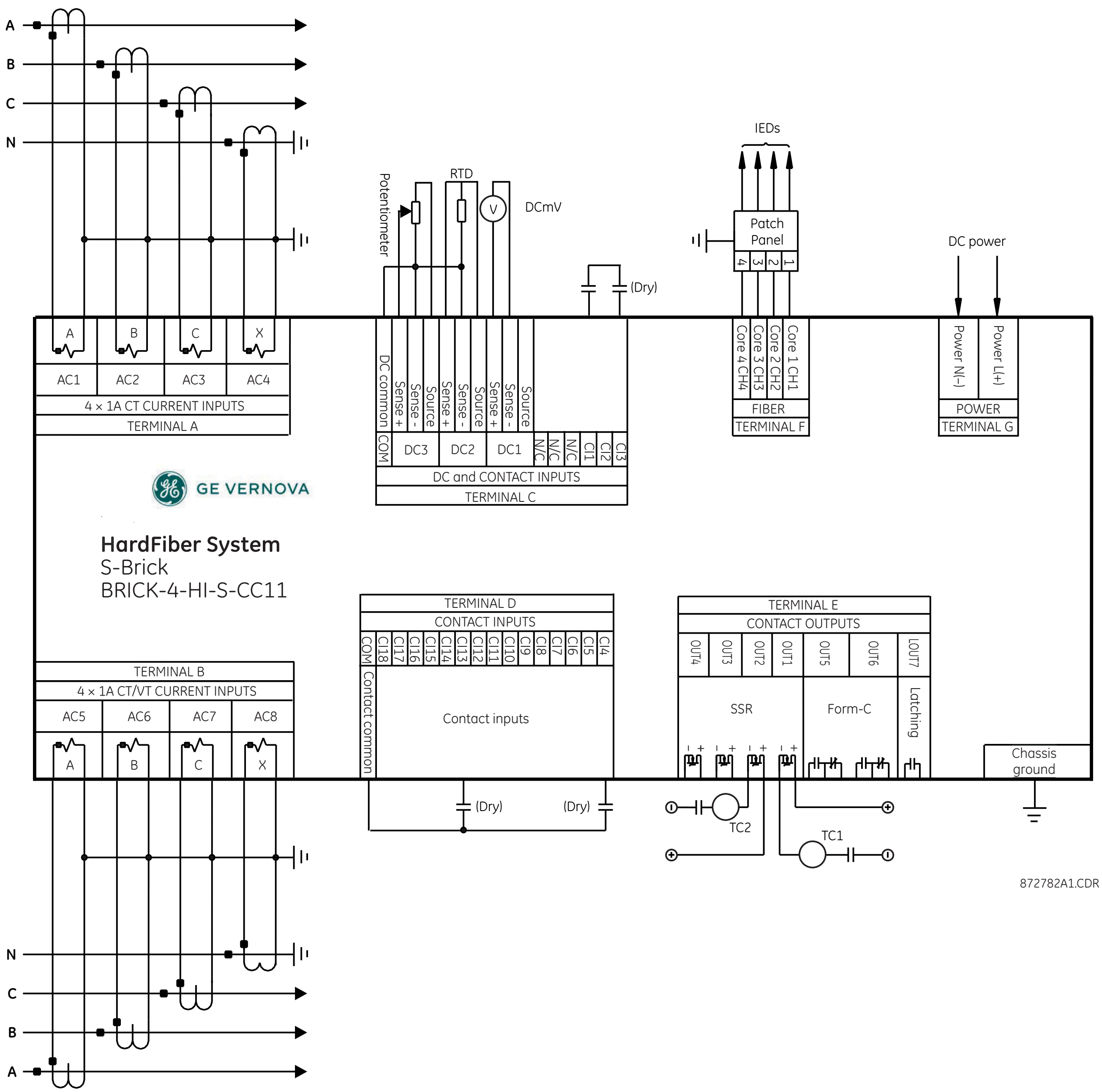


Figure 4-11: S-Brick CC55 typical wiring

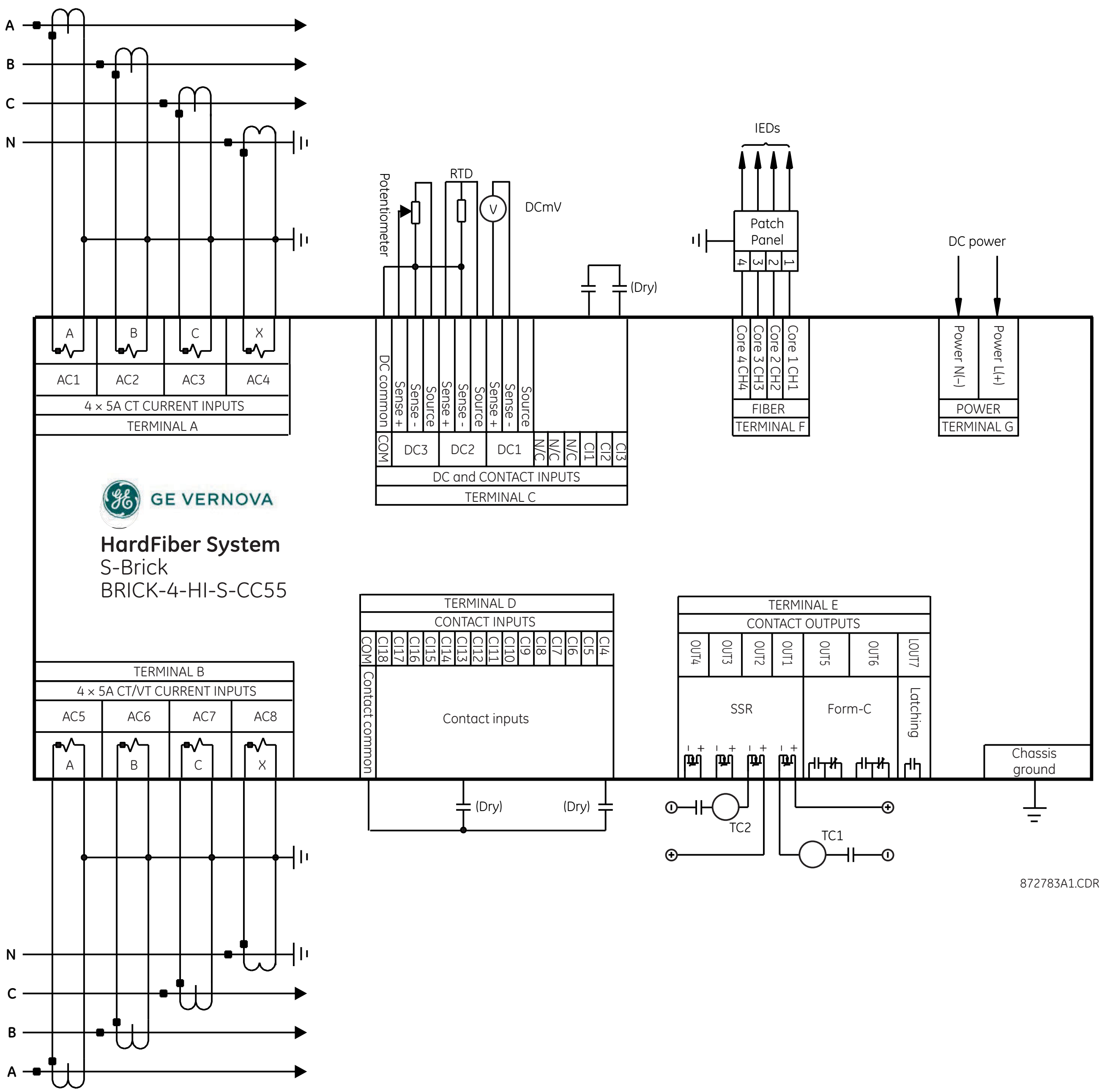


Figure 4-12: S-Brick CV50 typical wiring

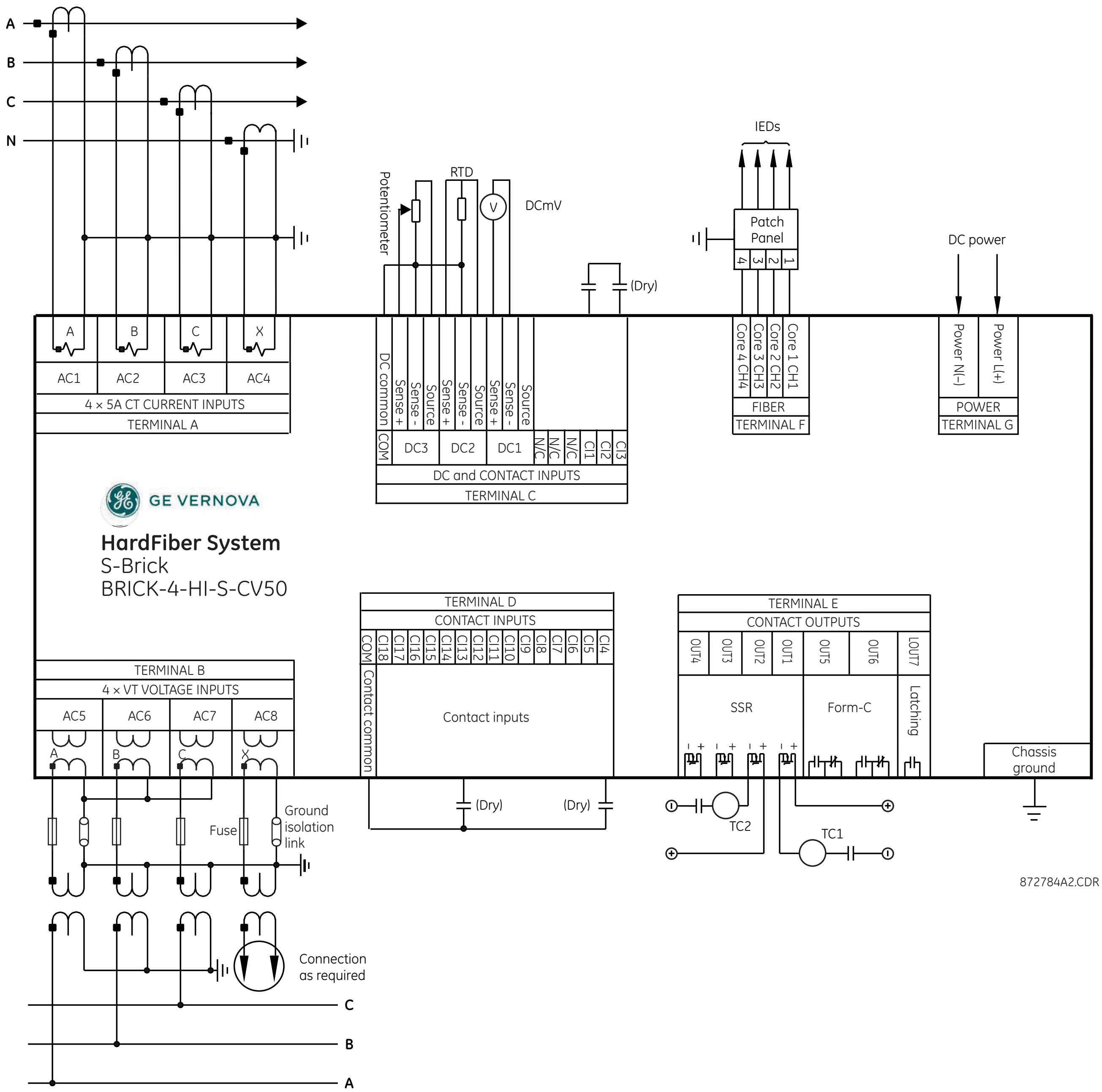
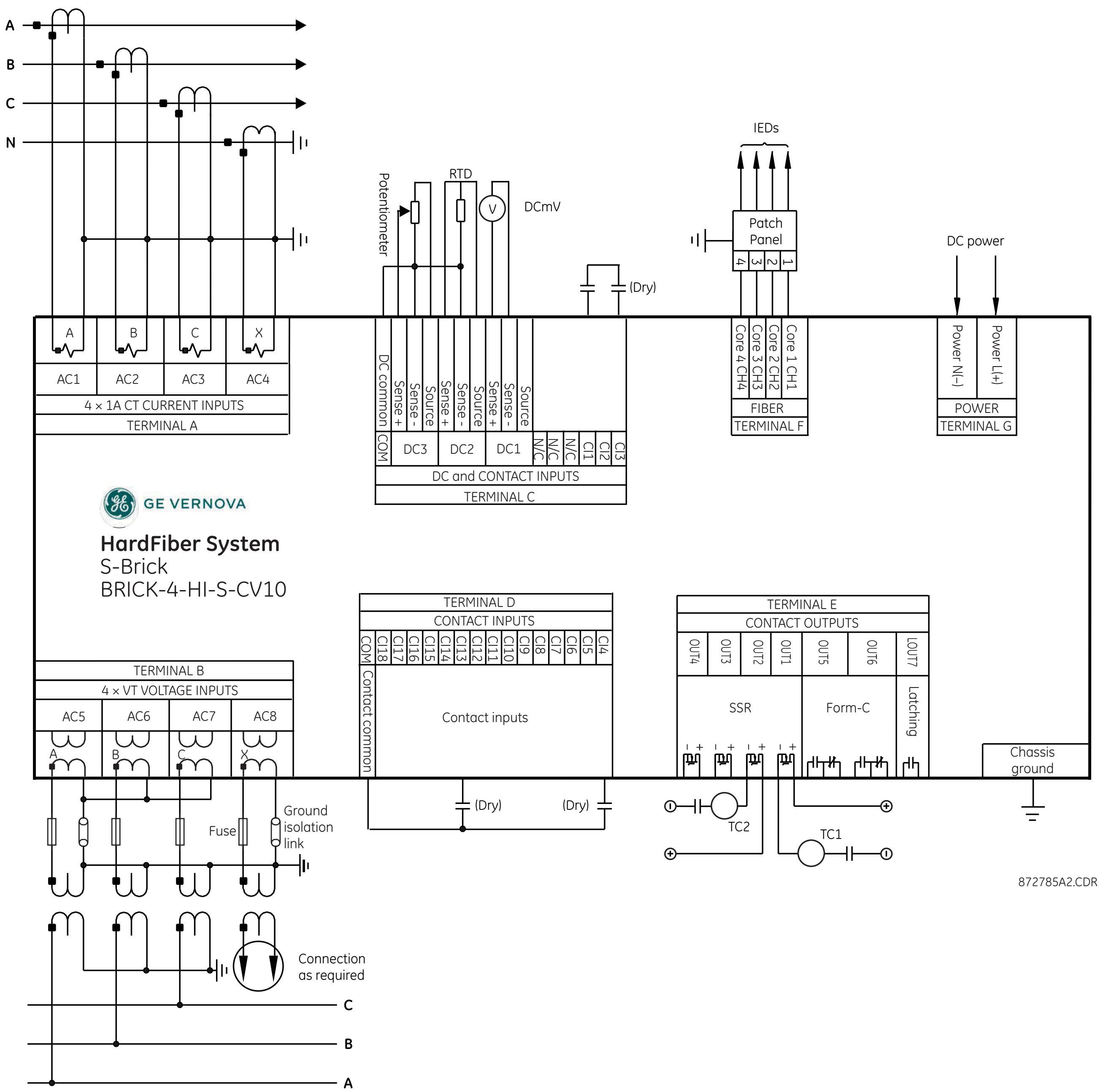


Figure 4-13: S-Brick CV10 typical wiring



HardFiber Process Bus System

Chapter 5: UR settings and actual values

This chapter outlines the settings, actual values, and FlexLogic operands used with UR devices in a HardFiber system.

5.1 Settings

UR devices containing a Process Card have an additional **Remote Resources** menu item in the EnerVista UR Setup software. The menu configures the relay to work as part of the HardFiber system.

With the exception of the relocation of the **AC Inputs** and the **Signal Sources** menu items to the **Remote Resources** menu and the addition of a new setting in the **User-Programmable Self-Tests** menu, the EnerVista software is unaffected when applied to a UR device with a Process Card.

NOTE

Remote resources configuration is only available through the EnerVista UR Setup software and is not available through the relay front panel.

Figure 5-1: Remote Resources menu for HardFiber settings

The remote resources settings establish the point-to-point connection between a specific fiber-optic port on the Process Card and a specific Brick fiber-optic core. Once the point-to-point connections are established, the UR device is then configured to measure currents and voltages from specific Bricks, accept the status of inputs from specific Bricks, and control outputs in specific Bricks.

The configuration process for remote resources is straightforward and involves the following steps in the following recommended sequence.

1. Configure the field units.

   This step establishes the point-to-point connection between a specific port on the Process Card and a specific fiber-optic core on a specific Brick. A field unit is a logical Brick in the relay that is mapped to a physical Brick via the Process Card.
2. Configure the AC banks.

   This step sets the AC input measurement parameters. These are the primary and secondary quantities and connections for currents and voltages. AC bank configuration also provides for reliability of measurement through the use of duplicate measurements, reliability of protection through the use of crosschecking, and powerful reliability improvements possible with process bus.
3. Configure the signal sources.

   This signal source functionality of the UR devices has not changed other than the requirement to use currents and voltages established by the dynamically configured AC banks. Note that while a relay can connect to eight different Bricks each with eight AC inputs for a total of 64 available AC measurements, the number of available signal sources remains determined by the functionality of a specific UR device.
4. Configure the field contact inputs, field contact outputs, field latching outputs, RTDs, and transducers as required for operating functionality.

   These inputs and outputs are the physical interface to circuit breakers, transformers, and other equipment. They replace the traditional inputs and outputs located at the relay to eliminate copper wiring.
5. Configure the shared inputs and shared outputs as required for operating functionality.

   The shared inputs and shared outputs interface to protection quality communications channels that provide high-speed signaling between relays through a shared Brick.
6. Configure the application by enabling and setting protection and control elements, FlexLogic, communications, and so on.

   For information, see the appropriate UR instruction manual.

5.1.1 Field units, AC banks, and sources

The field units, AC banks, and sources are configured in the same setup window. The three items are configured within the same context because of the substantial interaction among them, specifically a setting change in one table can make a setting in another table invalid. Each table is described individually here.

5.1.1.1 Field units

A field unit is a logical representation of a Brick within the relay. The settings allow organizing the connected Bricks by enabling their function, naming them, and setting serial numbers.

The primary responsibility of the field units is to ensure that the relay is connected to the same Brick that was verified as the correct Brick during testing. This ensures that the field process information the relay receives and the field commands the relay issues are from/to the correct origin/destination. This prevents, for instance, an inadvertent patching at the Cross Connect Panel from causing a trip intended for a breaker to instead raise a transformer's tap position, or from causing a transformer sudden gas pressure trip contact input to be handled as a breaker low temperature alarm. It also prevents inadvertent swapping of a Brick with 5 A nominal current inputs with a replacement unit with 1 A nominal inputs from causing a 1 pu current into a bus differential zone from appearing to be a 5 pu current.

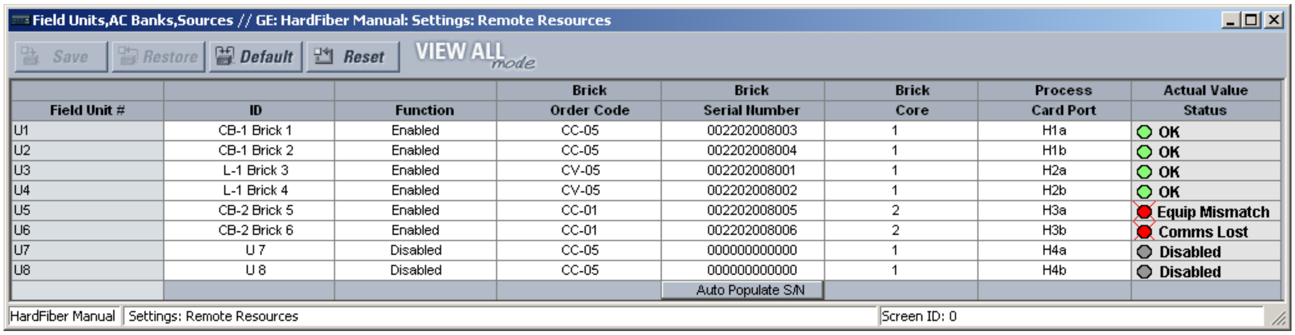
NOTE

The field unit normally accepts data from and sends commands only to Bricks with the user-specified serial number and order code, and only through the user-specified Process Card port and Brick digital core. If the Brick is swapped out or the optical fiber connection between the relay and a Brick is changed, the field unit normally alarms and blocks its data and commands. However, when the relay is in the test isolated or test forcible mode, it accepts Bricks with serial numbers other than the specified serial number. See the Testing and commissioning section on page 7-1 for details.

To configure the relay for the field units (Bricks):

1. Select the **Settings > Remote Resources > Field Units, AC Banks, Sources** menu item to open the configuration window.

Figure 5-2: Field unit configuration settings



Field Unit #	ID	Function	Brick Order Code	Brick Serial Number	Brick Core	Process Card Port	Actual Value Status
U1	CB-1 Brick 1	Enabled	CC-05	002202008003	1	H1a	OK
U2	CB-1 Brick 2	Enabled	CC-05	002202008004	1	H1b	OK
U3	L-1 Brick 3	Enabled	CV-05	002202008001	1	H2a	OK
U4	L-1 Brick 4	Enabled	CV-05	002202008002	1	H2b	OK
U5	CB-2 Brick 5	Enabled	CC-01	002202008005	2	H3a	Equip Mismatch
U6	CB-2 Brick 6	Enabled	CC-01	002202008006	2	H3b	Comms Lost
U7	U 7	Disabled	CC-05	000000000000	1	H4a	Disabled
U8	U 8	Disabled	CC-05	000000000000	1	H4b	Disabled
				Auto Populate S/N			

The following settings are available for each field unit (Brick).

ID

Range: 12 ASCII characters

Default: U1 through U8

This setting identifies a particular field unit. Typically this is the name of the power system device to which the field unit is connected, for example "Breaker 1."

Function

Range: Disabled, Enabled

Default: Disabled

This setting controls the operational state of the field unit. When disabled, the field unit forces all commands to the Brick to off, and it forces all values received from the Brick to their failsafe values. It also suppresses self-test errors for that field unit. Effectively, the disabled value of this setting detaches logically a Brick connected physically on the associated port. The disabled value is applied to unused Process Card ports and can be used to temporarily suppress communication with a Brick.

Brick Order Code

Range: CC-05, CV-05, CC-01, CV-01

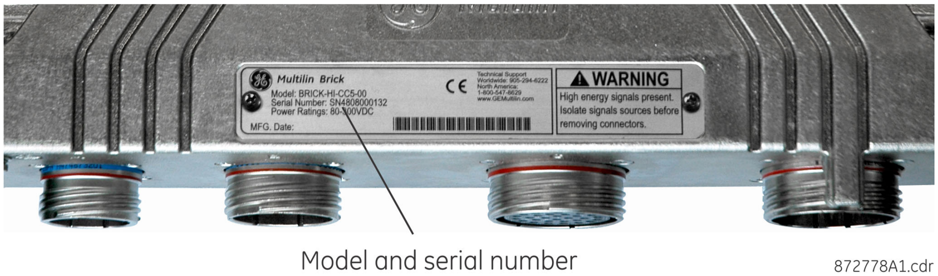
Default: CC-05

This setting selects the order code of the Brick intended for interfacing with the field unit. The field unit communicates with a Brick only when the Brick order code setting matches that of the actual connected Brick. This is a security feature implemented to prevent inadvertent use of a Brick for other than the intended type. The relay uses the setting to determine AC input type, CT or VT, and for CT inputs its nominal current.

- CC-05: Two 5 amp current banks
- CV-05: One 5 amp current bank and one voltage bank
- CC-01: Two 1 amp current banks
- CV-01: One 1 amp current bank and one voltage bank

The order code and serial number are viewable on the top of the Brick.

Figure 5-3: Location of order code and serial number on Brick



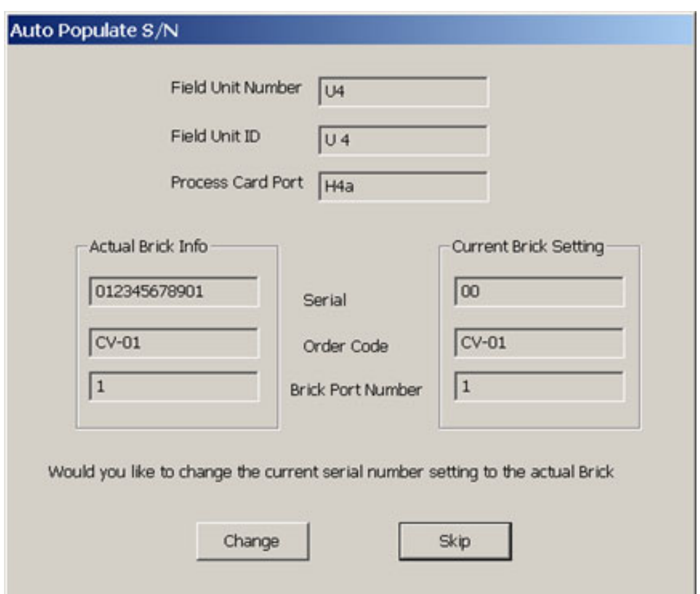
Brick Serial Number

Range: 12 alphanumeric characters
Default: 000000000000

This setting specifies the serial number of the Brick that is intended to interface with the field unit. The field unit communicates with a Brick only when the Brick serial number setting matches that of the actual connected Brick, a security feature to prevent inadvertent fiber connections resulting in incorrect mapping of Brick inputs/outputs to the relay. However, when the relay is in the test isolated or test forcible mode, it accepts Bricks with serial numbers other than the specified serial number. See the Testing and commissioning section on page 7-1 for details.

Because the settings engineer does not typically have available the Brick serial numbers at the time the relay settings are created, an auto-populate serial number command is provided that changes the serial number settings to match the Bricks actually connected at the time that the command is issued. Invoke this command after tests have established that the field units are communicating with the correct Bricks. On clicking the **Auto Populate S/N** button located under the Brick serial number settings (see the bottom of the earlier software figure), the relay checks the serial number, order code, and digital core number being received from the Brick on each Process Card port, and where there is a mismatch with the field unit settings, presents a window showing side-by-side the actual Brick serial number, order code, and core number and the corresponding field unit settings. Clicking the **Change** button in this window enters the actual Brick serial number into the field unit setting window, which must be saved as with other setting changes.

Figure 5-4: Auto-populate serial number window



Brick Core

Range: 1, 2, 3, 4

Default: 1

This setting selects the digital core that the field unit is intended to interface with in the Brick. The field unit communicates with a Brick only when the Brick core setting matches that of the actual connected digital core. This security feature is implemented to detect inadvertent fiber connections.

Process Card Port

Range: H1a, H1b...H4a, H4b

Default: H1a through H4b

This setting specifies the optical port on the Process Card to interface to the field unit. Note that all enabled field units must have unique Process Card port settings.

The following information displays for each field unit (Brick).

Actual Value Status

Range: Disabled, OK, Communications Lost, Equipment Mismatch, Trouble

This value indicates the current status of the field unit. Alarm states are shown in red, normal states in green or grey.

The alarm states are "Communications Lost," "Equipment Mismatch," and "Trouble." The Communications Lost value indicates that communications with the Brick has been lost. Equipment Mismatch indicates that the actual Brick serial number, order code, or digital core number does not match the field unit settings. The Trouble value indicates that the Brick is reporting one or more diagnostic alarms (see the Diagnostics and Troubleshooting chapter for details).

The normal states are "OK" and "Disabled." The OK value indicates that all data is available and reliable. When a field unit state is OK, the corresponding field unit FlexLogic operand (for example, U1 On) is asserted, otherwise this operand is off. The Disabled value indicates that the field unit has been disabled manually through the **Function** setting.

5.1.1.2 AC banks

An *AC bank* is a logical group of four AC inputs. The first three inputs in each bank are for either a three-phase CT set or a three-phase VT set. That is, the first three inputs are intended to be either IA/IB/IC, Vag/Vbg/Vcg, or Vab/Vbc/Vca. The fourth input of each bank is an auxiliary input, and can be either a CT or a VT type, Ix or Vx. Some typical applications for auxiliary AC inputs are ground current, neutral current, neutral voltage, capacitor unbalance current or voltage, and single-phase current or voltage.

The three phase quantities of an AC bank can be mapped either to a Brick's AC1 to AC3 physical inputs, or to the AC5 to AC7 physical inputs. The auxiliary input of an AC bank can be mapped to either AC4 or AC8 only, but not necessarily the same Brick as the phase quantities.

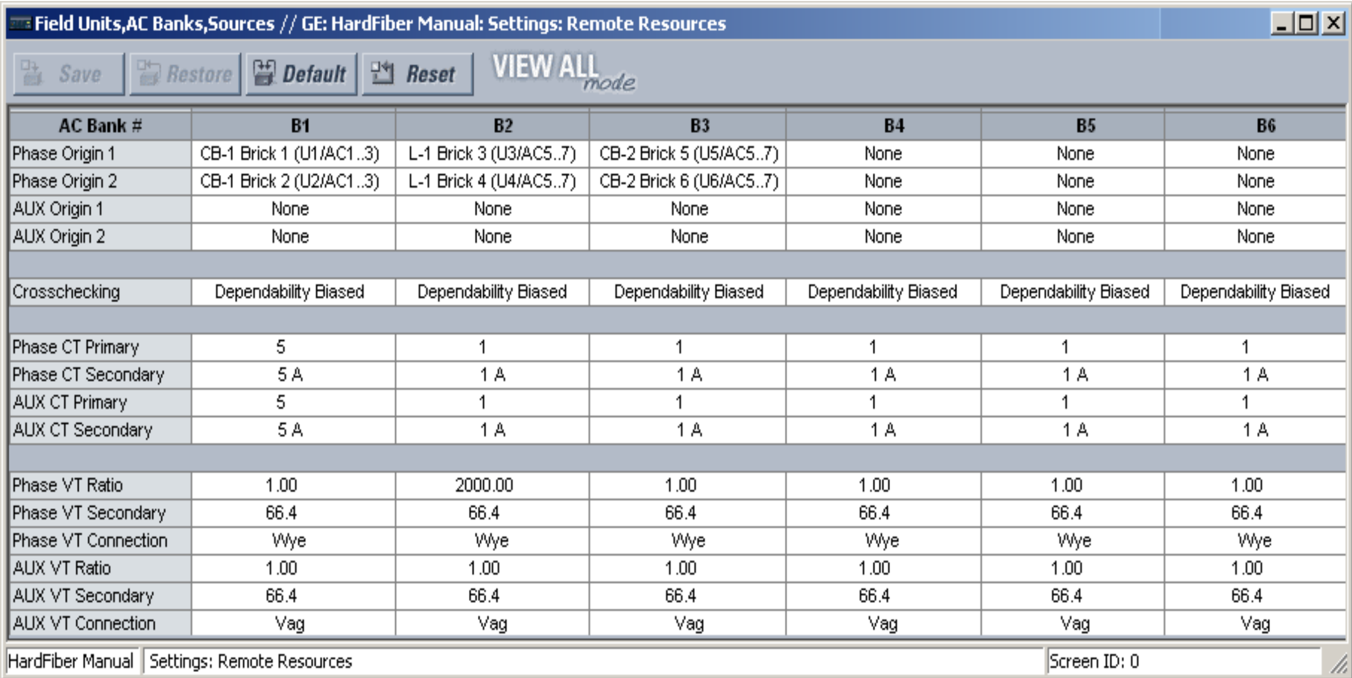
The HardFiber system provides for reliability of measurement of AC values by allowing each AC bank to have two Bricks as origins for its values. If one origin is lost, the relay instantaneously transfers to the other. The HardFiber system also addresses reliability of protection through the use of crosschecking. Both of these features are described under their corresponding settings.

Each bank can be either CT or VT type, depending on the order code of the originating Brick (or Bricks). Therefore, both CT and VT setpoints are provided to declare characteristics of the instrument transformer and its connection. However, the relay uses only the settings corresponding to the present type of the AC bank. These settings are otherwise identical to UR device settings for devices without a Process Card.

The number of AC banks varies from four to six depending on the UR product. See the Features per product on page 2-5 for details.

Select the **Settings > Remote Resources > Field Units, AC Banks, Sources** menu item to open the configuration window. The AC bank settings are contained in the third of four sections in the window.

Figure 5-5: AC bank configuration settings



AC Bank #	B1	B2	B3	B4	B5	B6
Phase Origin 1	CB-1 Brick 1 (U1/AC1..3)	L-1 Brick 3 (U3/AC5..7)	CB-2 Brick 5 (U5/AC5..7)	None	None	None
Phase Origin 2	CB-1 Brick 2 (U2/AC1..3)	L-1 Brick 4 (U4/AC5..7)	CB-2 Brick 6 (U6/AC5..7)	None	None	None
AUX Origin 1	None	None	None	None	None	None
AUX Origin 2	None	None	None	None	None	None
Crosschecking	Dependability Biased	Dependability Biased	Dependability Biased	Dependability Biased	Dependability Biased	Dependability Biased
Phase CT Primary	5	1	1	1	1	1
Phase CT Secondary	5 A	1 A	1 A	1 A	1 A	1 A
AUX CT Primary	5	1	1	1	1	1
AUX CT Secondary	5 A	1 A	1 A	1 A	1 A	1 A
Phase VT Ratio	1.00	2000.00	1.00	1.00	1.00	1.00
Phase VT Secondary	66.4	66.4	66.4	66.4	66.4	66.4
Phase VT Connection	Wye	Wye	Wye	Wye	Wye	Wye
AUX VT Ratio	1.00	1.00	1.00	1.00	1.00	1.00
AUX VT Secondary	66.4	66.4	66.4	66.4	66.4	66.4
AUX VT Connection	Vag	Vag	Vag	Vag	Vag	Vag

NOTE

Changes to AC bank origin settings that change an AC bank's type take effect upon restart of the relay. Restarting is done by cycling relay power or under **Maintenance > Reboot Relay Command**.

The following settings are available for each AC bank.

Phase Origin 1, Phase Origin 2

Range: None, U1/AC1…3, U2/AC1...3,..., U8/AC1…3, U1/AC5…7, U2/AC5...7,...,U8/AC5…AC7

Default: None

These settings specify the field unit and AC inputs to be the origin of the IA/IB/IC, Vag/Vbg/Vcg, or Vab/Vbc/Vca phase inputs.

An *origin* to an AC bank defines the physical measurement input to the bank by mapping specific AC inputs from a specific field unit to the bank.

The HardFiber system provides for the reliability of measurement of AC values for protection, metering, and oscillography by allowing duplicate origins of AC data. An origin is considered *unavailable* when the origin is set to "None", the field unit is disabled, Brick communications fail, or the Brick reports self-test alarms potentially affecting the AC inputs. If origin 1 is available, the relay uses the values from origin 1 for protection, metering, and oscillography. Otherwise if origin 2 is available, the relay uses the values from origin 2. If both origins are unavailable, then the bank AC values are forced to zero to prevent any ambiguity of measurement. When connecting to only one Brick, the Brick can be mapped to either origin. See the Crosschecking setting on page 5-7 for information regarding automatic protection blocking possibilities on loss of one or both origins.

The two phase origins in an AC bank must be of the same type: the two origins must be two currents with the same CT secondary setting, or two voltages, and must match the Brick order code. The current/voltage type of the phase and auxiliary origins must also match on each AC bank. The EnerVista UR Setup software aids this by applying setting consistency checks and alerting the user to any discrepancies. It is intended that the origin AC inputs measure the same primary quantity with the same ratio. The same ratio and connection settings are applied to both origins.

Auxiliary Origin 1, Auxiliary Origin 2

Range: U1/AC4-U8/AC4, U1/AC8-U8/AC8

Default: None

These settings specify the field unit that is the origin of the auxiliary input Ix or Vx.

Duplicate auxiliary origins are supported in the same way as phase origins.

The two auxiliary origins in an AC bank must be of the same type: the two origins must be two currents with the same CT secondary setting, or two voltages, and must match the Brick order code. The current/voltage type of the phase and auxiliary origins must also match on each AC bank. The EnerVista UR Setup software aids this by applying setting consistency checks and alerting the user to any discrepancies. It is intended that the origin AC inputs measure the same primary quantity with the same ratio. The same ratio and connection settings are applied to both origins.

Crosschecking

Range: None, Dependability Biased, Security Biased

Default: Dependability Biased

The crosschecking feature can block the relay protections in response to the loss of AC signal as a result of an AC bank origin being unavailable or due to a discrepancy between two origin readings.

NOTE

The crosschecking function only blocks protection elements. It does not inhibit metering, actual values, oscillography or other functions. It does not affect transfer between origin 1 data, origin 2 data, or zero as described in the Phase Origin 1, Phase Origin 2 setting on page 5-6.

In general, a crosschecking setting of None defeats the feature, a setting of Dependability Biased causes the protections to be blocked if there is no good signal, and a setting of Security Biased blocks if there are not two good signals. The following table shows specifically how the crosschecking setting, the availability of AC bank origins, and discrepancy checks determine whether this feature blocks the protections. Again, an origin is considered *unavailable* if the origin is set to None, the field unit is disabled, Brick communications fail, or the Brick reports self-test alarms potentially affecting the AC inputs. An origin is *mapped* if set to other than None.

Table 5-1: Availability of protection elements due to crosschecking

Crosschecking setting	Origin 1 status	Origin 2 status	Discrepancy check	Protection elements
None	Not relevant	Not relevant	Not relevant	
Dependability Biased	Available	Available	OK	
	Available	Unavailable	Not relevant	
	Unavailable	Available	Not relevant	
	Not mapped	Not mapped	Not relevant	
	Mapped but unavailable	Unavailable	Not relevant	Blocked
	Unavailable	Mapped but unavailable	Not relevant	Blocked
	Available	Available	Discrepant	Blocked
Security Biased	Available	Available	OK	
	Not mapped	Not mapped	Not relevant	
	Available	Unavailable	Not relevant	Blocked
	Unavailable	Available	Not relevant	Blocked
	Unavailable	Unavailable	Not relevant	Blocked
	Available	Available	Discrepant	Blocked

Crosschecking is typically set to None on a non-protection critical AC bank, such as one used for a synchrocheck voltage. It is set to Security Biased where it is so important that the protection not operate incorrectly due to AC measurement error that it is justified to require two independent measurements be in agreement to operate. It is set to Dependability Biased for other applications.

5

Phase CT Primary

Range: 1 to 65000 A in steps of 1

Default: 1 A

This setting specifies the connected primary rating of the phase CTs associated with this bank. This value is used to determine the phase CT ratio for ratio matching when multiple current inputs are combined within a source or in a protection element, and the base used for per-unit current values.

Phase CT Secondary

Range: 1 A, 5 A

Default: 1 A

This setting specifies the nominal secondary current rating of the phase CTs associated with this bank. This value is used to determine auxiliary CT ratio and per-unit values for protection functions. This setting must match the nominal rating of the originating Brick AC inputs, and should match the nominal secondary rating of the CTs.

Auxiliary CT Primary

Range: 1 to 65000 A in steps of 1

Default: 1 A

This setting specifies the connected primary rating of the auxiliary CTs associated with this bank. This value is used to determine the auxiliary CT ratio for ratio matching when multiple current inputs are combined within a source, and the base used for per unit current values.

Auxiliary CT Secondary

Range: 1 A, 5 A

Default: 1 A

Enter the nominal secondary current rating of the auxiliary CTs associated with this bank. This value is used to determine auxiliary CT ratio and per-unit values for protection functions. This setting must match the nominal rating of the originating Brick AC inputs, and should match the nominal secondary rating of the CTs.

Phase CT Polarity

Range: Standard, Inverted-3ph, Inverted Ph-A, Inverted Ph-B, Inverted Ph-C

Default: Standard

If CTs are wired with the correct polarity in all phases, i.e. CT polarity reversal is not required, “Standard” should be selected. If CT polarity is incorrect in just one phase, then select “Inverted Ph-A (B or C)”; choosing the affected phase. If CT polarities of all three phases are incorrect, select “Inverted-3Ph” to correct the CT polarities for all three phases. It should be noted that the oscillography record will capture the CTs current signal as applied to the relay terminal irrespective of this setting. This ensures correct relay behavior when recorded oscillography is played back to the relay.

AUX CT Polarity

Range: Standard, Inverted

Default: Standard

If the ground CT is wired with the correct polarity, select “Standard” for this setting. If the Aux CT polarity is incorrect, then select “Inverted” to correct it. It should be noted that the oscillography record will capture Aux CT current signal as applied to the relay terminal irrespective of this setting. This ensures the correct relay behavior when recorded oscillography is played back to the relay.

NOTE

It is important that the settings PHASE CT POLARITY and AUX CT POLARITY are set to the correct values before putting the relay into operation. Selecting the wrong value or changing this setting whilst relay is in operation would result in undesirable operation of the protection and control functions.

If the user intends to use the crosschecking functionality (redundancy at MU level), then this setting should be used carefully to ensure that CT Polarity is the same on both MUs on each phase/neutral channel.

Phase VT Ratio

Range: 1.00 to 24000.00 in steps of 0.01

Default: 1.00:1

Enter the ratio of the phase VTs associated with this bank. This value is used to calculate primary values for metering and per-unit values for protection functions.

Phase VT Secondary

Range: 25.0 to 240.0 V in steps of 0.1

Default: 66.4 V

Enter the voltage at the Brick terminals when the power system voltage is nominal. This value is used to determine per-unit values for protection functions.

The relay uses the secondary setting as the per unit base secondary voltage for the Brick VT inputs, and the product of the ratio and secondary settings as the corresponding primary per unit base voltage. Note that the VT input can be connected to either a phase-to-ground or a phase-to-phase voltage, so these base voltages are correspondingly either a base phase-to-ground voltage or a base phase-to-phase voltage. Normally the ratio settings are set to the overall ratio of the external VT circuits, and the secondary settings are set to the voltage that appears across the Brick VT input terminals when power system voltage is at the power system's nominal voltage (that is, 1 pu on a *system base*).

For example, on a 13.8 kV power system, with three 8400/70 V wye-connected VTs, the ratio setting is 8400 / 70 = 120, and the secondary voltage setting is (13800 / 3) / (8400/70) = 66.4 V. With these settings, a 1 pu voltage measurement in the relay corresponds to 13.8 kV phase-to-phase or 7.968 kV phase-to-ground primary, or 115 V phase-to-phase or 66.4 V phase-to-ground secondary. On the same 13.8 kV power system but with two 14400/120 V open-delta connected VTs, the ratio setting is 14400 / 120 = 120, and the secondary voltage setting is 13800 / (14400 / 120) = 115.0 V. With these settings, a 1 pu phase voltage measurement in the relay corresponds to 13.8 kV phase-to-phase primary or 115 V phase-to-phase secondary; phase-to-ground voltages are not measurable.

Phase VT Connection

Range: Wye, Delta

Default: Wye

This setting selects VT banks to be set for either wye or delta connection of the phase inputs. With wye, the three phase inputs are assumed to be phase-to-ground voltages (that is, Vag, Vbg, and Vcg) when calculating phase-to-phase and sequence voltages. With delta, the three phase inputs are assumed to be phase-to-phase voltages (that is, Vab, Vbc, and Vca).

Auxiliary VT Ratio

Range: 1.00 to 24000.00 in steps of 0.01

Default: 1.00

Enter the ratio of the auxiliary VTs associated with this bank. This value is used to calculate primary values for metering and per-unit values for protection functions and for matching primary voltage in voltage differential applications, such as synchrocheck or capacitor bank protection functions.

Auxiliary VT Secondary

Range: 25.0 to 240.0 V in steps of 0.1

Default: 66.4 V

Where used with a single phase voltage, see the Phase CT Secondary setting on page 5-8. Where used with a neutral VT, the strategy of using the voltage that appears across a Brick VT input when power system voltage is at the power system's nominal voltage is not suitable, as that voltage is zero. It is recommended instead that the secondary voltage setting be the nominal secondary voltage rating of the VT. The relay then uses as its primary and secondary base voltages the external VT's rated primary and secondary voltages.

Auxiliary VT Connection

Range: Vn, Vag, Vbg, Vcg, Vab, Vbc, Vca

Default: Vag

This setting selects the specific phase or ground voltage that is connected to the auxiliary voltage input. This setting is used to notify the relay regarding the meaning of the connected voltage, such as in the synchrocheck function.

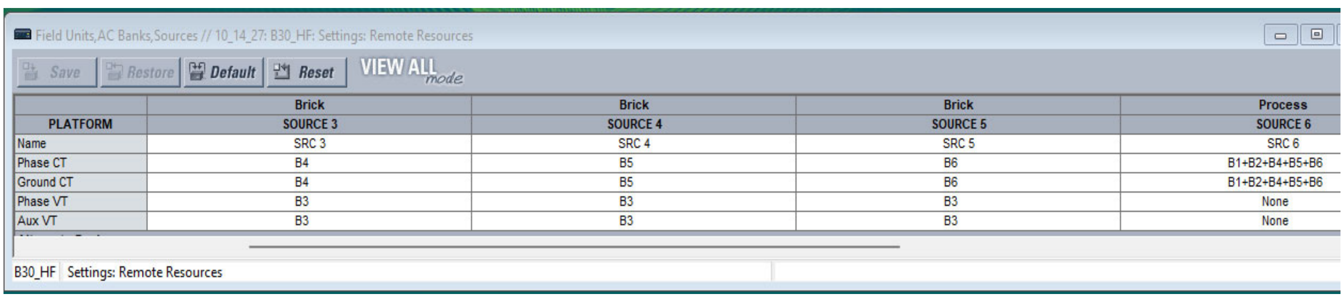
5

5.1.1.3 Platform Sources

UR devices with the Process Card use AC signal sources in the same way as conventional UR devices. See the *Introduction to AC Sources* section in the UR instruction manual for details. It is important that the voltage part of a source is either none or pointed to a voltage bank and that the current portion is either none or pointed to current banks. The EnerVista UR Setup software aids by applying setting consistency checks and alerting the user to any discrepancies.

Select the **Settings > Remote Resources > Field Units, AC Banks, Sources** menu item to open configuration window. The source settings are contained in the third of five sections in the window.

Figure 5-6: Platform Source configuration settings



The following settings are available for each source.

Source Name

Range: up to six alphanumeric characters

Default: SRC 1

This setting specifies an alphanumeric name for the source.

Source Phase CT

Range: None, B1, B2, B1+B2,...

Default: None

This setting selects the phase CTs of an AC bank or the sum the phase CTs of multiple AC banks to be the phase current of the source.

Source Ground CT

Range: None, B1, B2, B1+B2,...

Default: None

This setting selects the auxiliary CT input of an AC bank or sum of the auxiliary CT input of multiple AC banks to be the ground/auxiliary current of the source.

Source Phase VT

Range: None, B1, B2, …

Default: None

This setting selects the phase VTs of an AC bank to be the phase voltages of the source.

Source Auxiliary VT

Range: None, B1, B2, …

Default: None

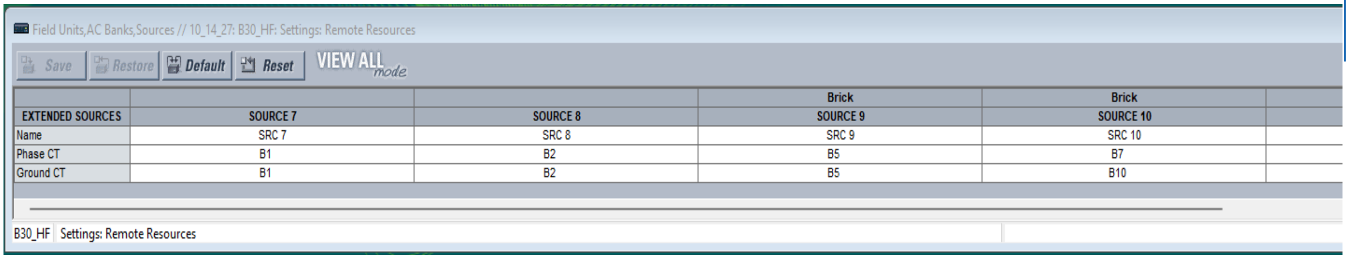
This setting selects the auxiliary VT input of an AC bank to be the auxiliary voltage of the source.

5.1.1.4 Extended Sources(Version 8.70 and higher HardFiber software options with 3 zones)

The extended sources can only be configured with CT banks and current summation is not allowed. Sources 7 to 14 can be configured with any of the CT banks 1 to 12.

Select the **Settings > Remote Resources > Field Units, AC Banks, Sources** menu item to open configuration window. The source settings are contained in the fifth of five sections in the window.

Figure 5-7: Extended Source configuration settings



The following settings are available for each source.

Source Name

Range: up to six alphanumeric characters
Default: SRC 7

Source Phase CT

Range: None, B1, B2, ...B12
Default: None

Source Ground CT

Range: None, B1, B2, ...B12
Default: None

The extended sources can only be configured with CT banks and current summation is not allowed. Sources 7 to 14 can be configured with any of the CT banks 1 to 12.

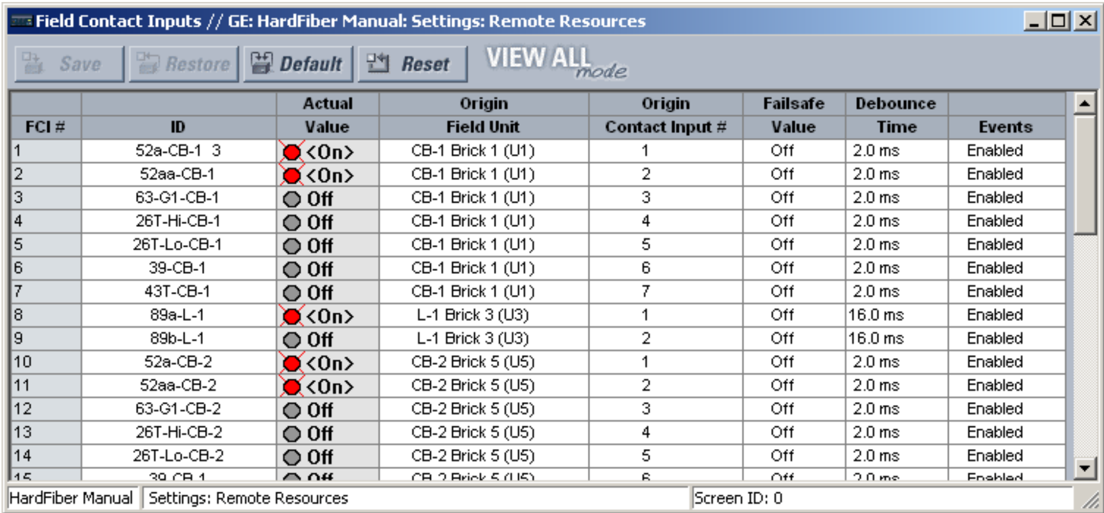
5.1.2 Field contact inputs

These settings map up to 40 of the contact inputs of the various Bricks connected to the relay to field contact input (FCI) FlexLogic operands. The FCI 1 On through FCI 40 On operands can be used wherever other FlexLogic operands can be used, such as in FlexLogic equations and as inputs for the protection elements. The FCI 1 On through FCI 40 On operands correspond to the Brick contact input being closed. These operands can be viewed in the Protection Element category under **Settings > FlexLogic > FlexLogic Equation Editor**.

Select the **Settings > Remote Resources > Field Contact Inputs** menu item to open the configuration window.

5

Figure 5-8: Field contact inputs configuration settings



FCI #	ID	Actual Value	Origin Field Unit	Origin Contact Input #	Failsafe Value	Debounce Time	Events
1	52a-CB-1 3	<On>	CB-1 Brick 1 (U1)	1	Off	2.0 ms	Enabled
2	52aa-CB-1	<On>	CB-1 Brick 1 (U1)	2	Off	2.0 ms	Enabled
3	63-G1-CB-1	Off	CB-1 Brick 1 (U1)	3	Off	2.0 ms	Enabled
4	26T-Hi-CB-1	Off	CB-1 Brick 1 (U1)	4	Off	2.0 ms	Enabled
5	26T-Lo-CB-1	Off	CB-1 Brick 1 (U1)	5	Off	2.0 ms	Enabled
6	39-CB-1	Off	CB-1 Brick 1 (U1)	6	Off	2.0 ms	Enabled
7	43T-CB-1	Off	CB-1 Brick 1 (U1)	7	Off	2.0 ms	Enabled
8	89a-L-1	<On>	L-1 Brick 3 (U3)	1	Off	16.0 ms	Enabled
9	89b-L-1	Off	L-1 Brick 3 (U3)	2	Off	16.0 ms	Enabled
10	52a-CB-2	<On>	CB-2 Brick 5 (U5)	1	Off	2.0 ms	Enabled
11	52aa-CB-2	<On>	CB-2 Brick 5 (U5)	2	Off	2.0 ms	Enabled
12	63-G1-CB-2	Off	CB-2 Brick 5 (U5)	3	Off	2.0 ms	Enabled
13	26T-Hi-CB-2	Off	CB-2 Brick 5 (U5)	4	Off	2.0 ms	Enabled
14	26T-Lo-CB-2	Off	CB-2 Brick 5 (U5)	5	Off	2.0 ms	Enabled
15	39-CB-1	Off	CB-2 Brick 5 (U5)	6	Off	2.0 ms	Enabled

The following settings are available for each field contact input.

ID

Range: 12 ASCII characters

Default: FCI1, FCI2, FCI3,..., FCI40

This setting specifies an alphanumeric name for each field contact input. Typically this name reflects the application or monitored device, for example "BRK1 52a."

Origin Field Unit

Range: None, U1, U2, U3, U4, U5, U6, U7, U8

Default: None

This setting selects the field unit from which the contact is mapped. If the origin field unit setting is set to none, the corresponding FCI 1 On to FCI 40 On operand takes on the failsafe setting value (see the Failsafe Value setting on page 5-12).

Origin Contact Input Number

Range: 1 to 18 in steps of 1

Default: 1

This setting selects the particular contact input on the corresponding Brick.

Failsafe Value

Range: Off, On

Default: Off

This setting selects the state assumed by the field contact input when the actual value is not available. The contact input state is considered unavailable when the origin is set to "None," the field unit is disabled, Brick communications fail, or the Brick reports self-test alarms potentially affecting the contact inputs.

Debounce Time

Range: 0.0 to 16.0 ms in steps of 0.5

Default: 2.0 ms

This setting specifies the time required to overcome induced noise in field contact wiring and *contact bouncing* conditions. Field contact input operands do not follow a change of state of the contact until the contact is known to have settled into a new state for as long as the set debounce time. This setting is therefore a delay in the relay's internal recognition of the new contact state.

In electrically noisy environments, a longer setting is required to prevent the relay from responding to noise hits. Where the user contact takes a long time to settle, and it is necessary to avoid the relay detecting multiple transitions on a single contact change of state, a long setting is required. However, due consideration must be taken of the tolerance of the application to the delay introduced by debouncing.

In order to provide accurate timestamps in the event record, the time of field contact input state change recognition in the event record is backdated to the time at which the debounce delay started and further backdated by the inherent communications delays within the HardFiber system.

Events

Range: Enabled, Disabled

Default: Enabled

When set to "Enabled," every change in the field contact input operand state triggers an event, which is placed in the event record. The timestamp is backdated as described in the Debounce Time setting on page 5-12, so it precedes the time of the operand state change. Preliminary *bounces* that precede the debounced change of state are not recorded.

The following information displays for each field contact input.

Actual Value

Range: Off, On

This value indicates the current status of the field contact input. A value of "On" signifies a closed contact and displays as a red LED indicator.

5.1.3 Field contact outputs

Each Brick contains four solid state relay (SSR) contact outputs and two form-C contact outputs.

The settings outlined here allow the mapping of user-selected FlexLogic operands to field contact outputs (FCO), to operate Brick SSR contact outputs and form-C contact outputs. Each field contact output operates a single specific SSR or form-C contact output. These contact outputs are equipped with various condition monitoring depending on their type; the monitored conditions are transmitted back to the field contact output status operands.

Up to four field contact outputs on four different relays can be configured to operate the same SSR or form-C output. The analogous field contact output commands from the different relays are combined in the Brick with an OR gate. If one or more field contact output commands is on, the output is driven on, and the status changes that results is transmitted back to the different relay's field contact output status operands. It is therefore possible for a relay to see an output turn on even though that particular relay did not issue a command.

The field contact output designation specifies the number of the field unit and the number of the contact on the corresponding Brick that the field contact output operates. For example, the field contact output designated U1/OUT2 operates the second contact output (OUT2) of the Brick configured to the first field unit (U1). OUT1 through OUT4 are SSR outputs, OUT5 and OUT6 are form-C outputs.

Each field contact output includes DOn, VOn, and IOn feedback FlexLogic operands that provide means for the user to use the condition of contact outputs to control the various features of the relay.

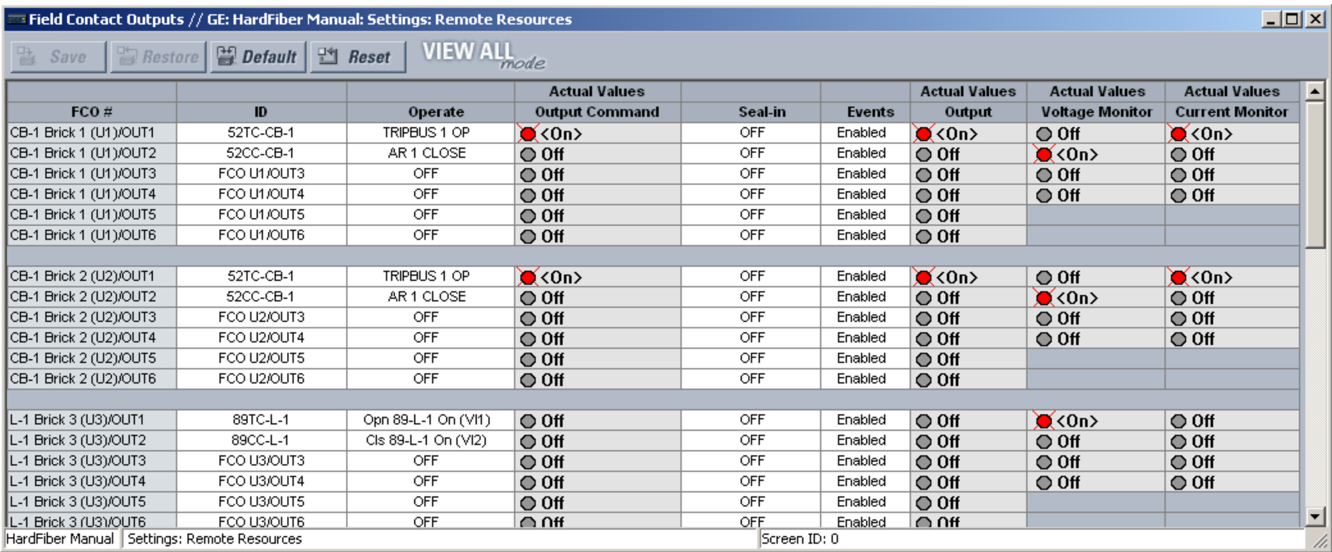
The DOn operands reflect the state of the contact output driver, and thus the contact itself. These driver operands are provided because even if the field contact output is off, the contact can be driven on by other relays, and because even though the field contact output is on, the contact driver can be off due to field unit communications being lost or disabled. The DOn operand can be used in a breaker close interlocking scheme intended to prevent issuing a close while a trip is being issued from another relay.

The VOn and IOn operands are provided only for the SSR outputs and reflect the Brick detected conditions of voltage across the contact and current through the contact respectively. The VOn operand is typically used for trip circuit or close circuit continuity monitoring. The IOn operand can be used to monitor the timing of the breaker auxiliary contact typically found in series with the trip coil.

If communications from a particular relay to a Brick are lost or disabled, the Brick behaves as if the field contact output command is off. If no other relay is commanding the driver on, it goes off. The relay driver, voltage, and current monitoring operands revert to the condition of driver off, no voltage detected, and no current detected. If this monitor operand action is not appropriate for the application, FlexLogic is used with the field unit communications failure operand (for example, U1 Off) to develop suitable action.

Select the **Settings > Remote Resources > Field Contact Outputs** menu item to open the configuration window.

Figure 5-9: Field contact outputs configuration settings



FCO #	ID	Operate	Actual Values Output Command	Seal-in	Events	Actual Values Output	Actual Values Voltage Monitor	Actual Values Current Monitor
CB-1 Brick 1 (U1)/OUT1	52TC-CB-1	TRIPBUS 1 OP	<On>	OFF	Enabled	<On>	Off	<On>
CB-1 Brick 1 (U1)/OUT2	52CC-CB-1	AR 1 CLOSE	Off	OFF	Enabled	Off	<On>	Off
CB-1 Brick 1 (U1)/OUT3	FCO U1/OUT3	OFF	Off	OFF	Enabled	Off	Off	Off
CB-1 Brick 1 (U1)/OUT4	FCO U1/OUT4	OFF	Off	OFF	Enabled	Off	Off	Off
CB-1 Brick 1 (U1)/OUT5	FCO U1/OUT5	OFF	Off	OFF	Enabled	Off		
CB-1 Brick 1 (U1)/OUT6	FCO U1/OUT6	OFF	Off	OFF	Enabled	Off		
CB-1 Brick 2 (U2)/OUT1	52TC-CB-1	TRIPBUS 1 OP	<On>	OFF	Enabled	<On>	Off	<On>
CB-1 Brick 2 (U2)/OUT2	52CC-CB-1	AR 1 CLOSE	Off	OFF	Enabled	Off	<On>	Off
CB-1 Brick 2 (U2)/OUT3	FCO U2/OUT3	OFF	Off	OFF	Enabled	Off	Off	Off
CB-1 Brick 2 (U2)/OUT4	FCO U2/OUT4	OFF	Off	OFF	Enabled	Off	Off	Off
CB-1 Brick 2 (U2)/OUT5	FCO U2/OUT5	OFF	Off	OFF	Enabled	Off		
CB-1 Brick 2 (U2)/OUT6	FCO U2/OUT6	OFF	Off	OFF	Enabled	Off		
L-1 Brick 3 (U3)/OUT1	89TC-L-1	Opn 89-L-1 On (VI1)	Off	OFF	Enabled	Off	<On>	Off
L-1 Brick 3 (U3)/OUT2	89CC-L-1	Cls 89-L-1 On (VI2)	Off	OFF	Enabled	Off	Off	Off
L-1 Brick 3 (U3)/OUT3	FCO U3/OUT3	OFF	Off	OFF	Enabled	Off	Off	Off
L-1 Brick 3 (U3)/OUT4	FCO U3/OUT4	OFF	Off	OFF	Enabled	Off	Off	Off
L-1 Brick 3 (U3)/OUT5	FCO U3/OUT5	OFF	Off	OFF	Enabled	Off		
L-1 Brick 3 (U3)/OUT6	FCO U3/OUT6	OFF	Off	OFF	Enabled	Off		

The following settings are available for each field contact output.

ID

Range: 12 ASCII characters

Default: FCO U1/OUT1 through FCO U8/OUT6

This setting can be used to assign an alphanumeric name reflective of the application, for example "BRK 1 TC1."

Operate

Range: any FlexLogic operand

Default: Off

This setting selects an operand to control the field contact output command. When the selected operand is on and the associated field unit status is OK, the Brick contact output is driven on.

Seal-In

Range: any FlexLogic operand

Default: Off

This setting selects an operand to control the field contact output command seal-in feature. Once a field contact output is turned on by the operate operand, it stays on until both the operate and the seal-in operands are off. The seal-in operand cannot turn the field contact output on, it can only hold it on once the operate operand has turned it on. Note that the seal-in feature provided by the field contact output is local only. It does not seal-in a contact output that was turned on by another relay, it only seals in the local command.

Events

Range: Enabled, Disabled

Default: Enabled

When "Enabled," each off-to-on and on-to-off transition of each of the contact output monitoring operands (DOn, VOn, and IOn), and each off-to-on and on-to-off transition of the field contact output command output triggers an event, which is placed in the event record.

The following information displays for each field contact output.

Actual Values Output Command

Range: Off, On

This value displays the output command status of the field contact output. The value is "On" (red LED indicator) when the FlexLogic operand configured to drive the output and assigned to the Operate setting is asserted and there is no major self-test.

Actual Values Voltage Monitor

Range: Off, On

This value displays the voltage monitor status of the field contact output. The value is "On" (red LED indicator) when the voltage across the output contact is greater than its threshold value. Note that the contact must be in the opened state with voltage applied to the control circuit in order for the voltage monitor to pick up.

Voltage monitoring is provided for the SSR outputs only (OUT1 through OUT4).

Actual Values Current Monitor

Range: Off, On

This value displays the current monitor status of the field contact output. The value is "On" (red LED indicator) when the current through the output contact is greater than its threshold value. Note that the contact must be in the closed state with voltage applied to the control circuit for the current monitor to pick up.

Current monitoring is provided for the SSR outputs only (OUT1 through OUT4).

5.1.4 Field latching outputs

Each Brick contains a single magnetically latched auxiliary relay controlled by two separate (open and close) coils. A single contact of the relay is brought out for use in lockout and other applications requiring a contact that does not drop out when power or communications to the Brick is lost. Note that the latching outputs are "open dominant," meaning that an open command from any relay overrides any and all close commands. This is to support lockout applications.

The latching contact is open when a Brick is shipped from the factory. It is highly recommended that the state of this contact be confirmed by continuity testing before installing a new or replacement unit in applications where the initial state of this contact is important.

The settings outlined here allow the mapping of user-selected FlexLogic operands to the field latching outputs (FLO), to operate the latching outputs. Each field latching output operates a single specific latching output. These latching outputs are equipped with various condition monitoring; the monitored conditions are transmitted back to field latching output status operands.

Up to four field latching outputs on four different relays can be configured to operate the same latching output. The field latching output commands from the four relays are combined in the Brick with an OR gate. If one or more field latching output open command is on, the output is driven open. If one or more field latching output close command is on, provided no open command is being received, the output is driven closed. The status changes that result are transmitted back to the different device’s field latching output status operands. It is therefore possible for a relay to see a latching output open even though that particular relay did not issue an open command, and for a latching output not to follow a close command due to some other relay issuing an open command.

The field latching output designation specifies the number of the field unit mapped to the Brick containing the controlled latching output. For instance, the field latching output designated U1/LO operates the latching output (LO) of the Brick mapped to the first field unit (U1).

Each field latching output includes Opened, Closed, OpnOn, and ClsOn feedback FlexLogic operands that provide means for the user to use the condition of latching outputs to control the various features of the relay.

The Opened and Closed operands reflect the status of an auxiliary contact of the latching relay (that is, the actual state of the relay). The OpnOn and ClsOn operands reflect the state of the latching relay’s open and close drivers. These driver operands are provided because even if the local relay is driving the latching output closed, the output can be driven open by other relays—open dominance is forced by Brick hardware.

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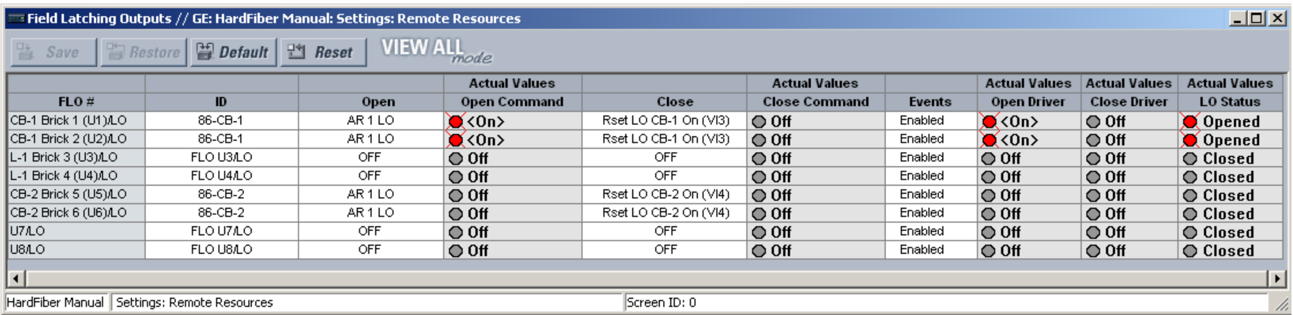
The user need not provide logic to extend open or close operand pulses. The Brick seals-in open and close commands for a duration sufficient to operate fully the latching relay.

If communication from a particular relay to a Brick is lost or disabled, the latching output stays in its last commanded state, unless some other relay is commanding it otherwise. The latching output Opened and latching output Closed operands monitoring the status of the auxiliary contact of the latching relay revert to the closed state. The relay driver monitoring operands OpnOn and ClsOn revert to the condition of drivers off. If this operand action is not appropriate for the application, use FlexLogic with the field unit communications failure operand (for example, U1 Off) to develop suitable action.

Select the **Settings > Remote Resources > Field Latching Outputs** menu item to open the configuration window.

Figure 5-10: Field latching outputs configuration settings



			Actual Values		Actual Values		Actual Values	Actual Values	Actual Values
FLO #	ID	Open	Open Command	Close	Close Command	Events	Open Driver	Close Driver	LO Status
CB-1 Brick 1 (U1)/LO	86-CB-1	AR 1 LO	<On>	Rset LO CB-1 On (VI3)	Off	Enabled	<On>	Off	Opened
CB-1 Brick 2 (U2)/LO	86-CB-1	AR 1 LO	<On>	Rset LO CB-1 On (VI3)	Off	Enabled	<On>	Off	Opened
L-1 Brick 3 (U3)/LO	FLO U3/LO	OFF	Off	OFF	Off	Enabled	Off	Off	Closed
L-1 Brick 4 (U4)/LO	FLO U4/LO	OFF	Off	OFF	Off	Enabled	Off	Off	Closed
CB-2 Brick 5 (U5)/LO	86-CB-2	AR 1 LO	Off	Rset LO CB-2 On (VI4)	Off	Enabled	Off	Off	Closed
CB-2 Brick 6 (U6)/LO	86-CB-2	AR 1 LO	Off	Rset LO CB-2 On (VI4)	Off	Enabled	Off	Off	Closed
U7/LO	FLO U7/LO	OFF	Off	OFF	Off	Enabled	Off	Off	Closed
U8/LO	FLO U8/LO	OFF	Off	OFF	Off	Enabled	Off	Off	Closed

The following settings are available for each field latching output.

ID

Range: 12 ASCII characters
Default: FLO U1 to FLO U8

This setting is used to assign an alphanumeric name that reflects the application, for example "BRK 1 LO."

Open

Range: any FlexLogic operand
Default: Off

This setting selects an operand to control the latching output's open driver. When the selected operand is on and the associated field unit status is OK, the Brick's latching output is driven to open.

Close

Range: any FlexLogic operand
Default: Off

This setting selects an operand to control the latching output's close driver. When the selected operand is on, the associated field unit status is OK, and no relay is energizing the open driver, the Brick's latching output is driven to close.

Events

Range: Enabled, Disabled
Default: Enabled

When "Enabled," each off-to-on and on-to-off transition of each of the latching output monitoring operands (Opened, Closed, OpnOn, and ClsOn) and each off-to-on and on-to-off transition of either of the field latching output command outputs triggers an event, which is placed in the event record.

The following information displays for each field latching output. These actual values indicate the current status of the field latching output open/close commands asserted by the relay, the status of the open and close drivers in the Bricks, and the status of the actual latching output contacts.

Actual Values Open Command

Range: Off, On

This value displays the open command status of the field latching output. The value is "On" (red LED indicator) when the FlexLogic operand configured to drive the contact open and assigned to the **Open** setting is asserted and there is no major self-test.

Actual Values Close Command

Range: Off, On

This value displays the close command status of the field latching output. The value is "On" (red LED indicator) when the FlexLogic operand configured to drive the contact close and assigned to the **Close** setting is asserted and there is no major self-test.

Actual Values Open Driver

Range: Off, On

This value displays the open driver status of the field latching output. The value is "On" (red LED indicator) when the open coil of the latching output is energized. Note that multiple relays can be mapped to the same output in the Brick such that the **Open Command** in a particular relay is "Off" at the same time that the **Open** driver in the Brick is "On."

Actual Values Close Driver

Range: Off, On

This value displays the close driver status of the field latching output. The value is "On" (red LED indicator) when the close coil of the latching output is energized. Note that multiple relays can be mapped to the same output in the Brick such that the **Close Command** in a particular relay is "Off" at the same time that the **Close** driver in the Brick is "On."

Actual Values LO Status

Range: Open, Closed

This value reflects the state of the auxiliary contact of the latching output, with a red LED indicator signifying an opened contact.

5.1.5 Shared inputs and outputs

Shared I/O is a feature that allows all relays connected to a particular Brick to communicate with each other via a Brick on multiple distinct binary channels. This feature is intended for applications requiring protection quality inter-relay signaling with high speed and deterministic latency. Application possibilities include breaker failure initiation, and inter-zone tripping.

The UR devices provide shared outputs (SOs) to transmit the values of local FlexLogic operands on selected shared I/O channels. They also provide shared inputs (SIs) to connect selected shared I/O channels to local operands that in turn can control the various features of the relay.

When any shared output operates, a signal is sent to the Brick on the optical fiber link, and the Brick sends the signal back to all the connected relays. Like PLC carrier on/off signaling, multiple shared outputs can send on the same channel. If any shared output on a particular channel is on, all shared inputs mapped to that channel receive are on. Only when all shared outputs on that channel are off are the shared inputs off.

In the following figure, each UR device has one shared output and one shared input interfacing to a particular shared I/O channel, an *any to all* type operation. However, shared I/O channels can also be used for *point to point* operation, *point to multi-point* operation, or *multi-point to point* operation by configuring only the required shared outputs and shared inputs onto the channel.

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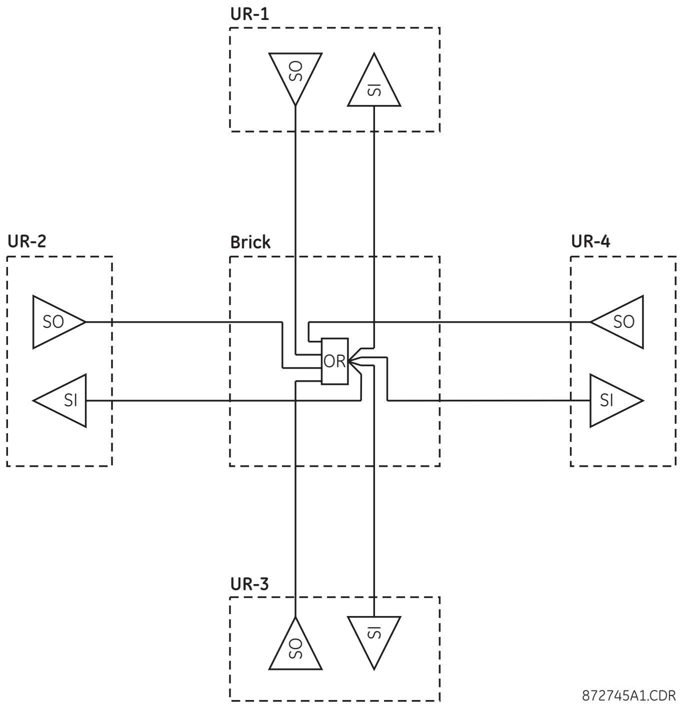
Figure 5-11: Basic shared I/O functionality example



For simplicity, each shared output is shown sending on only one channel. Shared outputs can be configured to send on two channels to facilitate applications where a single signal must be transmitted via different Bricks to reach all its destinations, and applications where redundant channels are used on duplicated Bricks. Each shared input can receive on only one channel. A second shared input can be configured to receive on a redundant channel, and the two shared inputs combined in the appropriate way (AND logic, OR logic, and so on) using FlexLogic.

For additional simplicity, only one shared I/O channel is shown in the Brick, although each Brick has 15 shared I/O channels. Each UR device supports 16 shared outputs and 16 shared inputs.

If communication from a particular relay to a Brick are lost, the field unit is disabled, or if the relay is not configured, the Brick behaves as if the shared output commands from that relay are off. If no other relay is commanding a shared I/O channel on, it goes off. If communication from a Brick to a relay is lost or the field unit disabled, the shared inputs default to off. Thus for shared I/O communications, use off as the failsafe state.

Shared I/O uses test bits to accomplish two objectives:

- Shared I/O can be tested from end to end, without requiring both sending and receiving relays to be taken out of service
- A test signal being received by mistake does not cause any undesired action, for example tripping

When the test mode function of a particular relay is selected either isolated or forcible, the relay notifies its connected Bricks via a test bit that the shared I/O values it is sending are test values and are not to be used for operational purposes. The Bricks in turn cascade this test condition to all relays connected to it. UR devices in normal test mode receiving a shared I/O from a shared output with the test bit set do not activate the shared input FlexLogic operands. The actual values display and the event recorder still operate, allowing correct operation to be verified to the receiving end. UR devices in isolated or forcible test mode ignore the test bits and activate the FlexLogic operands of the appropriate shared inputs. This allows a group of relays in test mode to interact as normal, but contain the effects of testing to within the group. In either mode, the receiving UR devices continue to display the shared I/O actual values, and record shared I/O events, allowing correct receipt to be verified. The recorded events are identified as being Test On or Test Off rather than the normal On or Off.

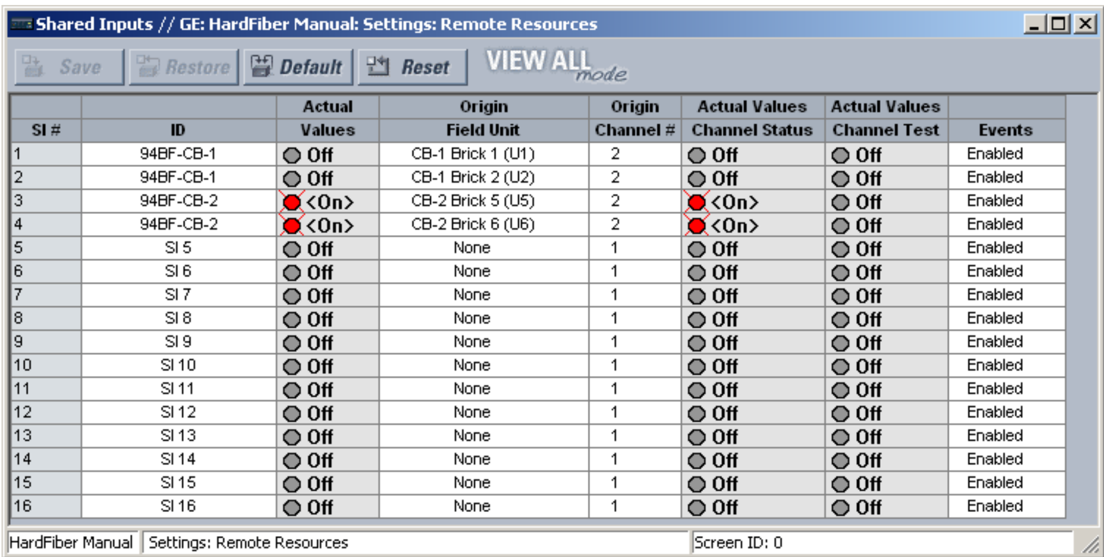
All UR shared inputs and all Bricks implement this shared I/O test blocking functionality. Therefore, if a relay in isolated or forcible mode sends a shared I/O command on an unintended channel through configuration or hard-fibering error, any receiving UR device not itself in test does no more than record the event. This is independent of the settings of any UR device involved and independent of the fiber connections between the UR devices and Bricks.

5.1.5.1 Shared inputs

The shared input settings allow the mapping of shared I/O channels to FlexLogic operands. These operands can be used wherever other FlexLogic operands can be used, such as in FlexLogic equations and as inputs for the protection elements.

Select the **Settings > Remote Resources > Shared Inputs** menu item to open the configuration window.

Figure 5-12: Shared inputs configuration settings



SI #	ID	Actual Values	Origin Field Unit	Origin Channel #	Actual Values Channel Status	Actual Values Channel Test	Events
1	94BF-CB-1	Off	CB-1 Brick 1 (U1)	2	Off	Off	Enabled
2	94BF-CB-1	Off	CB-1 Brick 2 (U2)	2	Off	Off	Enabled
3	94BF-CB-2	<On>	CB-2 Brick 5 (U5)	2	<On>	Off	Enabled
4	94BF-CB-2	<On>	CB-2 Brick 6 (U6)	2	<On>	Off	Enabled
5	SI 5	Off	None	1	Off	Off	Enabled
6	SI 6	Off	None	1	Off	Off	Enabled
7	SI 7	Off	None	1	Off	Off	Enabled
8	SI 8	Off	None	1	Off	Off	Enabled
9	SI 9	Off	None	1	Off	Off	Enabled
10	SI 10	Off	None	1	Off	Off	Enabled
11	SI 11	Off	None	1	Off	Off	Enabled
12	SI 12	Off	None	1	Off	Off	Enabled
13	SI 13	Off	None	1	Off	Off	Enabled
14	SI 14	Off	None	1	Off	Off	Enabled
15	SI 15	Off	None	1	Off	Off	Enabled
16	SI 16	Off	None	1	Off	Off	Enabled

The following settings are available for each shared input.

ID

Range: 12 ASCII characters

Default: SI1 through SI16

This setting is used to assign an alphanumeric name reflective of the application, for example "BRK1 BFI."

Origin Field Unit

Range: None, U1, U2, U3, U4, U5, U6, U7, U8

Default: None

This setting is used to map a field unit and thus a connected Brick to a shared input.

Origin Channel

Range: 1 to 15 in steps of 1

Default: 1

This setting maps a shared I/O channel on the specified field unit to a shared input.

Events

Range: Enabled, Disabled

Default: Enabled

When "Enabled," the transitions on each channel between On, Off, and TestOn independently trigger an event, which is placed in the event records.

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The following information displays for each shared input. These actual values indicate the current value of each input, its associated channel status, and its test mode status.

Actual Values

Range: Off, On

This value indicates the current status of the shared input. A value of "On" signifies the associated channel status is on and either the associated channel test is off or the local relay is in test isolated or test forcible mode.

Actual Values Channel Status

Range: Off, On

This value is "On" (red LED indicator) when the shared I/O channel of the originating Brick is on, whether in test mode or not.

Actual Values Channel Test

Range: Off, On

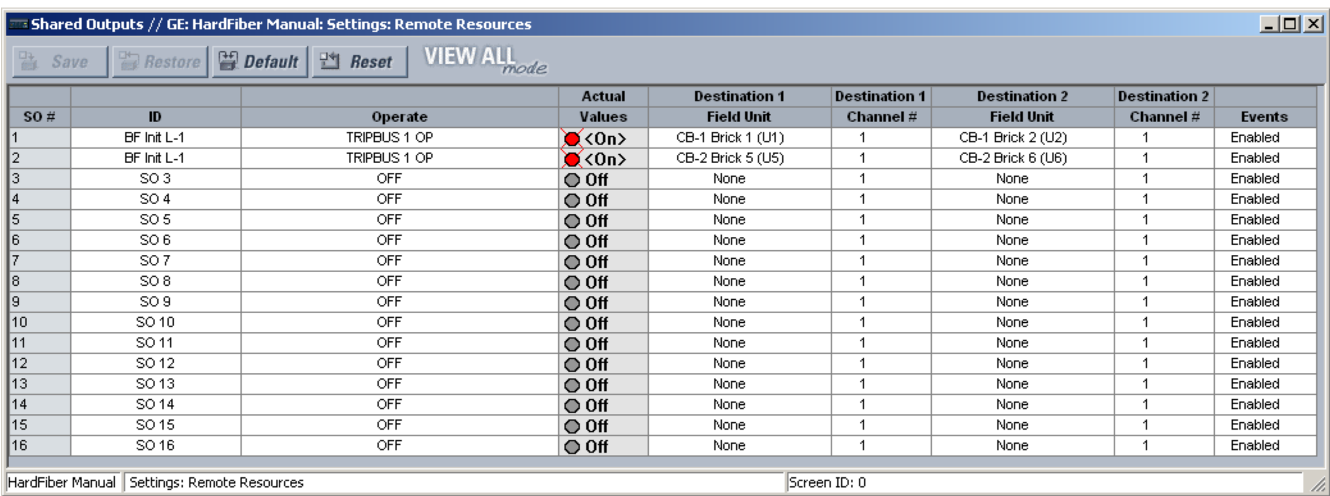
This value is "On" (red LED indicator) when the shared I/O channel test bit is set.

5.1.5.2 Shared outputs

The shared output settings allow the mapping of user-selected FlexLogic operands to shared outputs, and from the shared outputs to up to two shared I/O channels.

Select the **Settings > Remote Resources > Shared Outputs** menu item to open the configuration window.

Figure 5-13: Shared outputs configuration settings



SO #	ID	Operate	Actual Values	Destination 1 Field Unit	Destination 1 Channel #	Destination 2 Field Unit	Destination 2 Channel #	Events
1	BF Init L-1	TRIPBUS 1 OP	<On>	CB-1 Brick 1 (U1)	1	CB-1 Brick 2 (U2)	1	Enabled
2	BF Init L-1	TRIPBUS 1 OP	<On>	CB-2 Brick 5 (U5)	1	CB-2 Brick 6 (U6)	1	Enabled
3	SO 3	OFF	Off	None	1	None	1	Enabled
4	SO 4	OFF	Off	None	1	None	1	Enabled
5	SO 5	OFF	Off	None	1	None	1	Enabled
6	SO 6	OFF	Off	None	1	None	1	Enabled
7	SO 7	OFF	Off	None	1	None	1	Enabled
8	SO 8	OFF	Off	None	1	None	1	Enabled
9	SO 9	OFF	Off	None	1	None	1	Enabled
10	SO 10	OFF	Off	None	1	None	1	Enabled
11	SO 11	OFF	Off	None	1	None	1	Enabled
12	SO 12	OFF	Off	None	1	None	1	Enabled
13	SO 13	OFF	Off	None	1	None	1	Enabled
14	SO 14	OFF	Off	None	1	None	1	Enabled
15	SO 15	OFF	Off	None	1	None	1	Enabled
16	SO 16	OFF	Off	None	1	None	1	Enabled

The following settings are available for each shared output.

ID

Range: 12 ASCII characters

Default: SO1 through SO16

This setting can be used to assign a unique alphanumeric name reflective of the application, for example "BRK1 BFI."

Operate

Range: any FlexLogic operand

Default: Off

This setting selects an operand to control the shared output command output. When the selected operand is on and the associated field unit status is OK, the shared output is transmitted in the on state.

Destination 1 Field Unit, Destination 2 Field Unit

Range: None, any field unit

Default: None

These settings map the shared outputs to a field unit and thus a connected Brick.

Destination 1 Channel, Destination 2 Channel

Range: 1 to 15 in steps of 1

Default: 1

These settings map the shared outputs to shared I/O channels on the specified field unit.

Events

Range: Enabled, Disabled

Default: Enabled

When "Enabled," each off-to-on and on-to-off transition of the shared output command output triggers an event, which is placed in the events record.

The following information displays for each shared output.

Actual Values

Range: On, Off

This value displays the current status of the shared output. The value is "On" (red LED indicator) when the FlexLogic operand assigned to the **Operate** setting and configured to drive the shared output is asserted and there is no major self-test.

5.1.6 RTDs

Each Brick provides three analog DC inputs, which can be used with resistance temperature detectors (RTDs), DCmA transducers, DCmV transducers, and potentiometers, as determined by the actual physical wiring connection to the Brick. See Component descriptions on page 3-1 for details. Each DC input can be mapped to RTD or TDR (transducer) objects.

An RTD object contains the settings required to configure a DC input used as an RTD input and performs the scaling required to convert the data from the sensed resistance to degrees Celsius. Each UR device supports eight RTD objects.

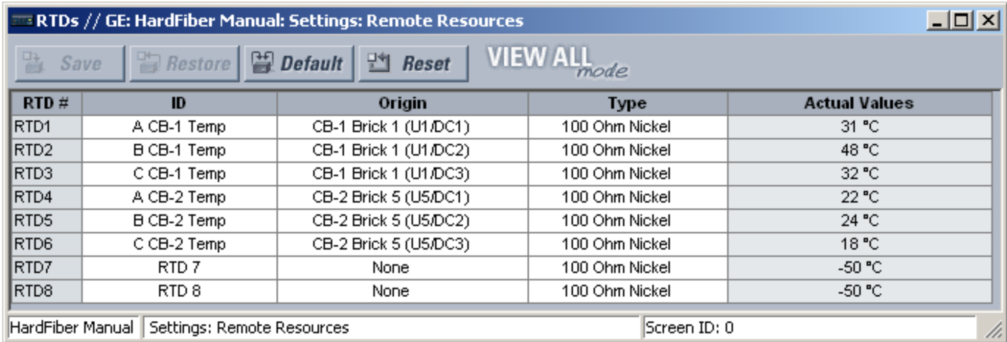
The UR device generates an actual value and FlexAnalog parameter for each RTD object. Actions based on RTD values, such as trips or alarms, are done in conjunction with the FlexElement feature using the FlexAnalog parameters. FlexElement operands are available to FlexLogic for further interlocking or to operate an output contact directly.

In FlexElements, the operate level from an RTD is scaled to a per unit base of 100°C, with zero per-unit corresponding to 0°C. For example, a trip level of 150°C is achieved by setting the operate level at 1.5 pu.

Whenever data from the Brick is unavailable or unreliable, or the Brick is reporting that the sensed RTD field connection does not match that of an RTD, the associated FlexAnalog parameter is forced to zero. In this case, an RTD trouble FlexLogic operand (for example, RTD1 Trouble On) is on. If this action is not appropriate for the application, use FlexLogic with the trouble operand to force a suitable action. The trouble operand is also on when the reported DC input value is outside of the RTD temperature range: greater than 250°C (likely open sensor circuit fault) or less than –50°C (likely shorted sensor fault).

Select the **Settings > Remote Resources > RTDs** menu item to open the configuration window.

Figure 5-14: RTD configuration settings



RTD #	ID	Origin	Type	Actual Values
RTD1	A CB-1 Temp	CB-1 Brick 1 (U1/DC1)	100 Ohm Nickel	31 °C
RTD2	B CB-1 Temp	CB-1 Brick 1 (U1/DC2)	100 Ohm Nickel	48 °C
RTD3	C CB-1 Temp	CB-1 Brick 1 (U1/DC3)	100 Ohm Nickel	32 °C
RTD4	A CB-2 Temp	CB-2 Brick 5 (U5/DC1)	100 Ohm Nickel	22 °C
RTD5	B CB-2 Temp	CB-2 Brick 5 (U5/DC2)	100 Ohm Nickel	24 °C
RTD6	C CB-2 Temp	CB-2 Brick 5 (U5/DC3)	100 Ohm Nickel	18 °C
RTD7	RTD 7	None	100 Ohm Nickel	-50 °C
RTD8	RTD 8	None	100 Ohm Nickel	-50 °C

The following settings are available for each RTD.

ID

Range: 12 characters
Default: RTD1 through RTD8

This setting assigns an alphanumeric name that reflects the application, for example "TX1 TOP OIL."

Origin

Range: None, any Brick DC1 through DC3
Default: None

This setting allows any of the DC inputs on any Brick that is mapped to a field unit to be mapped to any of the RTD objects. There is no restriction on mapping a DC input to more than one RTD.

Type

Range: 100Ω Ni, 120Ω Ni, 100Ω Pt
Default: 100Ω Ni

This setting selects the type of physical RTD connected to the Brick. The Brick injects a specified sensing current through the RTD and measures the resulting voltage drop across the sensor, compensating for lead resistance. Using the specified value for sensing current and the measured sensor voltage, the RTD object determines the sensor resistance, then interpolates according to the following table to determine the sensor's temperature.

Table 5-2: RTD temperature versus resistance

Temperature		Resistance (in ohms)		
°C	°F	100 Ω Pt (DIN 43760)	120 Ω Ni	100 Ω Ni
–50	–58	80.31	86.17	71.81
–40	–40	84.27	92.76	77.30
–30	–22	88.22	99.41	82.84
–20	–4	92.16	106.15	88.45
–10	14	96.09	113.00	94.17
0	32	100.00	120.00	100.00
10	50	103.90	127.17	105.97
20	68	107.79	134.52	112.10
30	86	111.67	142.06	118.38
40	104	115.54	149.79	124.82
50	122	119.39	157.74	131.45
60	140	123.24	165.90	138.25
70	158	127.07	174.25	145.20
80	176	130.89	182.84	152.37
90	194	134.70	191.64	159.70
100	212	138.50	200.64	167.20
110	230	142.29	209.85	174.87
120	248	146.06	219.29	182.75
130	266	149.82	228.96	190.80
140	284	153.58	238.85	199.04
150	302	157.32	248.95	207.45
160	320	161.04	259.30	216.08
170	338	164.76	269.91	224.92
180	356	168.47	280.77	233.97
190	374	172.46	291.96	243.30
200	392	175.84	303.46	252.88
210	410	179.51	315.31	262.76
220	428	183.17	327.54	272.94
230	446	186.82	340.14	283.45
240	464	190.45	353.14	294.28
250	482	194.08	366.53	305.44

The following information displays for each RTD.

Actual Values

Range: –250 to 250°C

This value displays the actual temperature value of the RTD.

5.1.7 Transducers

Each Brick provides three analog DC inputs, which can be used with RTDs, DCmA transducers, DCmV transducers, and potentiometers, as determined by the actual physical wiring connection to the Brick. See Component descriptions on page 3-1 for details. Each DC input can be mapped to RTD or TDR (transducer) objects.

A TDR (transducer) object contains the settings required to configure a DC input used as a potentiometer input, a DCmA input, or a DCmV input with various ranges, and maps the sensed input signal to a user specified scale with user specified units. Each UR device supports eight TDR objects.

The relay generates an actual value and FlexAnalog for each TDR object, where a FlexAnalog is an analog parameter. Actions based on transducer values, such as trips or alarms, are done in conjunction with the FlexElements feature using FlexAnalog parameters. A FlexElement is a universal comparator used to monitor any analog actual value calculated by the relay or a net difference of any two analog actual values of the same type. FlexElement operands are available to FlexLogic for further interlocking or to operate an output contact directly.

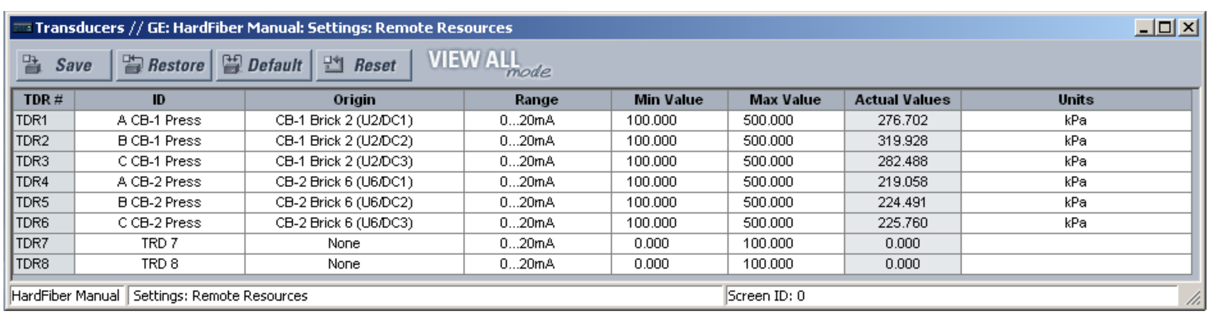
The actual value of a transducer is scaled based on the input range, minimum value, and maximum value user settings, as follows. The range setting contains a first range limit R1 and a second range limit R2: the first and second levels mentioned in its name. For example, for a 4 to 20 mA input, R1 is 4 mA and R2 is 20 mA. The input signal is expected to be within these limits. The potentiometer setting implies a range from zero to the value of the DC input sensing voltage source supply. Transducers with a *tap position* setting work the same as with potentiometer setting, except that the actual value output is rounded to the nearest whole number. A DC input at the first range limit results in an actual value display equal to the minimum value setting (Vmin). A DC input at the second range limit results in an actual value display equal to the maximum value setting (Vmax). Linear interpolation is used between these points. Setting the minimum value setting more positive than the maximum value is the equivalent to inverting the input.

The FlexElement operate level setting for a transducer is scaled in a per-unit system with a base equal to the maximum value setting, and with zero per-unit corresponding to zero in the unit system used by the maximum value setting. For example, on a transducer where the maximum value setting is 100, a trip level of 75 is achieved by setting the operate level at 75/100 = 0.75 pu, regardless of the input range (for example, "–5…5V," "4…20mA," and "Potentiometer") and regardless of the minimum value setting, provided only that 75 is within the hardware conversion range of the DC input.

Whenever data from the Brick is unavailable or unreliable, or the Brick is reporting that the sensed transducer field connection does not match that of a transducer, the associated FlexAnalog parameter is forced to a value corresponding to a DC input of zero. In this case, a transducer trouble FlexLogic operand (for example, TDR1 Trouble On) is on. If this action is not appropriate for the application, use FlexLogic with the trouble operand to force a suitable action. The trouble operand is also on when the reported DC input is outside of the set transducer input range, or the minimum value setting is equal to the maximum value setting. For example, this operand is on if a 4 to 20 mA transducer indicates current less than 4 mA or greater than 20 mA.

Select the **Settings > Remote Resources > Transducers** menu item to open the configuration window.

Figure 5-15: Transducer configuration settings



TDR #	ID	Origin	Range	Min Value	Max Value	Actual Values	Units
TDR1	A CB-1 Press	CB-1 Brick 2 (U2/DC1)	0...20mA	100.000	500.000	276.702	kPa
TDR2	B CB-1 Press	CB-1 Brick 2 (U2/DC2)	0...20mA	100.000	500.000	319.928	kPa
TDR3	C CB-1 Press	CB-1 Brick 2 (U2/DC3)	0...20mA	100.000	500.000	282.488	kPa
TDR4	A CB-2 Press	CB-2 Brick 6 (U6/DC1)	0...20mA	100.000	500.000	219.058	kPa
TDR5	B CB-2 Press	CB-2 Brick 6 (U6/DC2)	0...20mA	100.000	500.000	224.491	kPa
TDR6	C CB-2 Press	CB-2 Brick 6 (U6/DC3)	0...20mA	100.000	500.000	225.760	kPa
TDR7	TRD 7	None	0...20mA	0.000	100.000	0.000	
TDR8	TRD 8	None	0...20mA	0.000	100.000	0.000	

The following settings are available for each transducer.

ID

Range: 12 ASCII characters
Default: TDR1 through TDR8

This setting is used to assign an alphanumeric name that reflects the application, for example "T1 Tap Pos."

Origin

Range: None, any Brick DC1 to DC3
Default: None

This setting allows any of the DC inputs on any Brick that is mapped to a field unit to be mapped to any of the TDR objects. There is no restriction on mapping a DC input to more than one TDR object.

Range

Range: –5…+5V, –1…+1mA, 0…–1mA, 0… +1mA, 0…5mA, 0…10mA, 0…20mA, 4…20mA, Potentiometer, Tap Position
Default: 0…20mA

This setting selects the range of the connected transducer.

Minimum Value

Range: –9999.999 to 9999.999 in steps of 0.001
Default: 0.000

This setting specifies the value of the transducer measurement when the transducer output is at its minimum range (for example, 4 mA in the case of a 4 to 20 mA transducer).

Maximum Value

Range: –9999.999 to 9999.999 in steps of 0.001
Default: 0.000

This setting specifies the value of the transducer measurement when the transducer output is at its maximum range (for example, 20 mA in the case of a 4 to 20 mA transducer).

Units

Range: up to six alphanumeric characters
Default: units

This setting specifies the unit string displayed with the actual vales.

The following information displays for each transducer.

Actual Values

Range: –9999.999 to 9999.999 in steps of 0.001

This value displays the actual value of the transducer.

5.2 Actual Values

The actual values of remote resources and Brick status display in the EnerVista UR Setup online mode. These displays are the same as those found under the **Settings** menu item except that the actual values cannot be selected or modified.

Each actual value field is described in the previous sections with the settings.

Select the **Actual Values > Remote Resources** menu to display the selections for the actual values windows.

5.3 FlexLogic operands

When a UR device includes a Process Card, additional FlexLogic operands are available for use. These HardFiber operands can be used the same way as other FlexLogic operands. See the UR instruction manuals for more information on FlexLogic operands.

AC BANK

AC Bank1 Fail	Logic operands that are On when at least one origin is selected to an enabled field unit, but no measurements are being received without brick diagnostic flags relevant to AC inputs set.
AC Bank1 Discrepant	Logic operands that are On when current /voltage measurements are being received from both origins without brick diagnostic flags relevant to AC inputs set, but the two measurements are substantially different.

FIELD UNIT OPERANDS

U1 On	This operand is asserted when the field unit is enabled, Brick communications are normal, and the Brick is reporting no self-test alarms.
U2	The operand listed above is available for field units 2 through 8.

FIELD CONTACT INPUT OPERANDS

FCI 1 On	This operand is asserted when the associated contact input is closed.
FCI 2	The operand listed above is available for field contact inputs 2 through 40.

FIELD CONTACT OUTPUT OPERANDS

FCO U1/OUT1 DOn	This operand is asserted when the associated physical contact is being driven on.
FCO U1/OUT1 IOn	This operand is asserted when current is detected through the physical contact output.
FCO U1/OUT1 VOn	This operand is asserted when voltage is detected across the physical contact output.
FCO U1/OUT2	The operands listed above are available for field contact outputs 2 through 4. DOn is also available for contact outputs 5 and 6.
FCO U2	The operands listed above are available for field units 2 through 8.

FIELD LATCHING OUTPUT OPERANDS

FLO1 Opened	This operand is asserted when the latching output contact is opened.
FLO1 Closed	This operand is asserted when the latching output contact is closed.
FLO1 OpnDOn	This operand is asserted when the latching output contact is being driven to the open state.
FLO1 ClsDOn	This operand is asserted when the latching output contact is being driven to the closed state.

SHARED INPUT OPERANDS

SI 1 On	This operand is asserted when the received shared I/O channel status is "On" and either the channel test is "Off" or the relay is in the test isolated or test forcible mode.
SI 2	The operand listed above is available for shared inputs 2 through 16.

DC INPUT OPERANDS

RTD1 Trouble On	This operand is asserted when the RTD 1 data is unavailable, unreliable, out-of-range (short or open), or the sensed field connection is incorrect.
TDR1 Trouble On	This operand is asserted when the transducer data is unavailable, unreliable, out-of-range, the sensed field connection is incorrect, or the minimum and maximum settings are equal.
RTD2	The operands listed above are available for RTDs 2 through 8.
TDR2	The operands listed above are available for transducers 2 through 8.

SELF-TEST DIAGNOSTIC OPERANDS

PROCESS BUS FAILURE	See the PROCESS BUS FAILURE section on page 6-2.

5.4 FlexAnalog parameters

A FlexAnalog is an analog parameter. For the HardFiber system, additional FlexAnalog parameters are available. These parameters can be used the same way as other FlexAnalog parameters.

DC INPUT PARAMETERS

RTD1 Temperature	Indicates the metered RTD temperature in degrees Celsius.
RTD2	The parameter listed above is available for RTDs 2 through 8.
TDR 1 Value	Indicates the metered transducer value in the user-specified units.
TDR2	The parameter listed above is available for transducers 2 through 8.

HardFiber Process Bus System

Chapter 6: Diagnostics and troubleshooting

This chapter outlines self-test errors and troubleshooting features of the HardFiber system.

6.1 Overview

The HardFiber system contains extensive diagnostics to annunciate trouble with hardware and settings. The diagnostics include the following:

- Indicator LEDs on the Brick
- Indicator LEDs on the Cross Connect Panel
- Indicator LEDs on the rear of the Process Card
- Actual values in the EnerVista software
- Self-test error target messages on the UR front panel displays, EnerVista displays, and in events records
- Critical failure relay for the UR devices

The LEDs and actual values are described in the Component Descriptions chapter and Actual Values sections of this manual.

A critical failure relay is a form-C relay that is energized once control power is applied and the relay has successfully booted up with no critical self-test failures. A critical failure relay is de-energized when the UR looses power or when any major self-test error is present.

6.2 Self-test errors

In addition to self-tests of the UR devices, the UR devices implement HardFiber self-tests, outlined here. Any abnormal diagnostic condition indicated by the LEDs or the critical failure relay also results in a self-test message, so troubleshooting is also described here.

6.2.1 Major self-test errors

EQUIPMENT MISMATCH

- *Description of problem*: The number or type of installed hardware modules does not match the order code stored in the CPU. The standard UR-series Equipment Mismatch self-test is extended to cover the possible presence of a Process Card.
- *Severity*: Protection is not available and all contact outputs and shared outputs are de-asserted.
- *What to do*: Check all modules against the order code. Ensure they are inserted properly, and cycle the control power. If a module has intentionally been added or removed use the Update Order Code command to notify the relay that the current module configuration is correct.

MODULE FAILURE

- *Description of problem*: UR-series device module hardware failure detected.
- *Severity*: Protection is not available and all contact outputs and shared outputs are de-asserted.
- *What to do*: Contact the factory and supply the failure code noted in the display. Text in the message identifies the failed module (for example, H81). If operated on a Process Card failure, the Module Fail self-test seals-in (latches) till the UR-series device is restarted.

PROCESS BUS FAILURE

- *Description of problem*: Mission critical data is not available via the process bus. An AC quantity is considered critical if both AC bank origins and the crosschecking settings are other than None. This self-test is also initiated by an AC input discrepancy being detected. See the description of the setting Crosschecking on page 5-7 for further information. In addition, this self-test can be initiated by user logic responding to loss of critical contact input/output or other data using the **Process Bus Failure Operand** user-programmable self-test setting. This setting is located in the **Settings > Product Setup > User-Programmable Self Test** menu.
- *Severity*: Protection is not available and all contact outputs and shared outputs are de-asserted.
- *What to do*: First rectify any Process Bus Trouble and Brick Trouble self-test errors. Check the actual value of the operand referenced by the Process Bus Failure Operand setting, and if “On,” determine the cause and rectify.

  If the problem persists with the foregoing all clear, the cause must be an AC input discrepancy, which is typically the result of problems in the input signals to the Bricks, or faults in the Brick input conditioning hardware. If the error was annunciated the first time significant signal was encountered, suspect the former cause and check the copper connections external to the Brick. Where multiple UR-series devices have self-test errors, look for common causes.

  To further isolate AC input discrepancy errors, put the relay in test-isolated mode, then one by one, temporally change an AC bank Crosschecking setting to None, until the Process Bus Failure clears. Once the problem AC bank has been identified, the values from each of the two Bricks can be examined individually by temporarily mapping each to an AC bank with a single origin.

6.2.2 Minor self-test errors

PROCESS BUS TROUBLE

- *Description of problem*: Communications problems with one or more Bricks. The text of the message identifies the affected field units. This self-test is initiated by low received signal levels at either the Brick or Process Card end, and by the sustained failure to receive poll responses from the proper Brick.
- *Severity*: This self-test error does not directly inhibit protection. However, the affected Brick inputs/outputs may not be available to the UR device.
- *What to do*: Check the field unit actual values. An indication of equipment mismatch means that messages are being received from a Brick, but there is a discrepancy between the settings and the actual Brick serial number, order code, and/or core number. Check that the correct core on the correct Brick is patched through to the correct Process Card port, and that the field unit settings are correct. An indication of communications loss means that no messages are being received. Check that the patching is correct, and that the Brick has power. If

that is not the problem, use a professional optical fiber connector cleaning kit to clean both sides of all optical fiber connections from the Process Card through to the affected Brick. If the problem continues after cleaning, consult the factory.

BRICK TROUBLE

- *Description of problem*: Brick internal self-testing has detected trouble internal to the Brick.
- *Severity*: This self-test error does not directly inhibit protection. However, some or all of the affected Brick inputs/outputs may not be available to the UR device.
- *What to do*: Check the Brick environment for over/under temperatures and the voltage of its power source. If the ambient temperature and supply voltage are within Brick specifications, consult the factory. Troubles resulting from a Brick output failing to respond to an output command can only be detected while the command is active, and so in this case the target is latched. A latched target can be unlatched by pressing the front panel reset key if the command has ended, however the output can still be non-functional.

HardFiber Process Bus System

Chapter 7: Testing and commissioning

This chapter describes testing and commissioning of the HardFiber system components.

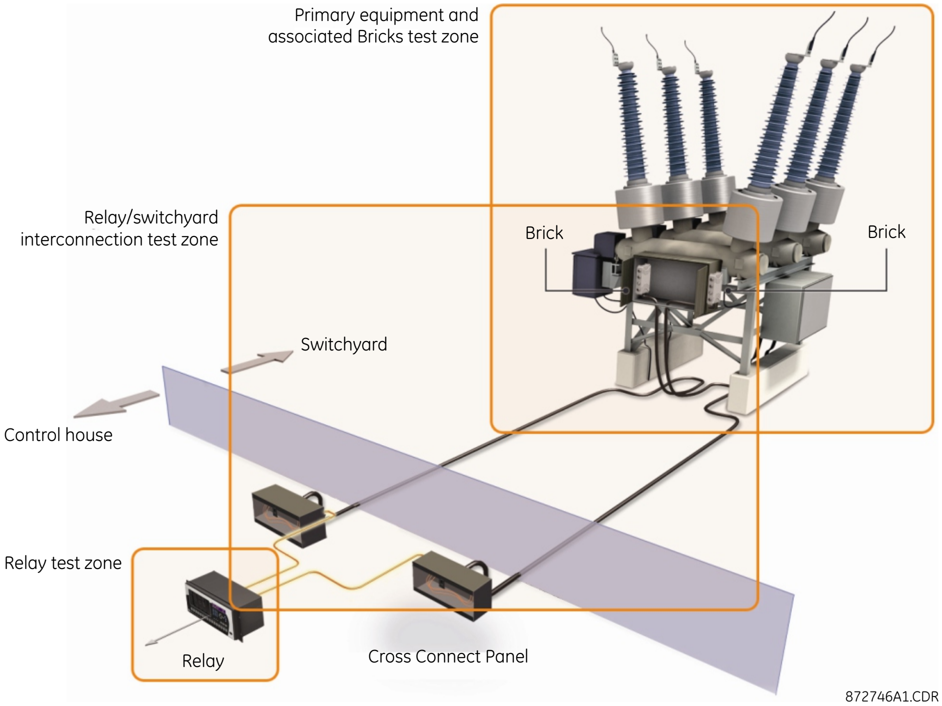
7.1 Introduction

Protection and control systems need to be tested to verify that they are capable of correctly performing their intended functions when initially placed in service and when modifications are made. They also need to be tested periodically in order to detect any hidden failures. Testing is required to isolate an operational problem to a specific component, and to verify system performance following repair. Tests must cover the entire protection and control system, not just the relay.

Traditionally, such protection and control system testing was based largely on input injection and output monitoring of secondary electrical (meaning copper-based) signals via test switches located at the relay panel using conventional relay test sets. At first it can appear that an entirely new approach is required with HardFiber systems as copper signals are distributed throughout the switchyard, out of practical reach of a conventional test set. In addition, in many cases a copper signal feeds more than one relay, making it impossible to electrically inject to only one protection. However, going back to the basic principle of input injection and output monitoring at the relay reveals a solution: test at the relay panel by substituting optical signals rather than electrical signals as is done with traditional testing.

This section of the manual outlines a practical HardFiber testing procedure. Other methods and variants are possible, depending on organizational and procedural needs.

Figure 7-1: HardFiber test zones



At a high level, the HardFiber test strategy is to divide the protection system into three types of test zone:

1. The relay, including its Process Card.

   The relay is tested in isolation from the rest of the protection system out to the optical fiber connectors on the process bus module card, which are the device’s terminal points. Optical signals generated by test equipment are injected and the optical signals generated by the relay are monitored at these terminal points. This is analogous to conventional relay testing procedures, except that optical rather than electrical signals are used.

2. The Brick, its associated primary power equipment, and the interconnections between these two.

   The Brick and primary power equipment are considered to be a single entity for the purpose of testing, and this entity is tested in isolation up to the Brick's fiber cable connector, which is the entity's terminal point for protection and control purposes. Optical signals generated by test equipment are injected to this terminal point, and the optical signals generated by it are monitored there. This is analogous to conventional primary power equipment protection test procedures, except that optical rather than electrical signals are used.

3. The optical fibers connecting the relay to the Bricks, including the indoor fiber cable, the Cross Connect Panel, and the outdoor fiber cable.

   To ensure proper overlap and integration of the relay and Brick and primary equipment zones, the testing of the optical fiber zone is fully integrated within the system, with continuous testing covering portions of both the relay and the Bricks.

As described here, this strategy puts the test zone division points and thus the points where test equipment is attached at the Process Card and at the Brick's fiber cable connector, but one or both of these points can be moved to the Cross Connect Panel.

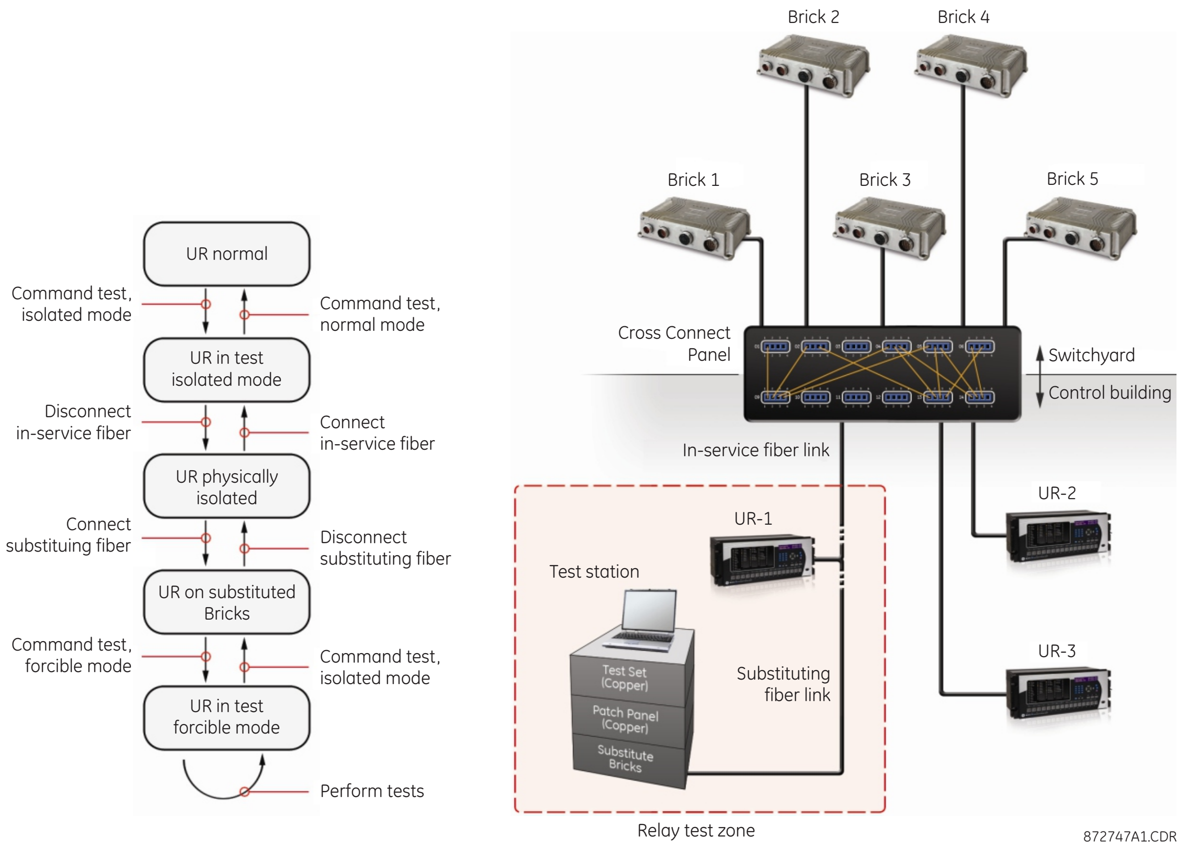
The test equipment used to generate optical signals to inject to the relay and monitor its optical outputs includes one or more substitute Bricks. Similarly, the test equipment used to generate optical signals to inject to the Brick and monitor the Brick's optical outputs can include a substitute relay. This assures that the test optical signals are of the same format as the in-service signals.

7.2 UR device testing

This section describes the HardFiber test strategy for HardFiber relays, using a UR device as an example.

As far as testing a process bus system is concerned, the test zone for a given relay includes the UR itself, along with any conventional copper inputs/outputs, direct inputs/outputs, and remote inputs/outputs interfaces. The testing of these extra interfaces are beyond the scope of this manual. In overview, the procedure consists of isolating the test zone, doing any required work, such as hardware replacement and settings or firmware changes, followed by the actual testing, and then finally restoring the test zone to service.

Figure 7-2: HardFiber relay test methodology and facility



7.2.1 UR device isolation

A critical testing step in the in-service environment is isolating (blocking) the UR device outputs from external circuits to prevent operation of those circuits (for example, tripping). Failure to perform this step properly can result in the testing effort causing more harm than good. For this reason, the UR device provides a manual user command that puts it in a test-isolated mode. When a Process Card is installed in a UR device, the test-isolated mode described in the UR instruction manual test mode section is extended such that all process bus command outputs from the UR device are also disabled. This is equivalent to opening the output test switches in a conventional copper connected protection, except that all of the command outputs are blocked with a single user action— there is no chance that wiring or personnel error can result in one output being overlooked and left operational. When in this mode, the front panel "In-Service" indicator is turned off, the "Test Mode" indicator is turned on, and the critical failure relay is de-energized (alarm state), so that there is little chance of even one output of the UR device being inadvertently left in this blocked state when work is complete. This mode is non-volatile; the only way to return to the normal in-service mode is by specific user command action. This mode does not in any way depend on relay settings, and thus can be relied on when uploading new settings to an existing relay application.

In the HardFiber relay test methodology and facility figure on page 7-3, the state transition resulting from this step is labeled *command test isolated mode*.

With conventional protection schemes connected via copper wiring, external circuits connected to the UR inputs must also be safely isolated from harmful test conditions (for example, opening a CT circuit) and test actions (for example, AC injection) with an adverse effect on other users of the signals. There is no equivalent concern with the HardFiber process bus implementation. There is no equipment harm in opening the fibers, and the fibers associated with the UR device under test have no client other than the UR device under test.

7.2.2 UR device injection testing

Traditionally relays are tested by injecting signals to check the following items:

- Current, voltage, and contact input hardware, to ensure that the measuring elements and scheme logic are operating correctly
- Settings are correct (for example, that the technician or settings engineer did not accidentally type 15.0 instead of 1.50 for a pickup value)
- Contact output hardware

Now with a process bus, the UR device has no physical current, voltage, or contact inputs, so there is no corresponding hardware to check. The digital hardware performs somewhat analogous functions, where the optical transceivers, internal circuits, and so on, are continuously self-tested with signal level margin detectors and with data security codes (that is, CRC), so there is little if any value in further testing the UR device process bus input/output hardware. The firmware and processors that implement the measuring elements and scheme logic is again checked continuously by CRC and watchdog timers.

A strong argument can be made that injection testing for checking the settings is of little value, as there are other less complex and more secure means of verifying the settings. Nevertheless, simulating power system faults and observing relay reaction has value as a method for checking the settings in a way that does not involve a human understanding of how the relay interprets its settings, and thus can be done by personnel with a different perspective than the settings engineers, and thus less likely to make the same mistake. This makes it advisable to have the ability to do injection testing with a process bus.

Traditionally, injection testing uses a relay test set connected to the UR device under test via test switches (for example, S20 switches). With the HardFiber process bus architecture, a conventional relay test set can still used, but is connected to the UR device optical fiber ports through test or substitute Bricks, identical to the actual in-service Bricks. The substitute Bricks and the relay test set together form a test station, which can be thought of as a process bus relay test set. It injects inputs and monitors outputs from the UR device process bus ports analogous to the way a conventional relay test set injects and monitors conventional current, voltage, and contacts.

With the HardFiber process bus implementation, Bricks with the same order code are directly interchangeable without any preparation other than updating the serial number settings in the UR devices. The initial Brick firmware version is irrelevant as the current version of the connected UR device is downloaded automatically. The Bricks themselves have no configuration settings. Therefore one can be confident that the test signals delivered to the UR device by the substituted Bricks are the same as those from the permanent Bricks, and vice versa.

This hardware substitution strategy tests outputs by checking the output signals at a break in the optical signal path made by an LC connector, using the test station as a measuring device. The assumption is made that a signal that made an output of the substituted Brick operate makes the permanent Brick operate if the LC connector instead closed the signal path to the permanent Brick. Traditional relay test strategy for checking outputs is by measuring voltage signal levels at a break in the signal path made by an S20 test switch, using a multimeter or a relay test set. The assumption is made that if the S20 switch were instead closed, the connected breaker trips. Thus it can be seen that the HardFiber substitution strategy is more realistic than the traditional test strategy; to be comparable the traditional strategy must use a test breaker to confirm that outputs are capable of supplying breaker trip level currents.

To use this technique, after putting the UR device in the test-isolated mode, disconnect the in-service process bus fiber connections either at the relay itself or at the Cross Connect Panel, and connect instead substituting fiber to the test station. Proper fiber handling practices need to be observed while disconnecting and reconnecting the fiber, especially to prevent contamination of the fiber ends.

The UR device can be attended to at this point, if required. That is, hardware can be replaced, new firmware uploaded, and new settings applied. The user then issues a command to the UR device causing it to switch from the test-isolated mode to the test-forcible mode. When a Process Card is installed in a UR device, the test-forcible mode described in the Test Mode Forcing section of the UR instruction manual is extended such that command outputs from the relay are again enabled onto the process bus, which now connects only to the test station. In addition, the configuration locking mechanism that normally prevents communications between a UR device and a Brick with other than the set serial number is bypassed in test-forcible mode, to allow the UR device under test to communicate with substituted Bricks. The front panel indicators and critical failure output continue to show that the UR device is not in-service.

Refer back to the labeled steps in the HardFiber relay test methodology and facility figure on page 7-3. Once in this test-forcible mode, the conventional relay test set can be used to perform any functional tests that can be performed on a non-process bus system. The nature of these tests, and how they accommodate station bus or conventional contact input/outputs, is beyond the scope of this document.

7.2.3 UR device restoration

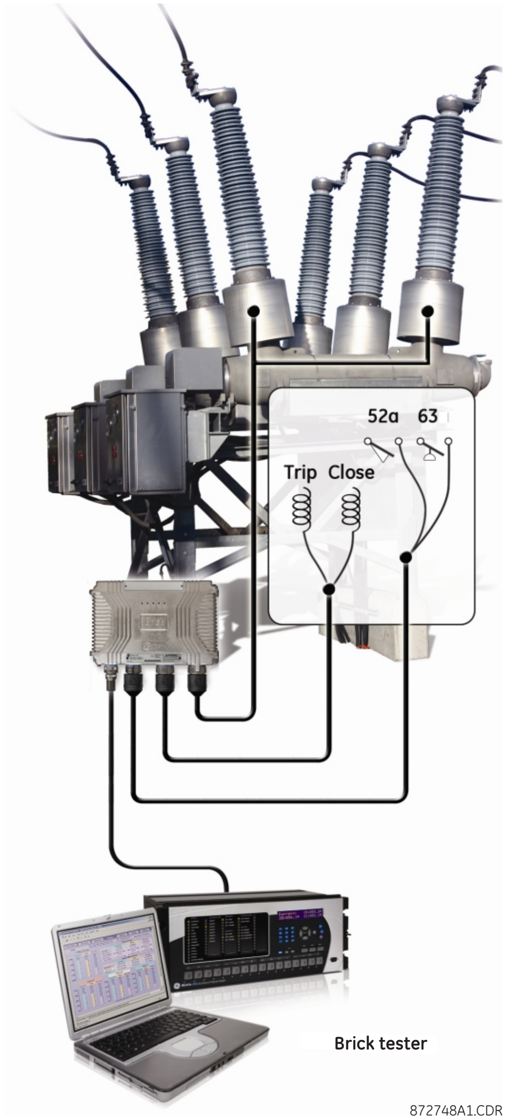
Once the testing is complete, restore the UR to service in a safe and secure way. Avoid the trap of closing a switch, making a connection, or restoring a mode that results in undesired action, such as tripping a circuit breaker. Without due care, such behavior can occur, for instance due to the seal-in of a protection scheme or the response to having some but not all live inputs restored. This can be accomplished by reversing the actions of the previous steps, moving up in the HardFiber relay test methodology and facility on page 7-3. First the user commands the test isolated mode so that when the permanent Bricks are re-connected, no process bus commands can result in unwanted action, such as tripping. The substituted Brick fiber links are disconnected, and the permanent Bricks are reconnected. At this stage the UR device is responding to the inputs from the permanent Bricks, and operands are being calculated just as when normally in service. Just before commanding the switch to the normal in-service mode, check the output command actual values of the UR device outputs, that they are in states that do not cause problems when re-enabled. At the same time, check that the relay has not raised any alarms resulting from missing or misconnected permanent Bricks, or unacceptable signal margins. One can also check that the data being received from the permanent Bricks is reasonable, internally consistent, and matches indications from other equipment. However, as neither the permanent Bricks nor their connections to the power equipment have been disturbed by this test procedure, anomalies caused by changes to the existing physical wiring are not expected.

7.3 Brick/primary equipment testing

7.3.1 Brick initial installation or major rework

The HardFiber high-level test strategy lumps the Brick testing with the testing of the associated primary equipment functions, with one test checking Brick function, the primary equipment function, and the interface between the two. This strategy also is part of the designing-out of test switches between the Brick and the primary equipment.

Figure 7-3: Brick/primary equipment testing



Testing of functions using Brick contact inputs is accomplished by forcing a change of state in the primary equipment and observing the result on the signal transmitted by the Brick. For instance, breaker position status contact inputs are tested by opening or closing the breaker and observing the signal change on the fiber port. The transmitted signal is observed either using the permanent relay, or with a substitute relay used in a way similar to how substitute Bricks were used in testing the permanent relay. A substitute relay can be more convenient than a permanent one, as the substitute can be made portable and used adjacent to the Brick/primary equipment. A substitute can also be used when the permanent relay or fiber cabling is unavailable, such as at the primary equipment factory, during initial on-site installation before the fiber cable and/or permanent relay is installed, or while the relays are in-service and cannot yet be configured for the new incoming Brick/primary equipment.

Testing of functions using Brick contact outputs is by activating that output from the substitute relay and observing the correct primary equipment response (for example, tripping).

Check CT and VT functions by observing the analog values transmitted by the Brick with primary voltage or current present. The observed magnitude and phase indication is compared with other devices metering the same primary quantity. In the case of initial testing before the primary equipment can be energized, the checks can be either by primary injection using the appropriate injection test equipment, or by separately testing the Brick (with secondary injection) and the instrument transformer (with conventional techniques). The latter method requires test cables with a plug to inject secondary signals to the Brick and a receptacle to break out the secondary signals from the instrument transformer. Where this latter method is used, use the comparison technique immediately after the primary equipment is energized to verify the correct connection between the instrument transformers and the Brick.

7.3.2 Brick replacement

Although Brick design is such that failures is rare, a strategy for handling such cases in a cost-effective manner with minimum time required is still needed. For maximum worker safety, the strategy of removing from service and de-energizing the power equipment element for replacement is preferred. Alternatively, a strategy can be implemented whereby Bricks can be replaced without outage to the associated power system element, and without undue worker safety risk. Isolating means have been built into the Brick itself that do not consume additional space or field labor for installation. The S-Brick uses standard copper terminal blocks. With either type of Brick, additional facilities are required to bypass (that is, short) CT secondary current loops. A variety of shorting terminal blocks are available commercially that can be used in place of the usual CT termination points where a live replacement option is required.

Prior to connecting the new Brick, it can be fully tested in a safe environment using a substitute relay and a conventional relay test set.

Once the fiber cable plug-in connections to the in-service relays are made, the communications system testing described in the Optical fiber communications system testing on page 7-7 is executed. Typically, the replacement activity concludes with a check that the controls are operational (that is, trip and close breaker, which can be done via SCADA as it uses the same hardware), a check that the currents' and voltages' magnitude and phase are reasonable and consistent with other sources, and that breaker and alarm status are correct.

7.3.3 Brick periodic testing

Regulations in some jurisdictions mandate that protection systems be re-tested periodically to verify that they are capable of performing the intended protection function. Most requirements of such regulations are satisfied by the continuous self-testing and event recording that the process bus system provides. For instance, the optical signal is continuously monitored in the system and degradations that can affect signal adequacy are alarmed. Event reports can be used to locate and verify the correctness of recent breaker operations, usually avoiding the need for trip tests. Any individual items not covered by either of these can be accomplished using the techniques described in the preceding sections.

7.4 Optical fiber communications system testing

The objective of the optical fiber communications system testing is to check those process bus functions not covered either by the relay injection testing or by the Brick/primary equipment testing. Relay injection testing using substitution hardware establishes that the relay properly consumes data streams presented to its process bus optical fiber ports, and properly generates control data streams on these same ports. Brick/primary equipment testing establishes that the Brick and primary equipment working together generate a data stream that properly encodes the primary quantities and properly executes commands received. What remains in checking the protection system as a whole is to establish that with the protection system fully in-service, the data streams generated by the relays and the Bricks are reaching the correct destinations.

With the HardFiber IEC 61850-9-2 process bus implementation, the hard-fiber approach eliminates communications system testing issues, such as LAN congestion, correctness of LAN configuration settings required to re-route automatically around failed switches/links, and non-deterministic latency—issues that make thorough testing very difficult in a packet switched network. Use of single bidirectional fiber technology eliminates the concern present with double simplex fiber links and with multiconductor copper cabling that the link is only partially correct. Correct communications of any bit of data in either direction establishes that all data on that link is communicated correctly. All that is necessary is to establish that there is a continuous optical path from each port of the UR device to and from the correct Brick, and that path losses leave adequate signal margin.

Excessive optical path losses can result from damage occurring during shipment or installation, though the more likely cause is contamination in the optical fiber connectors introduced during installation or maintenance. Establishing the value of path losses (and thus operating margin) is easily done in the system, as the optical transceivers at both ends are equipped with diagnostics that continuously measure the send and receive light levels even while the link is in normal operation. The UR device then generates process bus trouble self-test alarms if any levels fall out of tolerance.

Correct interconnection can be established in any of the following ways:

- Physically tracing the cable and patch cord routing from the back of the relay to the Brick
- Observing that data received by the relay over the link is reasonable and matches other indicators, for example, indicated current/voltage magnitude and phase matches other indicators of these same quantities
- Causing some change of state and observing its correct communication over the link. An example is to observe the reported effects of initiating a breaker operation or a tap change. Initiation can be from the operator's HMI where it uses the same fiber link.

The UR devices are designed such that when normally in-service, they alarm and reject data on a port when the Brick serial number that is included with the data fails to match the relay setting for that Brick's serial number. The Brick serial number setting is included with relay outgoing commands, and the Bricks are designed to accept commands only when the accompanying serial number matches its own serial number. Thus once the Brick serial numbers are correctly entered into the relay settings, the fact of normal communications establishes that the link is correct. The Brick serial number setting in the relay can be matched manually to the serial number on the Brick nameplate.

In short, testing of the passive communications system is simple, and once commissioning is complete, it can be entirely automatic.

HardFiber Process Bus System

Chapter 8: Application examples

This chapter provides application examples of the HardFiber system.

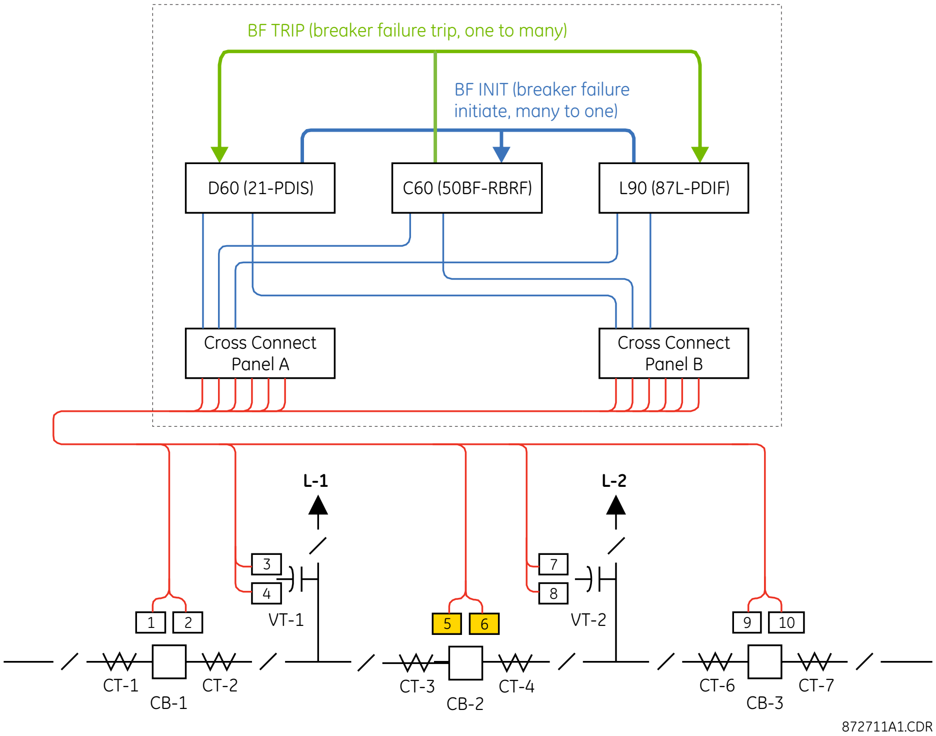
8.1 Breaker failure protection using shared I/O

The HardFiber system provides a fast and deterministic method for peer-to-peer messaging known as shared I/O, which is based on a fundamental premise of protective relaying: that critical signals need to be exchanged primarily between relays within the same zone or adjacent zones.

Shared I/O allows any relay connected to an individual Brick to message every other relay connected to the same Brick. This signaling is independent of other communication methods possible between relays, such as IEC 61850 GOOSE messaging on the station bus or physical contact signaling. Each Brick has 15 shared I/O channels to send signals to all four relays connected to the Brick. Each relay has 16 shared inputs and 16 shared outputs to enable signaling to all eight Bricks that can be connected to the same relay. The configuration process for using shared I/O is a simple matter of using a shared output of one or more sending devices to set a shared I/O channel in a Brick, and using a shared input of one or more receiving devices to read that same shared I/O channel in the Brick. Any FlexLogic operand in the relay can be used to operate the shared output and set the Brick shared I/O channel. The statuses of shared inputs are available as FlexLogic operands in the relay, enabling a variety of applications.

One important application that requires high-speed, dependable signaling is breaker failure. Using the following system example, the C60 Breaker Protection System is responsible for breaker failure for CB-2. Breaker failure must be initiated by any protection that trips CB-2. In this case, it is the D60 Line Distance Protection System and the L90 Line Differential Protection System. If CB-2 fails to operate, all breakers in the zones adjacent to CB-2 must be opened. These breakers are under the control of the D60 and the L90. In this example, Bricks 5 and 6 are redundant Bricks for the same CB-2 zone, so both Bricks are used for breaker failure signaling.

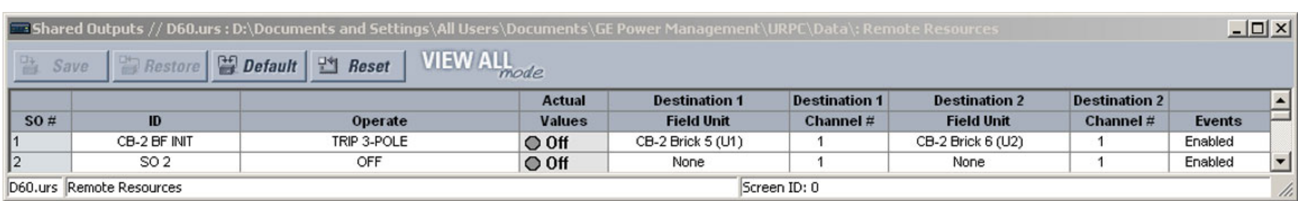
Figure 8-1: Example of a HardFiber system



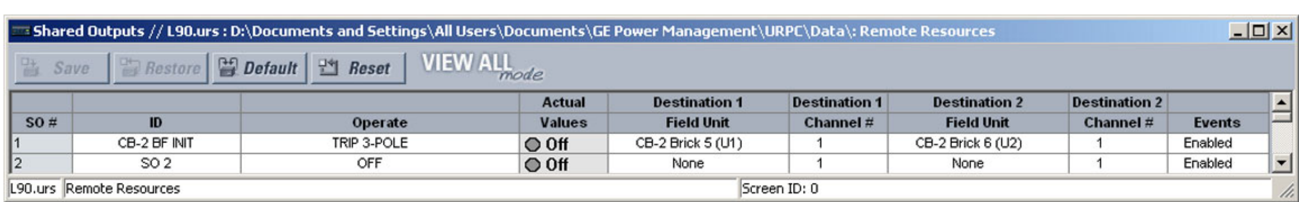
Breaker failure signaling involves two separate messages. Breaker failure initiate (BF INIT) is a many-to-one type of signal, which is created by multiple devices to tell one device to take a specific action. In this example, BF INIT is assigned to the shared I/O channel 1 on both Brick 5 and Brick 6. Breaker failure trip (BF TRIP) is a one-to-many type of signal, which is created by one device and sent to multiple devices. BF TRIP is assigned to the Brick shared I/O channel 2 on both Brick 5 and Brick 6.

Every relay in the CB-2 zone, in this case the D60 and L90 relays, must be able to send the BF INIT command. The shared I/O feature easily accommodates the many-to-one type signal, as multiple devices connected to the same Brick can set the same Brick shared I/O channel. The following figure shows the configuration of the D60 and L90 shared I/O; the configuration is the same for both products.

Figure 8-2: Breaker failure initiate configuration in the D60 and L90



SO #	ID	Operate	Actual Values	Destination 1 Field Unit	Destination 1 Channel #	Destination 2 Field Unit	Destination 2 Channel #	Events
1	CB-2 BF INIT	TRIP 3-POLE	Off	CB-2 Brick 5 (U1)	1	CB-2 Brick 6 (U2)	1	Enabled
2	SO 2	OFF	Off	None	1	None	1	Enabled

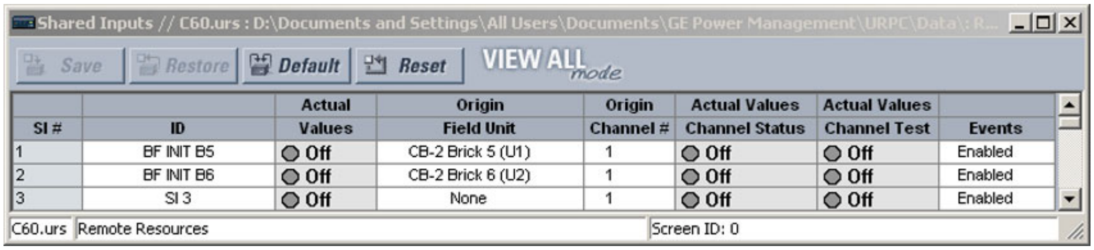


SO #	ID	Operate	Actual Values	Destination 1 Field Unit	Destination 1 Channel #	Destination 2 Field Unit	Destination 2 Channel #	Events
1	CB-2 BF INIT	TRIP 3-POLE	Off	CB-2 Brick 5 (U1)	1	CB-2 Brick 6 (U2)	1	Enabled
2	SO 2	OFF	Off	None	1	None	1	Enabled

Note that the FlexLogic operand responsible for tripping (TRIP 3-POLE) is chosen to generate BF INIT. This signal is mapped to channel 1 on both Bricks 5 and 6, using one of the shared output channels of each relay.

The C60 relay uses two shared input channels. One channel is reading Brick 5 shared I/O channel 1, and the second channel is reading Brick 6 shared I/O channel 1, as shown.

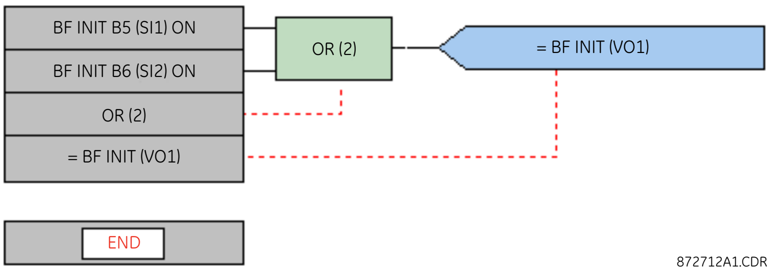
Figure 8-3: Breaker failure initiate configuration in the C60



SI #	ID	Actual Values	Origin Field Unit	Origin Channel #	Actual Values Channel Status	Actual Values Channel Test	Events
1	BF INIT B5	Off	CB-2 Brick 5 (U1)	1	Off	Off	Enabled
2	BF INIT B6	Off	CB-2 Brick 6 (U2)	1	Off	Off	Enabled
3	SI 3	Off	None	1	Off	Off	Enabled

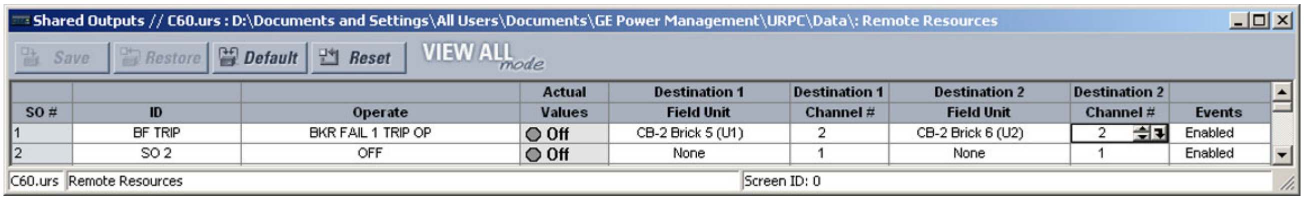
A relay shared input is assigned to channel 1 from each Brick. The Brick channel 1 is asserted if either line relay declares a breaker failure condition. Due to the use of redundant Bricks, either relay can initiate breaker failure via Brick 5 or Brick 6. The two shared inputs are combined in FlexLogic to produce the input signal for the breaker failure element.

Figure 8-4: Breaker failure initiate FlexLogic



The one-to-many signal of the BF TRIP command must operate multiple breakers to actually clear the fault event. The FlexLogic operand in the C60 representing the output from the breaker failure element (BKR FAIL 1 TRIP OP) is chosen to generate BF TRIP. This signal is mapped to shared I/O channel 2 on both Bricks 5 and 6. The C60 is configured as follows.

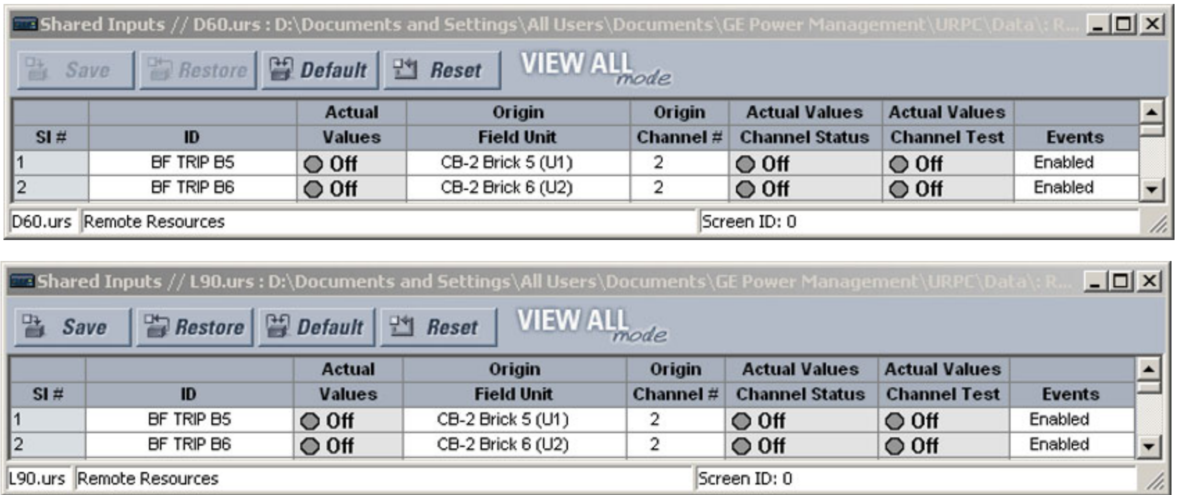
Figure 8-5: Breaker failure trip configuration in the C60



SO #	ID	Operate	Actual Values	Destination 1 Field Unit	Destination 1 Channel #	Destination 2 Field Unit	Destination 2 Channel #	Events
1	BF TRIP	BKR FAIL 1 TRIP OP	Off	CB-2 Brick 5 (U1)	2	CB-2 Brick 6 (U2)	2	Enabled
2	SO 2	OFF	Off	None	1	None	1	Enabled

The D60 and L90 relays must read the shared I/O channel 2 from each Brick into shared input channels. The shared inputs are configured as follows.

Figure 8-6: Breaker failure trip configuration in the D60 and L90

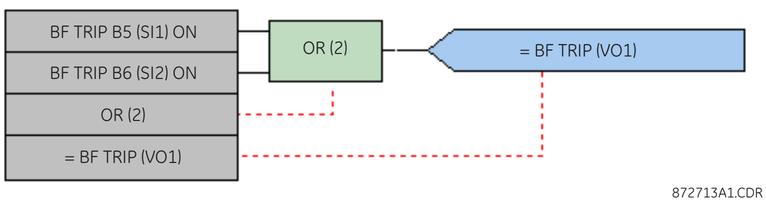


SI #	ID	Actual Values	Origin Field Unit	Origin Channel #	Actual Values Channel Status	Actual Values Channel Test	Events
1	BF TRIP B5	Off	CB-2 Brick 5 (U1)	2	Off	Off	Enabled
2	BF TRIP B6	Off	CB-2 Brick 6 (U2)	2	Off	Off	Enabled

SI #	ID	Actual Values	Origin Field Unit	Origin Channel #	Actual Values Channel Status	Actual Values Channel Test	Events
1	BF TRIP B5	Off	CB-2 Brick 5 (U1)	2	Off	Off	Enabled
2	BF TRIP B6	Off	CB-2 Brick 6 (U2)	2	Off	Off	Enabled

Two shared inputs are configured to receive the BF TRIP signal in each relay. Channel 2 is assigned in each Brick. The inputs are combined in FlexLogic to produce the BF TRIP signal.

Figure 8-7: Breaker failure trip Flexlogic



In both the L90 and D60, the BF TRIP signal trips all breakers forming the protection zone and sends transfer trip signals to the breakers at the remote terminals.

In general, the Bricks associated with a breaker zone are the correct choice for routing breaker failure signals, as the line protection relays and the breaker control relay are all connected to these Bricks. However, there can be a concern about using Bricks connected to a circuit breaker, such as Bricks 5 and 6 in this example, to route the breaker failure signals due to their proximity to the failed breaker. If so, alternate Bricks can be chosen: Bricks 3 and 7 (associated with the VTs) for instance. This requires that a core from each of these Bricks be assigned to the C60.

HardFiber Process Bus System

Appendix A: Message format

The Brick communicates according to the IEC 61850 international standard communication networks and systems in substations, first edition 2004-4. This appendix describes the particular implementation in the following sections:

- MICS - Model Implementation Conformance Statement
- PICS - Protocol Implementation Conformance Statement
- PIXIT - Protocol Implementation Extra Information for Testing
- TICS - IEC 61850 Tissue Implementation List
- ICD – IED Configuration Description

NOTE

Users of systems employing GE Vernova devices, such as UR, to communicate with the Bricks do not need this chapter. The chapter is included for compliance with the standard and for customers wanting to communicate with a Brick using a device other than a compatible GE Vernova device.

A.1 KEMA test summary

The content of this documentation has been independently verified as per the following test summary.

A.2 MICS - Model Implementation Conformance Statement

This section describes the Model Implementation Conformance Statement (MICS) for the IEC 61850 interface in Brick device.

A.2.1 GE Multilin Process Bus 2007 namespace

A new logical node IBRK has been defined. The data attributes of this logical node have been added according to the namespace “GE Multilin Process Bus 2007" which contains extensions to the IEC 61850-7-4 2003 namespace.

IBRK/NamPlt/lnNs = "GE Multilin Process Bus 2007"

NOTE

See the “semantics” tables at the end of this chapter for descriptions of the various attributes.

A

A.2.2 Logical nodes

Related data objects are combined into an entity at the next level up in the hierarchy known as a logical node (LN).

Logical node IBRK (Brick)

LN: Brick

Name: IBRK

An instance of this logical node in the Brick is used to interface all Brick data that can be communicated via IEC 61850 sampled values and GOOSE.

Table A-1: IBRK class

Attribute		Explanation	T	M/O
Name	**Type**			
LNName		Shall be inherited from Logical-Node class (see IEC 61850-7-2)		
Data				
Common logical node information				
		LN shall inherit all mandatory data from common Logical Node class (see IEC 61850-7-2)		M
Measured values, controls and status information				
U	BRICK	Contains all interface data for the Brick		M

An instance of this logical node in the UR is used for interfacing Brick data for up to eight Bricks.

Table A-2: IBRK class instance+.0

Attribute		Explanation	T	M/O
Name	**Type**			
LNName		Shall be inherited from Logical-Node class (see IEC 61850-7-2)		
Data				
Common logical node information				
		LN shall inherit all mandatory data from common Logical Node class (see IEC 61850-7-2)		M
Measured values, controls and status information				
U1	BRICK	Contains all interface for Brick on port 1		M
U2	BRICK	Contains all interface for Brick on port 2		M
U3	BRICK	Contains all interface for Brick on port 3		M
U4	BRICK	Contains all interface for Brick on port 4		M
U5	BRICK	Contains all interface for Brick on port 5		M
U6	BRICK	Contains all interface for Brick on port 6		M
U7	BRICK	Contains all interface for Brick on port 7		M
U8	BRICK	Contains all interface for Brick on port 8		M

A.2.3 Common data classes

Common data class BRICK (Brick interface)

This BRICK class is a collection of attributes containing all data exchanged with a single Brick device.

Table A-3: BRICK class

Attribute		FC	TrgOP	Value / value range	M/O/C
Name	Type				
Control and status					
SmpNum	INT32U	ST			M
model	VISIBLE STRING35	CF			M
serNum	VISIBLE STRING13	CF			M
outputs	Outputs	CO			M
analogs	Analogs	MX			M
contactInputs	ContactInputs	ST			M
sharedInputs	SharedInputs	ST			M
outputMonitors	OutputMonitors	ST			M
diagnostics	Diagnostics	ST			M

A.2.4 Common data attribute types

Outputs common data attribute type

This composite component is a collection of all the contact output, latching output, and shared output commands for a Brick in a packed list.

Table A-4: Output type definition

Attribute			Value / value range	M/O/C
Name		Type		
Packed list (encoded as specified in IEC 61850-8-1 clause 8.1.3.5)				
0	contactOutput1	CODED ENUM	off | on	M
1	contactOutput2	CODED ENUM	off | on	M
2	contactOutput3	CODED ENUM	off | on	M
3	contactOutput4	CODED ENUM	off | on	M
4	contactOutput5	CODED ENUM	off | on	M
5	contactOutput6	CODED ENUM	off | on	M
6	latchingOutputOpen	CODED ENUM	off | on	M
7	latchingOutputClose	CODED ENUM	off | on	M
8	sharedOutput1	CODED ENUM	off | on	M
9	sharedOutput2	CODED ENUM	off | on	M
10	sharedOutput3	CODED ENUM	off | on	M
11	sharedOutput4	CODED ENUM	off | on	M
12	sharedOutput5	CODED ENUM	off | on	M
13	sharedOutput6	CODED ENUM	off | on	M
14	sharedOutput7	CODED ENUM	off | on	M
15	sharedOutput8	CODED ENUM	off | on	M
16	sharedOutput9	CODED ENUM	off | on	M
17	sharedOutput10	CODED ENUM	off | on	M
18	sharedOutput11	CODED ENUM	off | on	M
19	sharedOutput12	CODED ENUM	off | on	M
20	sharedOutput13	CODED ENUM	off | on	M
21	sharedOutput14	CODED ENUM	off | on	M
22	sharedOutput15	CODED ENUM	off | on	M

A

Attribute			Value / value range	M/O/C
Name		Type		
23	Reserved	CODED ENUM	off | on	M
24	Reserved	CODED ENUM	off | on	M
25	Reserved	CODED ENUM	off | on	M
26	Reserved	CODED ENUM	off | on	M
27	Reserved	CODED ENUM	off | on	M
28	Reserved	CODED ENUM	off | on	M
29	Reserved	CODED ENUM	off | on	M
30	Reserved	CODED ENUM	off | on	M
31	Reserved	CODED ENUM	off | on	M

Analogs common data attribute type

This composite component is a collection of all the AC and DC analogs of the Brick in a packed list.

Table A-5: Analogs type definition

Attribute name	Attribute type	Value / value range	M/O/C
ac1	INT32		M
ac2	INT32		M
ac3	INT32		M
ac4	INT32		M
ac5	INT32		M
ac6	INT32		M
ac7	INT32		M
ac8	INT32		M
dc1	INT32		M
dc2	INT32		M
dc3	INT32		M

ContactInputs common data attribute type

This composite component is a collection of all the contact inputs of the Brick in a packed list.

Table A-6: ContactInputs type definition

Attribute			Value / value range	M/O/C
Name		Type		
Packed list (encoded as specified in IEC 61850-8-1 clause 8.1.3.5)				
0	ci1	BOOLEAN		M
1	ci2	BOOLEAN		M
2	ci3	BOOLEAN		M
3	ci4	BOOLEAN		M
4	ci5	BOOLEAN		M
5	ci6	BOOLEAN		M
6	ci7	BOOLEAN		M
7	ci8	BOOLEAN		M
8	ci9	BOOLEAN		M
9	ci10	BOOLEAN		M
10	ci11	BOOLEAN		M
11	ci12	BOOLEAN		M

Attribute			Value / value range	M/O/C
Name		Type		
12	ci13	BOOLEAN		M
13	ci14	BOOLEAN		M
14	ci15	BOOLEAN		M
15	ci16	BOOLEAN		M
16	ci17	BOOLEAN		M
17	ci18	BOOLEAN		M
18	Reserved	BOOLEAN		M
19	Reserved	BOOLEAN		M
20	Reserved	BOOLEAN		M
21	Reserved	BOOLEAN		M
22	Reserved	BOOLEAN		M
23	Reserved	BOOLEAN		M
24	Reserved	BOOLEAN		M
25	Reserved	BOOLEAN		M
26	Reserved	BOOLEAN		M
27	Reserved	BOOLEAN		M
28	Reserved	BOOLEAN		M
29	Reserved	BOOLEAN		M
30	Reserved	BOOLEAN		M
31	Reserved	BOOLEAN		M

SharedInputs common data attribute type

This composite component is a collection of all the shared inputs and their test status of the Brick in a packed list.

Table A-7: SharedInputs type definition

Attribute			Value / value range	M/O/C
Name		Type		
Packed list (encoded as specified in IEC 61850-8-1 clause 8.1.3.5)				
0	si1	CODED ENUM	off | on	M
1	si1test	CODED ENUM	off | on	M
2	si2	CODED ENUM	off | on	M
3	si2test	CODED ENUM	off | on	M
4	si3	CODED ENUM	off | on	M
5	si3test	CODED ENUM	off | on	M
6	si4	CODED ENUM	off | on	M
7	si4test	CODED ENUM	off | on	M
8	si5	CODED ENUM	off | on	M
9	si5test	CODED ENUM	off | on	M
10	si6	CODED ENUM	off | on	M
11	si6test	CODED ENUM	off | on	M
12	si7	CODED ENUM	off | on	M
13	si7test	CODED ENUM	off | on	M
14	si8	CODED ENUM	off | on	M
15	si8test	CODED ENUM	off | on	M
16	si9	CODED ENUM	off | on	M
17	si9test	CODED ENUM	off | on	M

A

Attribute			Value / value range	M/O/C
Name		Type		
18	si10	CODED ENUM	off | on	M
19	si10test	CODED ENUM	off | on	M
20	si11	CODED ENUM	off | on	M
21	si11test	CODED ENUM	off | on	M
22	si12	CODED ENUM	off | on	M
23	si12test	CODED ENUM	off | on	M
24	si13	CODED ENUM	off | on	M
25	si13test	CODED ENUM	off | on	M
26	si14	CODED ENUM	off | on	M
27	si14test	CODED ENUM	off | on	M
28	si15	CODED ENUM	off | on	M
29	si15test	CODED ENUM	off | on	M
30	reserved	CODED ENUM	off | on	M
31	reserved	CODED ENUM	off | on	M

OutputMonitors common data attribute type

This composite component is a collection of all the contact output monitoring of the Brick in a packed list.

Table A-8: OutputMonitors type definition

Attribute			Value / value range	M/O/C
Name		Type		
Packed list (encoded as specified in IEC 61850-8-1 clause 8.1.3.5)				
0	co1drv	CODED ENUM	output driver off | on status	M
1	co1vlt	CODED ENUM	output voltage monitor off | on	M
2	co1cur	CODED ENUM	output current monitor off | on	M
3	co2drv	CODED ENUM	off | on	M
4	co2vlt	CODED ENUM	off | on	M
5	co2cur	CODED ENUM	off | on	M
6	co3drv	CODED ENUM	off | on	M
7	co3vlt	CODED ENUM	off | on	M
8	co3cur	CODED ENUM	off | on	M
9	co4drv	CODED ENUM	off | on	M
10	co4vlt	CODED ENUM	off | on	M
11	co4cur	CODED ENUM	off | on	M
12	co5drv	CODED ENUM	off | on	M
13	co6drv	CODED ENUM	off | on	M
14	loOpenDrv	CODED ENUM	off | on	M
15	loCloseDrv	CODED ENUM	off | on	M
16	loAuxStatus	CODED ENUM	off | on	M
17	Reserved	CODED ENUM	off | on	M
18	Reserved	CODED ENUM	off | on	M
19	Reserved	CODED ENUM	off | on	M
20	Reserved	CODED ENUM	off | on	M
21	Reserved	CODED ENUM	off | on	M

Attribute			Value / value range	M/O/C
Name		Type		
22	Reserved	CODED ENUM	off | on	M
23	Reserved	CODED ENUM	off | on	M
24	Reserved	CODED ENUM	off | on	M
25	Reserved	CODED ENUM	off | on	M
2	Reserved	CODED ENUM	off | on	M
27	Reserved	CODED ENUM	off | on	M
28	Reserved	CODED ENUM	off | on	M
29	Reserved	CODED ENUM	off | on	M
30	Reserved	CODED ENUM	off | on	M
31	Reserved	CODED ENUM	off | on	M

Diagnostics common data attribute type

This composite component is a collection of all the self diagnostics of the Brick.

Table A-9: Diagnostics type definition

Attribute			Value / value range	M/O/C
Name		Type		
diagnosticFlags packed list (encoded as specified in IEC 61850-8-1 clause 8.1.3.5)				
0	diagRunning	CODED ENUM	normal | alarm	M
1	syncError	CODED ENUM	normal | alarm	M
2	fw_hw_Incompatible	CODED ENUM	normal | alarm	M
3	lossOfSupply	CODED ENUM	normal | alarm	M
4	mircoRestarted	CODED ENUM	normal | alarm	M
5	pldFail	CODED ENUM	normal | alarm	M
6	pldCommsError	CODED ENUM	normal | alarm	M
7	clockDiscrepancy	CODED ENUM	normal | alarm	M
8	wettingFail	CODED ENUM	normal | alarm	M
9	dc1AnalogMode	CODED ENUM	RTD | nonRTD	M
10	dc2AnalogMode	CODED ENUM	RTD | nonRTD	M
11	dc3AnalogMode	CODED ENUM	RTD | nonRTD	M
12	hi_lo_RangeDiscrepancy	CODED ENUM	normal | alarm	M
13	adcPowerTrouble	CODED ENUM	normal | alarm	M
14	adcBusyError	CODED ENUM	normal | alarm	M
15	adcTempTrouble	CODED ENUM	normal | alarm	M
16	transceiverDiagFail	CODED ENUM	normal | alarm	M
17	transceiverTempTrouble	CODED ENUM	normal | alarm	M
18	transceiverVoltsTrouble	CODED ENUM	normal | alarm	M
19	transceiverCurrentTrouble	CODED ENUM	normal | alarm	M
20	transceiverTxPowerTrouble	CODED ENUM	normal | alarm	M
21	transceiverRxPowerTrouble	CODED ENUM	normal | alarm	M
22	outputContactTrouble	CODED ENUM	normal | alarm	M
23	reserved	CODED ENUM	normal | alarm	M
24	reserved	CODED ENUM	normal | alarm	M
25	reserved	CODED ENUM	normal | alarm	M
26	reserved	CODED ENUM	normal | alarm	M
27	reserved	CODED ENUM	normal | alarm	M

Attribute			Value / value range	M/O/C
Name		Type		
28	reserved	CODED ENUM	normal | alarm	M
29	reserved	CODED ENUM	normal | alarm	M
30	reserved	CODED ENUM	normal | alarm	M
31	reserved	CODED ENUM	normal | alarm	M
adcTemp		INT16		M
transceiverTemp		INT16		M
transceiverVolts		INT16U		M
transceiverCurrent		INT16U		M
transceiverTxPower		INT16U		M
transceiverRxPower		INT16U		M

A.2.5 Data name semantics

Table A-10: Data name semantics

Data name	Semantics
U, U1, U2,..., U8	Data object containing all the information that has to be communicated to and from a single Brick

A.2.6 Data attribute name semantics

Table A-11: Data attribute name semantics

Data name	Semantics
SmpNum	Sample number of the sample. Starts at zero and increments by one each successive sample. Rolls over from $2^{32} - 1$ to 0.
model	String, in comma separated value format, with the first field the physical Brick product name, the second field the Brick order code, and the third field the Brick code version. For example: "GE Multilin Brick,CV-05,v5.601". The field is limited to 35 characters.
serNum	String, equal to the Brick's serial number, appended with the Brick core number: "1," "2," "3," or "4"
outputs	Data attribute, containing as members all Brick output command points, including contact outputs, latching outputs, and shared outputs
analogs	Data attribute, containing as members all Brick ac and dc process analog inputs at one sample instant
contactInputs	Data attribute, containing as members all Brick contact input status points
sharedInputs	Data attribute, containing as members all shared input status points
outputMonitors	Data attribute, containing as members output monitoring status points
diagnostics	Data attribute, containing as members all Brick diagnostics
diagnosticFlags	Data attribute, containing as members all Brick diagnostic flags
contactOutput1 to contactOutput6	Commanded state of Brick solid state relay driver outputs (1...4) and from C relay driver outputs (5, 6)
latchingOutputOpen	Commanded state of latching output open driver
latchingOutputClose	Commanded state of latching output close driver
sharedOutput1 to sharedOutput15	Commanded state of shared outputs
ac1 to ac8	Sampled value of ac inputs. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 2.980323E-08 instantaneous secondary amps for type BRICK-4-HI-CC11 and BRICK-4-HI-CV10 Bricks, 1.490161E-07 instantaneous secondary amps for type BRICK-4-HI-CC05 and BRICK-4-HI-CV50 Bricks, and 1.862701E-07 instantaneous secondary volts.
dc1 to dc3	Sampled value of dc inputs. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 2.328377E-09 instantaneous volts differential on Brick sensing input.
ci1 to ci18	Sampled values of contact inputs

Data name	Semantics
co1drv to co6drv	Sensed value of contact output relay drivers
co1vlt to co4vlt	Sensed value of solid state relay output voltage monitoring
co1cur to co4cur	Sensed value of solid state relay output current monitoring
loOpenDrv	Sensed value of latched output relay open driver
loCloseDrv	Sensed value of latched output relay close driver
loAuxStatus	Sensed state of latched output relay's auxiliary contact
si1 to si15	State of shared input
si1test to si15test	State of shared input test bit
diagRunning	Factory Diagnostics Running (for example, ADC range forced high or low)
syncError	The sync error flag is set if any of the last eight received smpNum values is out of numerical sequence, indicating a lost, duplicate or spurious sync function frame. It is also set if any extraneous communications activity occurred (e.g. TFTP traffic), as this activity can have disturbed the sync timing.
fw_hw_Incompatible	Firmware is incompatible with Brick hardware board's version and/or variants
lossOfSupply	Brick power loss of supply - Brick is going down
mircoRestarted	Brick microcontroller restarted since last transmission – held for two sampled value frames
pldFail	Brick PLD fail – sustained (>10 ms) loss of PLD communications in either direction detected by microcontroller
pldCommsError	Brick PLD communications error – single frame CRC error or lost frame
clockDiscrepancy	Brick microcontroller clock vs. PLD clock frequency discrepancy
wettingFail	Contact input wetting supply fail
dc1AnalogMode to dc3AnalogMode	Process analog auto-detected mode is RTD
hi_lo_RangeDiscrepancy	ADC trouble – hi/lo range discrepancy on one or more channels
adcPowerTrouble	ADC trouble – weighted sum of various ADC supply voltages out of normal range
adcBusyError	ADC trouble – busy line error
adcTempTrouble	ADC trouble – actual temperature is outside of the manufacturer's tolerance limits
transceiverDiagFail	SPI link from optical transceiver's diagnostics failed – transceiver diagnostic quantities invalid
transceiverTempTrouble	Transceiver temperature is outside of the manufacturer's tolerance limits
transceiverVoltsTrouble	Transceiver supply voltage is outside of the manufacturer's tolerance limits
transceiverCurrentTrouble	Transceiver transmitter bias current is outside of the manufacturer's tolerance limits
transceiverTxPowerTrouble	Transceiver transmitted optical power is outside of the manufacturer's tolerance limits
transceiverRxPowerTrouble	Transceiver received optical power is less than the manufacturer's tolerance limits
outputContactTrouble	Monitoring detected trouble with contact output(s)
adcTemp	ADC temperature value. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 1/256 degrees Celsius.
transceiverTemp	Transceiver temperature value. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 1/256 degrees Celsius.
transceiverVolts	Transceiver supply voltage value. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 1.000000E-04 volts.
transceiverCurrent	Transmitter bias current value. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 2.000000E-06 amps.
transceiverTxPower	Transmitted optical power value. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 1.000000E-07 watts.
transceiverRxPower	Received optical power value. Similar to Attribute "i" in IEC 61850-7-3 common data attribute type AnalogValue, with offset = 0 and scaleFactor = 1.000000E-07 watts.

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A.2.7 Data sets

Dataset "C" (commands)

This dataset, also known as the all Brick command dataset, is expected in the received GOOSE messages. The members of this dataset are defined formally in previous sections of this chapter, the Brick information model.

DSRef: <LDName>/LLN0.C

Table A-12: Dataset "C" commands

Member offset	DSMemberRef	Attribute type	Description
1	<LDName>/IBRK.U1.SmpNum	INT32U	Sequence number of sampled data[1]
2	<LDName>/IBRK.U1.serNum	VISIBLE STRING13	Brick 1's serial number[2]
3	<LDName>/IBRK.U1.outputs	Outputs	All Brick 1's commanded states for contact outputs, latching output, and shared outputs
4	<LDName>/IBRK.U2.serNum	VISIBLE STRING13	
5	<LDName>/IBRK.U2.outputs	Outputs	
6	<LDName>/IBRK.U3.serNum	VISIBLE STRING13	
7	<LDName>/IBRK.U3.outputs	Outputs	
8	<LDName>/IBRK.U4.serNum	VISIBLE STRING13	
9	<LDName>/IBRK.U4.outputs	Outputs	
10	<LDName>/IBRK.U5.serNum	VISIBLE STRING13	
11	<LDName>/IBRK.U5.outputs	Outputs	
12	<LDName>/IBRK.U6.serNum	VISIBLE STRING13	
13	<LDName>/IBRK.U6.outputs	Outputs	
14	<LDName>/IBRK.U7.serNum	VISIBLE STRING13	
15	<LDName>/IBRK.U7.outputs	Outputs	
16	<LDName>/IBRK.U8.serNum	VISIBLE STRING13	
17	<LDName>/IBRK.U8.outputs	Outputs	

Table notes:

1. smpNum is a sample sequence number and must be incremented by the relay each successive sample, wrapping from the maximum code to the minimum code on overflow. The value of smpNum sent here is attached to the sample data returned to the relay by each Brick, allowing the correlation of samples from different Brick, and detection of missing sample data. All Bricks use this value, whether or not their serial numbers match a serNum attribute.
2. Where the serNum attribute of a "Data" object matches a Brick serial number appended with the core number, that core accepts the "outputs" attribute of the same Data as its commands.

Dataset "F" (fast)

This dataset, also known as the fast dataset, appears eight times in each sampled value frame. The members and their scaling and so on are formally defined in chapter 1.

DSRef: <LDName>/LLN0.F

Table A-13: Dataset "F" commands

Member offset	DSMemberRef	Attribute type	Description
1	<LDName>/IBRK.U.analogs.ac1	INT32	AC1 - Bank 1 Ia
2	<LDName>/IBRK.U.analogs.ac2	INT32	AC2 – Bank 1 Ib
3	<LDName>/IBRK.U.analogs.ac3	INT32	AC3 – Bank 1 Ic
4	<LDName>/IBRK.U.analogs.ac4	INT32	AC4 – Bank 1 Ix
5	<LDName>/IBRK.U.analogs.ac5	INT32	AC5 – Bank 2 Ia/Va

Member offset	DSMemberRef	Attribute type	Description
6	<LDName>/IBRK.U.analogs.ac6	INT32	AC6 – Bank 2 Ib/Vb
7	<LDName>/IBRK.U.analogs.ac7	INT32	AC7 – Bank 2 Ic/Vc
8	<LDName>/IBRK.U.analogs.ac8	INT32	AC8 – Bank 2 Ix/Vx
9	<LDName>/IBRK.U.analogs.dc1	INT32	DC1 – first analog process input
10	<LDName>/IBRK.U.analogs.dc2	INT32	DC2
11	<LDName>/IBRK.U.analogs.dc3	INT32	DC3
12	<LDName>/IBRK.U.contactInputs	ContactInputs	
13	<LDName>/IBRK.U.sharedInputs	SharedInputs	
14	<LDName>/IBRK.U.outputMonitors	OutputMonitors	

Dataset "S" (slow)

This dataset, also known as the slow dataset, appears once in each sampled value frame. The members are formally defined in chapter 1.

DSRef: <LDName>/LLN0.S

Table A-14: Dataset "S" commands

Member offset	DSMemberRef	Attribute type	Description
1	<LDName>/IBRK.U.model	VISIBLE STRING35	Product name, order code, Brick code version[1]
2	<LDName>/IBRK.U.SmpNum	INT32U	Sequence number of sampled data[2]
3	<LDName>/IBRK.U.diagnostics	Diagnostics	

Table notes:

1. The serial number of the Brick is not included here as it is contained in MsvID field of the sampled value's ASDU.
2. The smpNum value here is the value for the present instance of this dataset, and of the last of the eight F datasets contained in the same frame. Provided there has been no sample sequence error (syncError is not on), the SmpNum of the other F datasets can be determined by noting that they ought to be in chronological order.

A.3 PICS - Protocol Implementation Conformance Statement

This section describes the Protocol Implementation Conformance Statement (PICS) for the IEC 61850 interface in Brick device.

A.3.1 ACSI conformance statement

The following ACSI conformance statements shall be used to provide an overview and details about a device claiming conformance with ACSI:

- ACSI basic conformance statement
- ACSI models conformance statement
- ACSI service conformance statement

These statements are used to specify the communication features mapped to an SCSM.

Notation

For the following clauses, these definitions apply:

Y: The item is implemented

N: The item is not implemented

AA: Application Association
TP: Two-party (application association)
MC: Multicast (application association)

Table A-15: ACSI basic conformance statement

	Description	Client/ subscriber	Server/ publisher	Value/ comments
Client-server roles				
B11	Server side (of TWO-PARTY APPLICATION-ASSOCIATION)	---	N	
B12	Client side (of TWO-PARTY APPLICATION-ASSOCIATION)	N	---	
SCSMs supported				
B21	SCSM: IEC 61850-8-1 used	---	Y	GOOSE only
B22	SCSM: IEC 61850-9-1 used	---	N	
B23	SCSM: IEC 61850-9-2 used		Y	
B24	SCSM: other		N	
Generic substation event model (GSE)				
B31	Publisher side	---	N	
B32	Subscriber side	Y	-	GOOSE
Transmission of sampled value model (SVC)				
B41	Publisher side	---	Y	
B42	Subscriber side	N	---	

Table A-16: ACSI models conformance statement

	Description	Client/ subscriber	Server/ publisher	Value/ comments
If server side (B11) supported				
M1	Logical device	-	N	
M2	Logical node	-	N	
M3	Data	-	N	
M4	Data set	-	N	
M5	Substitution	-	N	
M6	Setting group control	-	N	
Reporting				
M7	Buffered report control	-	N	
M7-1	Sequence-number	-	N	
M7-2	Report-time-stamp	-	N	
M7-3	Reason-for-inclusion	-	N	
M7-4	Data-set-name	-	N	
M7-5	Data-reference	-	N	
M7-6	Buffer-overflow	-	N	
M7-7	entryID	-	N	
M7-8	BufTm	-	N	
M7-9	IntgPd	-	N	
M7-10	GI	-	N	
M7-11	Conf-revision	-	N	
M8	Unbuffered report control	-	N	
M8-1	Sequence-number	-	N	
M8-2	Report-time-stamp	-	N	
M8-3	Reason-for-inclusion	-	N	

	Description	Client/ subscriber	Server/ publisher	Value/ comments
M8-4	Data-set-name	-	N	
M8-5	Data-reference	-	N	
M8-6	BufTm	-	N	
M8-7	IntgPd	-	N	
M8-8	GI	-	N	
M8-9	Conf-revision	-	N	
Logging				
M9	Log control	-	N	
M9-1	IntgPd	-	N	
M10	Log	-	N	
M11	Control	-	N	
If GSE (B31/B32) supported				
M12	GOOSE	Y	N	
M13	GSSE	N	N	
If SVC (B41/B42) supported				
M14	Multicast SVC	N	Y	
M15	Unicast SVC	N	N	
If server or client side (B11/B12) supported				
M16	Time	-	N	
M17	File transfer	-	N	

The ACSI service conformance statement shall be defined depending on the statements in previous tables.

Table A-17: ACSI service conformance statement

Services		AA: TP / MC	Client/ subscriber	Server/ publisher	Comments
Server (Clause 6)					
S1	ServerDirectory	TP	-	N	
Application association (Clause 7)					
S2	Associate		-	N	
S3	Abort		-	N	
S4	Release		-	N	
Logical device (Clause 8)					
S5	LogicalDeviceDirectory	TP	-	N	
Logical node (Clause 9)					
S6	LogicalNodeDirectory	TP	-	N	
S7	GetAllDataValues	TP	-	N	
Data (Clause 10)					
S8	GetDataValues	TP	-	N	
S9	SetDataValues	TP	-	N	
S10	GetDataDirectory	TP	-	N	
S11	GetDataDefinition	TP	-	N	
Data set (Clause 11)					
S12	GetDataSetValues	TP	-	N	
S13	SetDataSetValues	TP	-	N	
S14	CreateDataSet	TP	-	N	
S15	DeleteDataSet	TP	-	N	

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Services		AA: TP / MC	Client/ subscriber	Server/ publisher	Comments
S16	GetDataSetDirectory	TP	-	N	
Substitution (Clause 12)					
S17	SetDataValues	TP	-	N	
Setting group control (Clause 13)					
S18	SelectActiveSG	TP	-	N	
S19	SelectEditSG	TP	-	N	
S20	SetSGValues	TP	-	N	
S21	ConfirmEditSGValues	TP	-	N	
S22	GetSGValues	TP	-	N	
S23	GetSGCBValues	TP	-	N	
Reporting (Clause 14)					
Buffered report control block (BRCB)					
S24	Report	TP	-	N	
S24-1	data-change (dchg)		-	N	
S24-2	qchg-change (qchg)		-	N	
S24-3	data-update (dupd)		-	N	
S25	GetBRCBValues	TP	-	N	
S26	SetBRCBValues	TP	-	N	
Unbuffered report control block (URCB)					
S27	Report	TP	-	N	
S27-1	data-change (dchg)		-	N	
S27-2	qchg-change (qchg)		-	N	
S27-3	data-update (dupd)		-	N	
S28	GetURCBValues	TP	-	N	
S29	SetURCBValues	TP	-	N	
Logging (Clause 14)					
Log control block					
S30	GetLCBValues	TP	-	N	
S31	SetLCBValues	TP	-	N	
Log					
S32	QueryLogByTime	TP	-	N	
S33	QueryLogAfter	TP	-	N	
S34	GetLogStatusValues	TP	-	N	
Generic substation event model (GSE) (Clause 14.3.5.3.4)					
GOOSE-CONTROL-BLOCK					
S35	SendGOOSEMessage	MC	-	N	
S36	GetGoReference	TP	-	N	
S37	GetGOOSEElementNumber	TP	-	N	
S38	GetGoCBValues	TP	-	N	
S39	SetGoCBValues	TP	-	N	
GSSE-CONTROL-BLOCK					
S40	SendGSSEMessage	MC	-	N	
S41	GetGsReference	TP	-	N	
S42	GetGSSEElementNumber	TP	-	N	
S43	GetGsCBValues	TP	-	N	
S44	SetGsCBValues	TP	-	N	

Services		AA: TP / MC	Client/ subscriber	Server/ publisher	Comments
Transmission of sampled value model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	-	N	
S46	GetMSVCBValues	TP	-	N	
S47	SetMSVCBValues	TP	-	N	
Unicast SVC					
S48	SendUSVMessage	TP	-	N	
S49	GetUSVCBValues	TP	-	N	
S50	SetUSVCBValues	TP	-	N	
Control (Clause 17.5.1)					
S51	Select		-	N	
S52	SelectWithValue	TP	-	N	
S53	Cancel	TP	-	N	
S54	Operate	TP	-	N	
S55	Command- Termination	TP	-	N	
S56	TimeActivated-Operate	TP	-	N	
File transfer (Clause 20)					
S57	GetFile	TP	-	N	
S58	SetFile	TP	-	N	
S59	DeleteFile	TP	-	N	
S60	GetFileAttributeValues	TP	-	N	
Time (Clause 5.5)					
T1	Time resolution of internal clock			N	Nearest negative power of 2 in seconds
T2	Time accuracy of internal clock			N	T0
				N	T1
				N	T2
				N	T3
				N	T4
				N	T5
T3	Supported TimeStamp resolution			N/A	Nearest value of 2**-n in seconds according to 5.5.3.7.3.3 of Part 7-2

A.4 Protocol implementation extra information for testing (PIXIT)

This section describes the Protocol Implementation Extra Information for Testing (PIXIT) for the IEC 61850 interface in Brick device.

A.4.1 Introduction

This document specifies the protocol implementation extra information for testing (PIXIT) of the IEC 61850 interface in Brick device.

Together with the PICS and the MICS the PIXIT forms the basis for a conformance test according to IEC 61850-10.

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A.4.2 Contents of this document

Each chapter specifies the PIXIT for each applicable ACSI service model as structured in IEC 61850-10.

A.4.3 General information

The typical startup time after a power supply interrupt is 0.15 seconds.

The device implements the functionality of GOOSE subscriber and Sampled Value publisher.

Sampled Value transmission is implemented with fixed Data Sets, which means that the device always transmits the same Data Set format. There are two types of Data Sets in each Sampled Value transmission. Dataset "F" is included eight times, once for each of eight sample instants, followed by dataset "S". These datasets are defined in the MICS. All optional fields in SV headers are omitted. Except where otherwise indicated herein, mandatory fields are set to the default specified in the standard.

GOOSE reception is implemented with a fixed Data Set, which means that the device always expects the same Data Set format. The dataset is the "C" data set defined in the MICS. All optional fields in GOOSE headers are expected to be omitted. Each field (including the ASN.1 header and tag) is expected to be of a fixed number of octets as follows.

Table A-18: Field length

Field	Length (in octets)
gocbRef	24
timeAllowedtoLive	4
datSet	21
t	10
stNum	6
sqNum	3
test	3
confRev	3
ndsCom	3
numDatSetEntries	3
allData	185
INT32U	6
VISIBLE STRING13	15
Outputs	7

A.4.4 Description of sampling

As shown in the next figure, a compliant relay sends a stream of GOOSE messages to facilitate the sampling process at the Brick. A point in time 100 μs prior to the tail end of the Ethernet packet envelope is interpreted by the Brick as a sample and hold signal (S&H) for this IED. The Brick digital core samples its data at this instant. The IED can apply any sampling rate and can sample freely at constant sampling intervals, variable sampling intervals, asynchronously with the absolute time, or in synchronism with the absolute time or any other internal or external process.

For time stamping purposes, the compliant IED is expected to keep track of timing of the tail end of the GOOSE Ethernet packet envelope so that samples can be correlated with the absolute time.

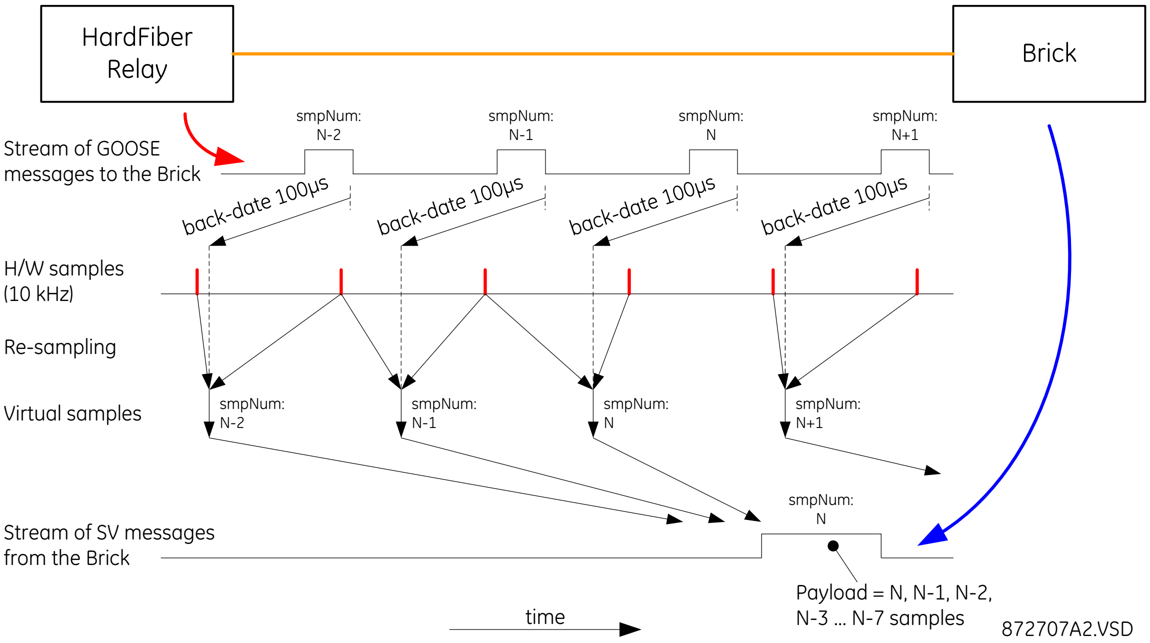
The Brick supports sampling intervals between 10 ms and 0.1 ms. These intervals can be constant or vary from sample to sample.

All inputs are sampled at the same time. This includes AC currents and voltage, contact inputs, and monitoring points for control outputs.

Each GOOSE message carries a sample number (smpNum). This number is used by the compliant IED to correlate samples with absolute time. GOOSE messages containing a 802.1Q Virtual LAN tag also "poll" for a set of eight samples to be returned to the compliant IED in a sampled value frame.

When the poll frame is received, the Brick responds with the SV payload. The SV data set contains one sample number corresponding to the newest sample in the set of eight. This sample number is equal to the sample number in the initiating GOOSE frame.

Figure A-1: Sampling and time synchronization process (smpNum = *N* is assumed a poll frame)



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A.4.5 PIXIT for generic substation events model (GOOSE)

Table A-19: PIXIT events

Description	Value	Clarification
What elements of a subscribed GOOSE header are checked to decide the message is valid and the allData values are accepted? If yes, describe the conditions.	Source MAC address	No
	Destination MAC address	Yes. Multicast, broadcast, or unicast. If it is unicast, it is equal to the MAC address of the device.
	LAN ID	Yes. The device accepts GOOSE frames with any VID or no VID at all. However, the presence of VID initiates a sampled value transmission from the device.
	LAN priority	No
	Ethertype	Yes. Ethertype = 0x88B8.
	APPID	No
	timeAllowedtoLive	Yes. The device uses this field for clearing all commands included as Data Set payload when the timeAllowedtoLive expires.
	goID	No
	t	No
	stNum	No
	sqNum	No
	test	Yes. The device uses this field for setting the quality flag "test" of shared I/O included as payload of sampled value frames it is publishing).
	confRev	No
	ndsCom	No
	NumDatSetEntries	No
	allData	Yes. The serNum member is to match the Brick serial number and core number.
Can the GOOSE publish be turned on / off by using SetGoCBValues(GoEna)?	N/A (GOOSE publishing not supported)	
Can the test flag in the published GOOSE be turned on/off?	N/A (GOOSE publishing not supported)	
What is the behavior when the GOOSE publish configuration is incorrect?	N/A (GOOSE publishing not supported)	
What is the behavior when one subscribed GOOSE message is not received or syntactically incorrect (missing GOOSE)?	A single "missing" or syntactically incorrect GOOSE message causes the syncError alarm flag to be raised	
What is the behavior when one subscribed GOOSE message exceeds the previous time Allowed to Live (TAL)?	All contact and shared outputs are turned off in the affected core	
What is the behavior when a subscribed GOOSE message is out-of-order?	Sequence number is ignored, the message is accepted	
What is the behavior when a subscribed GOOSE message is duplicated?	No. Sequence number is ignored, the message is accepted.	
Can the GOOSE data set contain:	structured data objects?	No. The reception data set is fixed.
	data attributes?	Yes. The reception data set is fixed.
	timestamp data attributes?	No. The reception data set is fixed.
Does the device subscribe to GOOSE messages without the VLAN tag?	Yes	
What is the slow retransmission time? Is it fixed or configurable?	N/A (GOOSE publishing not supported)	
What is the fast retransmission scheme? Is it fixed or configurable?	N/A (GOOSE publishing not supported)	

Description	Value	Clarification
Additional Items:		
Maximum number of GOOSE messages which can be received	4	The device implements four "digital cores," each core can receive one GOOSE message

A.4.6 PIXIT for sampled value model

Table A-20: PIXIT information

Description	Value/clarification
What is the supported sampling interval?	Supported sampling intervals are between 10 ms and 100 µs. These intervals can be constant or vary from sample to sample.
What initiates transmission of SV frame?	The reception of a GOOSE "poll frame" initiates SV transmission from the device. The GOOSE "poll frame" is any GOOSE frame that contains VID field.
Is the data set configurable in transmitted SV frames?	No
Is the destination MAC address configurable in SV frames?	No. The destination MAC address is fixed to 01:0C:CD:04:00:00
What is the source MAC address in SV frames?	Each Brick device contains four "digital cores" (seen as Ethernet ports), each core having its globally unique Ethernet MAC address. Thus SV frames sent from each core have the source MAC address of that core.

A.5 IEC 61850 Tissue Implementation List (TICS)

This section describes the IEC 61850 Tissue Implementation List (TICS) for the IEC 61850 interface in the Brick device.

A.5.1 Introduction

This document provides a template for the tissues conformance statement. According to the UCA IUG QAP, the tissue conformance statement is required to perform a conformance test and is referenced on the certificate.

This document is applicable for Brick devices with firmware version 5.601.

A.5.2 Mandatory IntOp Tissues

During the October 2006 meeting IEC TC57 working group 10 decided that:

- Green Tissues with the category "IntOp" are mandatory for IEC 61850 edition 1
- Tissues with the category "Ed.2" Tissues should not be implemented

The following table gives an overview of the implemented IntOp Tissues.

Table A-21: Tissues

Part	Tissue Nr	Description	Implemented
8-1	116	GetNameList with empty response?	N/A
	165	Improper Error Response for GetDataSetValues	N/A
	183	GetNameList error handling	N/A
7-4	None		

Part	Tissue Nr	Description	Implemented
7-3	28	Definition of APC	N/A
	54	Point def xVal, not cVal	N/A
	55	Input = Ires?	N/A
	60	Services missing in tables	N/A
	63	mag in CDC CMV	N/A
	65	Deadband calculation of a Vector and trigger option	N/A
	219	operTm in ACT	N/A
	270	WYE and DEL rms values	N/A
7-2	30	control parameter T	N/A
	31	Typo	N/A
	32	Typo in syntax	N/A
	35	Typo Syntax Control time	N/A
	36	Syntax parameter DSet-Ref missing	N/A
	37	Syntax GOOSE "T" type	N/A
	38	Syntax "AppID" or "GoID"	N/A
	39	Add DstAddr to GoCB	N/A
	40	GOOSE Message "AppID" to "GoID"	N/A
	41	GsCB "AppID" to "GsID"	N/A
	42	SV timestamp: "EntryTime" to "TimeStamp"	N/A
	43	Control "T" semantic	N/A
	44	AddCause - Object not sel	N/A
	45	Missing AddCauses (neg range)	N/A
	46	Synchro check cancel	N/A
	47	"." in LD Name?	Y
	49	BRCB TimeOfEntry (part of #453)	-
	50	LNName start with number?	Y
	51	ARRAY [0...num] missing	N/A
	52	Ambiguity GOOSE SqNum	Y
	53	Add DstAddr to GsCB, SV	N/A
	151	Name constraint for control blocks etc.	Y
	166	DataRef attribute in Log	N/A
	185	Logging - Integrity period	N/A
	189	SV Format	Y
	190	BRCB: EntryId and TimeOfEntry (part of #453)	-
	191	BRCB: Integrity and buffering reports (part of #453)	-
	234	New type CtxInt (Enums are mapped to 8 bit integer)	N/A
7-2	275	Confusing statement on GI usage (part of #453)	-
	278	EntryId not valid for a server (part of #453)	-
6	1	Syntax	Y
	5	tExtensionAttributeNameEnum is restricted	N/A
	8	SIUnit enumeration for W	N/A
	10	Base type for bitstring usage	N/A
	17	DAI/SDI elements syntax	Y/N/A
	169	Ordering of enum differs from 7-3	N/A

A

NOTE

Tissue 49, 190, 191, 275, and 278 are part of the optional tissue #453, all other technical tissues in the table are mandatory if applicable.

NOTE

Editorial tissues are marked as "na."

A.5.3 Optional IntOp Tissues

After the approval of the server conformance test procedures version 2.2 the following IntOp tissues were added or changed. It is optional to implement these tissues.

Table A-22: Tissues

Part	Tissue Nr	Description	Implemented
8-1	246	Control negative response (SBOns) with LastApplError	N/A
8-1	545	Skip file directories with no files	N/A
7-2	333	Enabling of an incomplete GoCB	N/A
7-2	453	Combination of all reporting and logging tissues	N/A
6	245	Attribute RptId in SCL	Y/N/na
6	529	Replace sev - Unknown by unknown	Y/N/na

A.5.4 Other Implemented Tissues

Table A-23: Other tissues

Part	Tissue Nr	Description
9-2	125	The field SmpRate should be set to optional in order to be in line with IEC 61850-7-2. SmpRate is omitted from SV headers.

A.6 ICD - IEC 61850 IED Configuration Description (ICD)

This section describes the IEC 61850 IED Configuration Description (ICD) for the IEC 61850 interface in the Brick device.

```
<?xml version="1.0" encoding="UTF-8" ?>
<!-- Created by GE Multilin Mon Jun 30, 2008 -->
<SCL xmlns="http://www.iec.ch/61850/2003/SCL"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://www.iec.ch/61850/2003/SCL SCL.xsd">
<Header id="Brick" version="5.601" revision="1" toolID="ICDGenerator"
        nameStructure="IEDName"/>
<Communication>
  <SubNetwork name="NONE">
    <ConnectedAP iedName="IEDName" apName="P1">
      <Address>
        <P type="IP" xsi:type="tP_IP">192.168.37.199</P>
        <P type="IP-SUBNET" xsi:type="tP_IP-SUBNET">255.255.255.0</P>
        <P type="IP-GATEWAY" xsi:type="tP_IP-GATEWAY">0.0.0.0</P>
        <P type="S-Profile">1</P>
      </Address>
      <SMV ldInst="LDInst" cbName="MSVCB01">
        <Address>
          <P type="MAC-Address" xsi:type="tP_MAC-Address">
          01-0C-CD-04-00-00</P>
```

```
          <P type="APPID" xsi:type="tP_APPID">0000</P>
          <P type="VLAN-ID" xsi:type="tP_VLAN-ID">007</P>
          <P type="VLAN-PRIORITY" xsi:type="tP_VLAN-PRIORITY">0</P>
        </Address>
      </SMV>
      <SMV ldInst="LDInst" cbName="MSVCB02">
        <Address>
          <P type="MAC-Address" xsi:type="tP_MAC-Address">
          01-0C-CD-04-00-00</P>
          <P type="APPID" xsi:type="tP_APPID">0000</P>
          <P type="VLAN-ID" xsi:type="tP_VLAN-ID">007</P>
          <P type="VLAN-PRIORITY" xsi:type="tP_VLAN-PRIORITY">0</P>
        </Address>
      </SMV>
    </ConnectedAP>
  </SubNetwork>
</Communication>
<IED type="GE Brick Merging Unit" configVersion="1.0" desc="Brick"
     name="IEDName" manufacturer="GE Multilin">
  <Services>
    <ConfLNs fixPrefix="true" fixLnInst="true"/>
    <ConfDataSet max="2" maxAttributes="14"/>
    <GOOSE max="0"/>
    <GSESettings cbName="Fix" appID="Dyn"/>
    <SMVSettings cbName="Fix" datSet="Fix" svID="Fix" optFields="Fix"
                 smpRate="Fix">
      <SmpRate>128</SmpRate>
      <SmpRate>16</SmpRate>
    </SMVSettings>
  </Services>
  <AccessPoint name="P1">
    <Server>
      <Authentication none="true"/>
      <LDevice inst="LDInst">
        <LN0 lnType="IEDName/LDInst/LLN0_0" lnClass="LLN0" inst="">
          <DataSet name="F" desc="Fast Data Set of Brick's Sampled Values
                   Transmitted via Multicast SV Service">
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac1"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac2"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac3"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac4"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac5"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac6"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac7"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.ac8"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.dc1"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.dc2"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="MX" doName="U" daName="analogs.dc3"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="ST" doName="U" daName="contactInputs"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="ST" doName="U" daName="sharedInputs"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="ST" doName="U" daName="outputMonitors"/>
```

A


```
          </DataSet>
          <DataSet name="S" desc="Slow Data Set of Brick's Sampled Values
                   Transmitted via Multicast SV Service">
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="CF" doName="U" daName="model"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="ST" doName="U" daName="smpNum"/>
            <FCDA ldInst="LDInst" prefix="" lnInst="1" lnClass="IBRK"
                  fc="ST" doName="U" daName="diagnostics"/>
          </DataSet>
          <SampledValueControl name="MSVCB01" smvID="0022040080141/F"
                               smpRate="128" nofASDU="8" confRev="1"
                               datSet="F">
            <SmvOpts refreshTime="false" sampleSynchronized="true"
                       sampleRate="false" security="false" dataRef="false"/>
          </SampledValueControl>
          <SampledValueControl name="MSVCB02" smvID="0022040080141/S"
                               smpRate="16" nofASDU="1" confRev="1"
                               datSet="S">
            <SmvOpts refreshTime="false" sampleSynchronized="true"
                       sampleRate="false" security="false" dataRef="false"/>
          </SampledValueControl>
        </LN0>
        <LN lnType="IEDName/LDInst/LPHD_0" lnClass="LPHD" inst="1"/>
        <LN lnType="IEDName/LDInst/IBRK_0" lnClass="IBRK" inst="1"
            prefix=""/>
      </LDevice>
    </Server>
  </AccessPoint>
</IED>
<DataTypeTemplates>
  <LNodeType id="IEDName/LDInst/LLN0_0" lnClass="LLN0">
    <DO name="Mod" type="INC_0"/>
    <DO name="Beh" type="INS_0"/>
    <DO name="Health" type="INS_1"/>
    <DO name="NamPlt" type="LPL_0"/>
  </LNodeType>
  <LNodeType id="IEDName/LDInst/LPHD_0" lnClass="LPHD">
    <DO name="PhyHealth" type="INS_1" />
    <DO name="Proxy" type="SPS_1"/>
    <DO name="PhyNam" type="DPL_0"/>
  </LNodeType>
  <LNodeType id="IEDName/LDInst/IBRK_0" lnClass="IBRK">
    <DO name="Mod" type="INC_0"/>
    <DO name="Beh" type="INS_0"/>
    <DO name="Health" type="INS_1"/>
    <DO name="NamPlt" type="LPL_0"/>
    <DO name="U" type="BRICK_0"/>
  </LNodeType>
  <DOType id="INC_0" cdc="INC">
    <DA name="stVal" fc="ST" dchg="true" bType="Enum" type="Mod"/>
    <DA name="q" fc="ST" qchg="true" bType="Quality"/>
    <DA name="t" fc="ST" bType="Timestamp"/>
    <DA name="ctlModel" fc="CF" bType="Enum" type="ctlModel"/>
  </DOType>
  <DOType id="INS_0" cdc="INS">
    <DA name="stVal" fc="ST" bType="Enum" type="Beh"/>
    <DA name="q" fc="ST" bType="Quality"/>
    <DA name="t" fc="ST" bType="Timestamp"/>
  </DOType>
  <DOType id="INS_1" cdc="INS">
    <DA name="stVal" fc="ST" bType="Enum" type="Health"/>
    <DA name="q" fc="ST" bType="Quality"/>
    <DA name="t" fc="ST" bType="Timestamp"/>
  </DOType>
```

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```
<DOType id="LPL_0" cdc="LPL">
  <DA name="vendor" fc="DC" bType="VisString255"/>
  <DA name="swRev" fc="DC" bType="VisString255"/>
  <DA name="d" fc="DC" bType="VisString255"/>
  <DA name="configRev" fc="DC" bType="VisString255"/>
</DOType>
<DOType id="DPL_0" cdc="DPL">
  <DA name="vendor" fc="DC" bType="VisString255">
    <Val>GE Multilin</Val>
  </DA>
  <DA name="swRev" fc="DC" bType="VisString255">
    <Val>5.601</Val>
  </DA>
  <DA name="serNum" fc="DC" bType="VisString255"/>
  <DA name="model" fc="DC" bType="VisString255"/>
  <DA name="location" fc="DC" bType="VisString255"/>
</DOType>
<DOType id="SPS_1" cdc="SPS">
  <DA name="stVal" fc="ST" dchg="true" bType="BOOLEAN"/>
  <DA name="q" fc="ST" qchg="true" bType="Quality"/>
  <DA name="t" fc="ST" bType="Timestamp"/>
</DOType>
<DOType id="BRICK_0" cdc="BRICK">
  <DA name="smpNum" fc="ST" bType="INT32U" dchg="true"/>
  <DA name="model" fc="CF" bType="VisString35"/>
  <DA name="serNum" fc="CF" bType="VisString13"/>
  <DA name="outputs" fc="CO" bType="BitString32" dchg="true"/>
  <DA name="analogs" fc="MX" bType="Struct" type="Analogs_0"/>
  <DA name="contactInputs" fc="ST" bType="BitString32" dchg="true"/>
  <DA name="sharedInputs" fc="ST" bType="BitString32" dchg="true"/>
  <DA name="outputMonitors" fc="ST" bType="BitString32" dchg="true"/>
  <DA name="diagnostics" fc="ST" bType="Struct" type="Diagnostics_0"/>
  <DA name="lnNs" fc="EX" bType="VisString255"/>
</DOType>
<DAType id="Analogs_0">
  <BDA name="ac1" bType="INT32U"/>
  <BDA name="ac2" bType="INT32U"/>
  <BDA name="ac3" bType="INT32U"/>
  <BDA name="ac4" bType="INT32U"/>
  <BDA name="ac5" bType="INT32U"/>
  <BDA name="ac6" bType="INT32U"/>
  <BDA name="ac7" bType="INT32U"/>
  <BDA name="ac8" bType="INT32U"/>
  <BDA name="dc1" bType="INT32U"/>
  <BDA name="dc2" bType="INT32U"/>
  <BDA name="dc3" bType="INT32U"/>
</DAType>
<DAType id="Diagnostics_0">
  <BDA name="diagnosticFlags" bType="BitString32"/>
  <BDA name="adcTemp" bType="INT16"/>
  <BDA name="transceiverTemp" bType="INT16"/>
  <BDA name="transceiverVolts" bType="INT16"/>
  <BDA name="transceiverCurrent" bType="INT16"/>
  <BDA name="transceiverTxPower" bType="INT16"/>
  <BDA name="transceiverRxPower" bType="INT16"/>
</DAType>
<EnumType id="Mod">
  <EnumVal ord="1">on</EnumVal>
  <EnumVal ord="2">blocked</EnumVal>
  <EnumVal ord="3">test</EnumVal>
  <EnumVal ord="4">test/blocked</EnumVal>
  <EnumVal ord="5">off</EnumVal>
</EnumType>
<EnumType id="ctlModel">
  <EnumVal ord="0">status-only</EnumVal>
```

```
    <EnumVal ord="1">direct-with-normal-security</EnumVal>
    <EnumVal ord="2">sbo-with-normal-security</EnumVal>
    <EnumVal ord="3">direct-with-enhanced-security</EnumVal>
    <EnumVal ord="4">sbo-with-enhanced-security</EnumVal>
  </EnumType>
  <EnumType id="Beh">
    <EnumVal ord="1">on</EnumVal>
    <EnumVal ord="2">blocked</EnumVal>
    <EnumVal ord="3">test</EnumVal>
    <EnumVal ord="4">test/blocked</EnumVal>
    <EnumVal ord="5">off</EnumVal>
  </EnumType>
  <EnumType id="Health">
    <EnumVal ord="1">Ok</EnumVal>
    <EnumVal ord="2">Warning</EnumVal>
    <EnumVal ord="3">Alarm</EnumVal>
  </EnumType>
</DataTypeTemplates>
</SCL>
```

HardFiber Process Bus System

Appendix B: Specifications

See the specific UR instruction manual for specifications related to relay functions, such as protection elements, monitoring, metering, communications, power supply, and inputs and outputs. All accuracies and ranges claims per UR manuals are met or exceeded when a UR device is used in a HardFiber system.

B.1 Brick specifications

B.1.1 Brick inputs

AC CURRENT

Number of AC current inputs	4 or 8, depending on order code
Rated current	1 or 5 A, depending on order code
Nominal frequency	50 or 60 Hz
Input burden	<0.2 VA at rated secondary
Conversion range	0 to 46 × rated RMS symmetrical
Current withstand	20 ms at 250 times rated (ruggedized Brick); 1 second at 100 times rated; continuous at 3 times rated

AC VOLTAGE

Number of AC voltage inputs	0 or 4, depending on order code
Rated voltage	50 to 240 V
Nominal frequency	50 or 60 Hz
Input burden	<0.25 VA at 120 V, 60 Hz
Conversion range	0 to 260 V RMS
Voltage withstand	1 min/hour at 420 V to neutral; continuous at 260 V to neutral

CONTACT INPUTS

Number of contact inputs	18
Wetting voltage	Brick internal 24 V DC power supply
External contacts	dry contact <400 Ω or dry solid-state contact
Voltage threshold	ON State <4 V DC, OFF state >7 V DC
Speed	refreshed at the sampling rate
Continuous current draw	>5 mA at 0 V

DC INPUTS

Number of DC inputs	3
Modes	100 Ω Platinum RTD, 100 Ω Nickel RTD, 120 Ω Nickel RTD, ±5 V DC, 0 to –1 mA, 0 to 1 mA, –1 to +1 mA, 0 to 5 mA, 0 to 10 mA, 0 to 20 mA, 4 to 20 mA, potentiometer, tap position
RTD sensing current	2.5 mA
RTD range	–50 to +250°C
RTD accuracy	±2°C
RTD external lead resistance	25 Ω maximum per lead
DCmV input impedance	≥500 kΩ
DCmV accuracy	±0.2 mV DC or 0.1% of reading, whichever is greater
DCmA external resistor	200 Ω ±0.2 Ω
DCmA conversion range	–1 to + 20 mA DC
DCmA accuracy	±0.2% of 1 mA or 0.2% of reading, whichever is greater
Potentiometer range	2 to 20 kΩ
Potentiometer sensing voltage	5 V
Potentiometer accuracy	±5 mV DC
Speed	value refreshed at the sampling rate

SHARED I/O

Number of channels	15
Speed	refreshed at the sampling rate

B.1.2 Brick outputs

SOLID-STATE OUTPUT RELAY

Number of outputs	4
Relay operate and release time	<100 µs
Maximum voltage	280 V DC
Maximum leakage current in off state	500 µA
Maximum continuous current	5A DC at 45°C; 4A DC at 65°C
Make and carry current (applied to four channels at same time)	300 A DC for 0.03 s at 25°C; 30 A DC for 0.2 s as per ANSI C37.90; 20 A DC for 1 minute at 25°C
Voltage monitor threshold	15 V ±1 V DC
Current monitor threshold	100 mA ±10 mA DC

SOLID-STATE OUTPUT RELAY BREAK CURRENT

Specification	UL 508	Utility application (autoreclose scheme)	Industrial application
Operations per interval	5000 operations, 1 second on, 9 seconds off	5 operations 0.2 seconds on 0.2 seconds off within 1 minute	10000 operations 0.2 seconds on 30 seconds off
	1000 operations 0.5 seconds on, 0.5 seconds off		
Break capability (0 to 250 V DC)	3.2 A at L/R = 10 ms 1.6 A at L/R = 20 ms 0.8 A at L/R = 40 ms	10 A at L/R = 40 ms 30 A at L/R = 4 ms	10 A at L/R = 40 ms 30 A at L/R = 4 ms

LATCHING CONTACT OUTPUT RELAY

Number of outputs	1
Maximum voltage	280 V DC
Make and carry current	30 A DC for 0.2 seconds as per ANSI C37.90; 6 A DC continuous
Relay operate and release time	<4 ms
Minimum number of operations	10 000
Control mode	separate open and close commands, open dominant

LATCHING OUTPUT BREAK CURRENT (DC INDUCTIVE LOAD, L/R = 40 MS)

Voltage	Current
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.25 A

FORM-C CONTACT OUTPUT RELAY

Number of outputs	2
Maximum voltage	280 V DC
Make and carry current	30 A DC for 0.2 seconds as per ANSI C37.90; 8 A DC continuous
Relay operate and release time	<8 ms
Minimum number of operations	10 000

FORM-C OUTPUT BREAK CURRENT (DC INDUCTIVE LOAD, L/R = 40 MS)

Voltage	Current
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

B.1.3 Brick communications

COMMUNICATIONS TO THE RELAY

Number of transceivers	4
Brick transceiver	transmit 1310 nm, receive 1550 nm, 100 Mb/s, bidirectional single-fiber 50/125 μm multimode module (complies with IEEE 802.3 standard 100Base-BX-U)
Optical transmit power	−14 dBm ~ −8 dBm
Maximum optical input power	−8 dBm
Optical receiver sensitivity	−30 dBm
Termination, ruggedized Brick	socket terminus M29504/5; outdoor fiber/power cable provided as a part of the HardFiber system
Termination, S-Brick	multimode fiber LC connector

B.1.4 Brick power supply

POWER SUPPLY

Nominal DC voltage	110 to 250 V DC
Minimum/maximum DC voltage	88 to 300 V DC
Power consumption	<25 W
Voltage interruption ride-through time	0 ms (maximum interruption duration for which Brick operation is unaffected; the Brick complies with type tests applicable to the power supply terminals)
Voltage interruption recovery time	150 ms (maximum duration from rated power supply voltage being applied until the Brick is ready to provide full service)
Voltage withstand	2 × highest nominal DC voltage for 10 ms, 250 V AC continuously
Fusing	no internal fuse; fuses installed in the outdoor fiber cable protect the cable and Brick
Termination, ruggedized Brick	socket terminus M29504/5; outdoor fiber/power cable provided as a part of the HardFiber system
Termination, S-Brick	two 18 AWG wire crimped with ferrule termination/18 AWG bare wires

B

B.1.5 Brick environmental specifications

AMBIENT TEMPERATURES

Operating temperature	–40 to +70°C continuous
Storage temperature	–40 to +85°C

OTHER ENVIRONMENTAL

Humidity (non-condensing), ruggedized Brick	100% at 40°C
Humidity (non-condensing), S-Brick	operating up to 95% (non-condensing) at 55°C (as per IEC60068-2-30 variant 2, 6 days)
Altitude	up to 2000 m
Installation/overvoltage category	III
IP rating, S-Brick rack mount	IP10 back, IP30 top, IP40 all other sides
IP rating, S-Brick surface mount	IP10 bottom, IP40 all other sides
Pollution degree	II
Insulation category	I

TYPE TESTS: S-BRICK

Cold	IEC 60068-2-1, 16 h at –40°C
Dry heat	IEC 60068-2-2, 16 h at +85°C
Humidity	IEC 60068-2-30, 55°C, >95%, variant 2, 6 days
Vibration	IEC 60255-21-1 class 1
Shock and bump	IEC 60255-21-2 class 1
Seismic	IEC 60255-21-3 class 1
Insulation	ANSI/IEEE C37.90, IEC 60255-5
Impulse	IEC 60255-5/27 5 kV impulse
Dielectric strength	IEC 60255-5/27, 2.2 kV AC / 1 minute
Insulation resistance	>500 ohm at 500 V DC
Electrostatic discharge	ANSI/IEEE C37.90.3, IEC 61000-4-2 8 kV Contact / 15 kV Air
Fast transient	IEC 61000-4-4 4 kV at 5 kHz; IEEE C37.90.1 4 kV at 5 kHz for common mode test and transverse mode test
Oscillatory transient	IEC 61000-4-18 2.5 kV for common mode test, 1 kV for differential mode test; IEEE C37.90.1 2.5 kV for common mode test and transverse mode test
Surge	IEC 61000-4-5, 4 KV CM 1KV, 2KV DM
RF conducted immunity	IEC 61000-4-6 10 Vrms from 150 KHz to 80 MHz
Magnetic field immunity	IEC 61000-4-8 1000 A/m short and 30 A/m continuous
Radiated immunity	IEC 61000-4-3 20 V/m; 80 MHz to 1 GHz 10 V/m from 1.4 to 2.7 GHz; IEEE C37.90.2 35 V/m
Electromagnetic emission	CISPR11/22 class A

MECHANICAL PROPERTIES

Dimensions (H × W × D)	8.25" (209.55 mm) × 13.32" (338.33 mm) × 3.325" (84.46 mm)
Mounting dimensions	12.47" × 7.5" (316.7 mm × 190.5 mm) with 4 bolts (¼-20 (M6))
Weight	12 lb. (5.5 kg)
Installation locations	a) outdoors exposed directly to sun and weather (ruggedized Brick only) b) switchgear mechanism cabinets c) indoors

B.1.6 Approvals and certification

APPROVALS AND CERTIFICATION

Compliance ISO

Compliance	Applicable council directive	According to
ISO	---	ISO 9001:2008

B.2 Cable specifications

B.2.1 Copper cable specifications

CABLE

Type	FR PVC outdoor control cable
Shield	copper braid
Voltage rating	600 V
Standard cable length	2 m, 5 m, 10 m, and 20 m
Factory termination	38999 series III plug at Brick end, unterminated at other end
Conductor labeling	numbers in digits and spelled out in English

NUMBER OF CONDUCTORS, SIZE (AWG), AND DIAMETER

CUD-CC55 CT input cable	16 × 12 AWG stranded copper conductors, cable outside diameter (O.D.) 23 mm (0.9")
CUD-CV50 CT/VT input cable	8 × 12 AWG and 8 × 16 AWG stranded copper conductors, cable O.D. 23 mm (0.9")
CUD-CC11 CT input cable	16 × 16 AWG stranded copper conductors, cable O.D. 18 mm (0.7")
CUD-CV10 CT/VT input cable	16 × 16 AWG stranded copper conductors, cable O.D. 18 mm (0.7")
Contact output cable	16 × 16 AWG stranded copper conductors, cable O.D. 18 mm (0.7")
Contact input cable	29 × 16 AWG stranded copper conductors, cable O.D. 25 mm (1.0")

ENVIRONMENTAL

Minimum installation temperature	–10°C
Operating temperature	–40 to +70°C
Standard performance features	sunlight resistant and FT4 flame resistant
IP rating	IP66 at the Brick end

B.2.2 Outdoor fiber cable specifications

OPTICAL PART SPECIFICATIONS

Number of fibers	4
Fiber type	class 1; graded index, size 50/125 μm, wavelength 1300 nm and 1550 nm
Standard cable length	1 to 690 m
Application requirements	MIL-PRF 49291/1-01

ELECTRICAL PART SPECIFICATIONS

Number of copper conductors	2
Conductor	#16 AWG, 1.31 mm^2, stranded
Voltage rating	600 V AC
Shield	Aluminum/polyester tape
Drain wire	#22 AWG, 0.33 mm^2, stranded copper
Fusing	incorporated in the connector at the Cross Connect Panel end; 1A rating, fast acting, 10000 A DC interrupting capacity, Littelfuse KLKD001 or equivalent

MECHANICAL PROPERTIES

Jacket	FR LSZH polyurethane, rodent resistant
Cable outside diameter (O.D.)	12 mm, (0.5") nominal
Maximum installation tension	1780 N (400 lbs)
Maximum operating tension	670 N (150 lbs)
Minimum bend radius (installation)	25 cm (10 inches)
Minimum bend radius (operation)	12 cm (5 inches)
Cable weight	164 kg/km (110 lbs/1000 ft.)
Application requirements	MIL-PRF 85045F
Intended usage	a) outdoor exposed directly to sun and weather b) direct buried c) common use cable pans, raceways, trenches, ducts d) indoor

ENVIRONMENTAL

Storage temperature	–40 to +85°C
Operating/installation temperature	–40 to +85°C

B.2.3 Indoor fiber cable specifications

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OPTICAL PART SPECIFICATIONS

Number of fibers	4
Fiber type	class 1; graded index, size 50/125 μm, wavelength 1300 nm and 1550 nm
Standard cable length	1 to 50 m

MECHANICAL PROPERTIES

Jacket	black flame retardant polyurethane
Cable O.D.	8 mm (0.3 inches) nominal
Maximum installation tension	2180 N (490 lbs)
Maximum operating tension	490 N (110 lbs)
Minimum bend radius (installation)	13 cm (5 in.)
Minimum bend radius (operation)	6 cm (2.5 in.)
Cable weight	50 kg/km (34 lbs/1000 ft.)
Intended usage	indoor

ENVIRONMENTAL

Storage temperature	–40 to +85°C
Operating/installation temperature	–40 to +85°C

B.3 Cross Connect Panel specifications

B.3.1 Cross connect physical and environmental specifications

MOUNTING

Mounting dimensions	4U for 19 inch rack mounting

TEMPERATURE

Operating temperature	–40 to +85°C

B.3.2 Cross connect electrical specifications

ELECTRICAL

Nominal DC voltage	110 to 250 V DC
Number of cable positions	16
Patch cord type	multimode 50/125 μm, 1300/1550 nm, with LC connector (10 cords each 0.5 m are provided with the Cross Connect Panel)

B.4 Process Card specifications

These specifications for the process bus module, or CPU, apply to UR devices.

B.4.1 Process Card optical specifications

OPTICAL

Number of transceivers	8
Transceiver type	transmit 1550 nm, receive 1310 nm, 100 Mb/s, bidirectional single-fiber 50/125 μm multimode module (complies with IEEE 802.3 standard 100Base-BX-D)
Optical transmit power	–14 to –8 dBm
Maximum optical input power	–8 dBm
Optical receiver sensitivity	–30 dBm
Termination	LC fiber connector

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B.4.2 Process Card plus Brick operate times

OPERATE TIMES

Brick AC input to UR CPU	<2 ms
Brick contact input to UR CPU	<3 ms
UR CPU to Brick SSR output	<2 ms
UR CPU to Brick form-C output	<10 ms
UR CPU to Brick latching output	<6 ms
Shared I/O UR CPU to UR CPU	<3 ms

This chapter outlines the warranty and revision history.

C.1 Warranty

For products shipped as of 1 October 2013, GE VERNOVA warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see the GE VERNOVA Terms and Conditions at

https://www.gevernova.com/grid-solutions/multilin/warranty

For products shipped before 1 October 2013, the standard 24-month warranty applies.

C

C.2 Revision history

The tables outline the releases and revision history of this document.

Table C-1: Revision history

Part number	Revision	Release date	ECO
1601-9076-T1	5.6x	15 August 2008	08-0475
1601-9076-T2	5.6x	26 September 2008	08-0587
1601-9076-T3	5.6x	11 March 2009	09-0930
1601-9076-U1	5.7x	30 April 2009	09-0939
1601-0011-X2	6.0x	12 April 2012	12-3267
1601-0011-Y1	7.0x	17 August 2012	12-3471
1601-0011-Y2	7.0x	31 January 2013	13-0122
1601-0011-AA1	7.2x	11 August 2013	13-0401
1601-0011-AB2	7.3x	4 May 2016	16-2839
1601-0011-AF2	7.6x	4 October 2017	17-4112
1601-0011-AF3	7.6x	27 October 2017	17-4173
1601-0011-AF4	7.6x	12 December 2017	17-4274
1601-0011-AH1	7.8x	3 October 2018	18-4786
1601-0011-AI1	7.9x	30 September 2019	19-5181
1601-0011-AM1	8.3x	29 April 2022	22-6815
1601-0011-AN1	8.4x	14 December 2022	22-7333
1601-0011-AQ1	8.7x	27 October 2025	25-0478

C.2.1 Major changes

For information on the updates included in this release of the HardFiber Process Bus System manual, please refer to the latest release notes for the UR 8.7x version online.

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