Multilin HardFiber System

IEC 61850 Process Bus Solution

The Multilin HardFiber System is an IEC 61850 Process Bus Solution that allows the mapping of measurements made in the switchyard to protection relays located in the control house using secure communications. The HardFiber System addresses the key technical and logistic challenges affecting the labor required for substation design, construction and maintenance.

The HardFiber System is designed to reduce the overall labor associated with the tasks of designing, documenting, installing and testing protection and control systems. By specifically targeting copper wiring and all of the labor it requires, the HardFiber System allows for greater utilization and optimization of resources with the ultimate goal of reducing the Total Life Cost (TLC) for protection & control.

Key Benefits

- Eliminates majority of copper wiring to better utilize resources for the design, building, commissioning and maintenance of power system protection and control
- Robust and simple architecture for deploying IEC 61850 process bus
- Extends the Universal Relay (UR) family of products, is available for a wide array of protection applications
- Limits exposure to cyber security threats to only physical interruption
- Improves employee safety by limiting the number of high-energy signals in the control building
- Saves up to 50% in P&C labor costs

Applications

- Retrofit and greenfield installations for power generation, transmission and distribution systems
- Generator, Transformer, Transmission Line, Bus, Feeder, Motor, Capacitor Bank, Wide Area Network protection
- Distributed busbar protection and bay control, enabling centralized overcurrent backup protection
- Substation automation
- Air-insulated and GIS stations
- Multi-terminal line differential where 2 or more terminal are less than 2 km away
- Remote protection and control rooms for medium voltage switchgear to mitigate exposure of operators to arc flash hazard

Cost of Field Wiring

- Standardizes wiring for all protection and control applications
- Bricks are simple settings-free I/O devices that requires no configuration
- Allows entire protection and control system to be tested during factory acceptance tests

Simplifies Maintenance

- Designed for redundant Bricks for redundant analog measurements in one UR
- Continuous cross-checking of redundant measurement signals eliminates the need for routine testing of analog measurements
- Reduces maintenance testing to simple verification of contact I/O

Lifecycle Management

- Removes the cost and effort of field wiring for future relay replacement projects
- URs and Bricks can be replaced independently of each other
- Bricks are simple I/O devices that can be replaced without engineering projects
- Reduces protection and control replacement costs by 80% over conventional relays

Standard Mounting

- Rugged outdoor mounting available
- Standard case for surface, flush, and panel mounting
- Supports customer standards for fiber and copper cable

GE Grid Solution
An Industrial Revolution for Protection & Control

The HardFiber Process Bus System represents a true breakthrough in the installation and ownership of protection and control systems, by reducing the overall labor required for substation design, construction, and testing. This innovative solution addresses the three key issues driving the labor required for protection and control design, construction and testing:

- Every substation is unique making design and drafting a one-off solution for every station
- Miles of copper wires needs to be pulled, spliced and terminated
- Time consuming testing and troubleshooting of thousands of connections must be performed by skilled personnel

The Multilin HardFiber System was designed to address these challenges and reduce the overall labor associated with the tasks of designing, documenting, installing and testing protection and control systems. By specifically targeting copper wiring and all of the labor it requires, the HardFiber System allows for greater utilization and optimization of resources with the ultimate goal of reducing the Total Life Cost (TLC) for protection & control.

Key Benefits of the HardFiber System

The underlying driver for the HardFiber System is the reduction of Total Life Costs of protection and control through labor and resource optimization. This optimization is achieved by replacing individual, labor-intensive, individually terminated copper wires with standardized physical interfaces and open digital communications

- Reduces up to 50% of labor for protection & control
- Replaces extensive copper wiring with pre-terminated copper and fiber cables
- Reduces specialized on-site labor by shifting spending to readily available materials
- Improves employee safety by leaving potentially dangerous high-energy signals in the switchyard
- Reduces the chances for operational mistakes made during isolation and restoration for routine maintenance
- Built on the Universal Relay (UR) family, allowing for fast transition into most protection and control applications including:
  - Generator protection
  - Transformer protection
  - Transmission Line protection
  - Bus protection
  - Feeder protection
  - Motor Protection
  - Capacitor Bank protection
  - Wide-Area network protection

Save Up To 50% Of Your Protection & Control Labor...

Traditional Substation

<table>
<thead>
<tr>
<th>Materials</th>
<th>Labor</th>
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<tbody>
<tr>
<td>Relays</td>
<td>Head Office Engineering and Drafting</td>
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<tr>
<td>Copper Cabling</td>
<td>Construction &amp; Installation</td>
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<td>Terminal Blocks</td>
<td>Commissioning and Testing</td>
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<tr>
<td>Test Switches</td>
<td>On-going Maintenance</td>
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<td>Misc. Materials</td>
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Traditional substation designs require large amounts of skilled labor to create engineering drawings, pull and terminate miles of copper cables, and test and troubleshoot thousands of connections.
The Challenges of Copper Wiring

With the introduction and progression of microprocessor-based protection and control devices, there has been the continued integration of discrete functions into a single device. This integration has delivered cost savings in terms of materials, but the installation uses the same labor-intensive technology dating back to electromechanical relays.

Copper wiring is installed in a substation to integrate the protection and control devices by providing a set of signal paths to move raw information, in the form of analog currents and voltages, representing the status of and controlling the operation of the primary power system. These copper wires have an extremely low signal density, and the installation details are highly dependent on each specific application.

The process of designing, installing and testing all of these copper connections is exceedingly labor-intensive, with most of the labor requirements being the on-site labor. This labor is almost exclusively manual, with very little opportunity of automation or optimization. The end result is a very labor-intensive and error-prone process that adds significant time and cost to every project and makes long-term maintenance and changes difficult to implement.

The Multilin HardFiber System replaces labor-intensive processes with quick installation, off-the-shelf equipment and made-to-order cables.
**Before**
- Traditional breaker wiring
- Low density copper needs 1000s of terminations
- Manual, one-by-one installation by highly skilled workers

**After**
- HardFiber
- All copper wiring ends at the Brick
- Eliminate 33% of breaker terminations
- Easy replacement of Bricks reduces maintenance

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**Outdoor Fiber Cables**
- Point-to-point fiber communications and fused power supply
- Cut to length, pre-terminated cables require no field splicing
- Extremely rugged: run in cable trays, pull through conduits, direct bury

**Brick - Hardened Switchyard Interface**
- Performs all measurement and control for primary apparatus
- Suitable for outdoor installation - IP-66, -40°C to 85°C
- Error-proof copper and fiber installation via standard connectors
Cross Connect Panel
- Breaks out fiber communication channels from Bricks and devices
- Mapping is ‘hard-fibered’ using simple patch cord connections
- No firmware, settings, or maintenance required

Universal Relay IEC 61850 Process Card
- Communications interface between the relay and up to 8 Bricks
- Communicates with Bricks to operate primary power systems apparatus
- Secure real-time system health monitoring

3
Thousands of individual copper wires from switchyard

4
Thousands of hand wired terminations into a rack
- Labor-intensive using specialized workers

Fiber cross connect panels replace copper terminations

- Eliminate 90% of control building terminations
- Fewer high energy signals improve employee safety

Only fiber connections at the relay via the UR IEC 61850 Process Card

- Power system protection behaves as today
- Built on established Universal Relay platform

Traditional System
What is IEC 61850 Process Bus?
Process Bus is a term used to describe a protection and control system that uses a digital communications architecture to carry information between the switchyard and protection and control devices in the control building. This information consists of sampled values, equipment status and output commands. IEC 61850 is the international standard that defines the specific communication protocol for Process Bus implementations used for protection and control applications.

HardFiber Process Bus System
The Multilin HardFiber System is a KEMA tested IEC 61850 Process Bus Solution that allows the mapping of measurements made in the switchyard to protection relays located in the control house using secure communications. The HardFiber System addresses the key technical and logistic challenges affecting the labor required for substation design, construction and maintenance. This unique system provides a total labor saving solution and yet still adheres to the practices used today for protective relaying and control.

Adhering to existing practices:
• Providing a complete system with all the necessary components for measurement, control, and protection
• Covering all utility substation protection applications
• Being understood and deployed by the current utility workforce

Added benefits:
• Reduce dedicated on-site labor with pre-fabricated material to reduce costs
• Is practical to commission and maintain
• Is as reliable as existing protection and control systems
• Uses an open IEC 61850 Process Bus architecture that can supports multi-vender applications
• Is scalable and can be integrated into existing substation designs

The HardFiber System uses IEC 61850 to communicate measurements and commands between Bricks and relays in the control building over dedicated point-to-point fiber optic connections that avoids cyber-security issues altogether.
**System Architecture**

The architecture of the Multilin HardFiber System is driven by the mapping of signals between the primary apparatus and the protection and control devices.

The measurement of field signals and respective mapping of these signals, using the open IEC 61850 communications protocol, back to the control house is done through a hardened interface device called the HardFiber Brick.

Using made-to-order Outdoor Fiber Cables connecting the Brick to a Cross Connect Panel in the control house provides fast and error-proof installation without the need for on-site splicing or terminating.

Keeping true to the existing topology of traditional substations, each protection and control device included in the zone of protection will be connected directly to Bricks through dedicated fiber optic connections.

This simple, purpose-driven architecture that uses the IEC 61850 open standard for communications, provides dedicated point-to-point connections between the Brick and protective relays without introducing any issues relating to data synchronization, setting management or Cyber-Security.

Each Brick transmits measurements and accepts controls from up to 4 separate protection and control devices.

The HardFiber System can easily be incrementally scaled to include new equipment as stations evolve. Duplicated Bricks in the switchyard provide a drastic improvement in reliability and security over today’s technology.
Process Interface Unit Options

The Multilin HardFiber system uses Brick Process Interface Units as the I/O device. The process interface unit is available in two versions: the ruggedized Brick version, and the standard case S-Brick version. Both models of the Brick are exactly the same in terms of performance, functionality, and I/O options. Bricks have 8 analog measurements, either 4 currents / 4 voltages, or 8 currents, along with 18 contact inputs, 3 universal DC inputs, 4 Form-A tripping contacts, 2 Form-C signalling contacts, and latching contact.

Brick

The HardFiber Brick Process Interface Unit (Order Code BRICK-4-HI-R-****-R-X-X) is ruggedized I/O device designed for mounting outdoors in utility switchyards. The Brick uses connectorized copper and fiber optic cables for ease of installation and for environmental protection. The Brick works directly with models of the GE Universal Relay (UR) family, and any compliant third party device.

Fiber cable options for the Brick

Custom FOA cable

The custom FOA cables are ordered to length, and are connectorized at each end. These FOA cables require the use of the Cross Connect Panel, and the FOR Indoor Relay Fiber Cable, to connect to the UR or other compliant devices. DC power to the Brick is distributed by the Cross Connect Panel, and short circuit protection for the Brick power supply is included in the FOA cable.

FOA Splice cable

The FOA Splice Cable is intended to meet customer standards for fiber optic cable distribution through the switchyard. The FOA Splice Cable is connectorized at the Brick end, and ends in copper and fiber pigtails. The customer must provide their own fiber optic cables across the switchyard, DC supply to power the Brick, DC short circuit protection for the Brick power supply, and perform their own splicing to the pigtails of the FOA Splice Cable.
S-Brick

The HardFiber S-Brick Process Interface Unit (Order Code BRICK-4-HI-S-****-*-X-X) is intended for mounting inside marshalling cabinets, kiosks, and equipment control cabinets. The S-Brick uses standard terminal blocks for connecting copper cables to interface with primary equipment. Fiber optic cables require the use of one simplex LC connector for each of the four fiber optic cores.

Cabling requirements for S-Brick, Brick FOA Splice Cable

Fiber optic cabling

The Multilin HardFiber System requires the use of 50/125 µm multimode fiber, that support 1310nm and 1550nm 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 the UR have female LC connectors, so cables must use male LC connectors at these ends. The S-Brick has 4 LC connectors, while the UR has 8 LC connectors. Any commercially available fiber optic patch panel may be used for cable management.

DC supply

The customer must provide a 125 or 250 VDC rated supply to power the S-Brick. The DC circuit must provide short circuit protection for the S-Brick power supply, (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.

Equipment cabinets for the S-Brick

The S-Brick is intended to be mounted close to primary power system equipment. When mounting in utility switchyards for example, the S-Brick must be mounted inside equipment cabinets with appropriate environmental protection. GE Grid Solutions can provide single or multiple S-Bricks mounted in environmentally secure cabinets, with all wiring, test switches, terminations, and related auxiliary equipment provided to meet customer design standards. Our cabinets can be free standing on pedestals or mounted to existing structures in the switchyard. Typical dimensions for the free standing cabinet are 1000mmH x 800mm W x 300mm D with 300mm Floor Stand.

GE Grid Solutions also provides all associated, design, setting studies, configuration, test and commissioning needed to support the installation of this equipment. Please visit our website: GEGridSolutions.com/PowerD/SubstationProjects for more information.
Scalability

The true test of any system, including a Process Bus system, is its ability to incrementally scale up to meet specific applications without adversely affecting the other devices in the system. Today’s protection and control systems are already naturally scalable.

The challenge for communication-based protection systems becomes making extensions and modifications without disrupting the in-service protection and control system.

By recognizing that the mapping between power system signals and protection and control devices is fundamentally driven by the topology of the underlying substation, the HardFiber System is optimally partitioned and connected to allow for additions, modifications and upgrades to the system – without risking interruption or degradation to critical in-service protection.

Reliability, Dependability, Security

The Multilin HardFiber System provides an unprecedented level of diagnostics and self-checking, allowing critical protection and control systems to do something that they have never done before – operate without routine maintenance.

Internal diagnostics and self-tests within each Brick monitor dozens of critical internal subsystems and provide this information several hundred times per second. Duplicate Bricks can be provisioned to acquire each input signal twice, allowing protection and control devices to continuously crosscheck critical protection measurements before executing commands via fully redundant outputs.

With the HardFiber redundant architecture, each protection and control device can be configured to maximize dependability and security, addressing specific application requirements.

The Challenge for Utilities

Modern electricity companies deal with many individual challenges every day with one of the largest being the ability to address the constant inflationary pressures on both labor and materials while still having to manage their demand for increase in load by their customers.

The HardFiber IEC 61850 Process Bus System is a solution that addresses these very concerns and provides utilities with a means to reduce the labor associated with substation construction and expansion, and at the same time uses technologies and methodologies familiar to existing resources and skill sets.

Dedicated Digital Cores within each Brick allows for application additions and modifications without affecting other devices accepting information from the Brick.
Technical Specifications

**BRICK INPUTS**

**AC CURRENT**
- Number of inputs: 4 or 8
- CT rated secondary: 1A or 5A
- Nominal frequency: 50 Hz or 60 Hz
- Relay burden: <0.2 VA at rated secondary
- Conversion range: 0 to 46 CT rating RMS symmetrical
- Current withstand: 20 mA at 250 times rated 1 sec. at 400A

**AC VOLTAGE**
- VT rated secondary: 25 to 240 V
- Number of Inputs: 1 or 0
- Nominal frequency: 50 Hz or 60 Hz
- Relay burden: <0.25 VA at 120 V, 60 Hz
- Conversion range: 0 to 260 RMS V
- Voltage withstand: continuous at 260 V to neutral, 1 min./15 sec. at 420 V to neutral

**CONTACT INPUTS**

- Wetting power: brick internal 24VDC power supply
- External contacts: dry contact, dry solid state contact
- Voltage threshold: 6x1VDC
- Speed: refreshed at sampling rate
- Current Draw: 2.5 mA at 6VDC, 5 mA at 12VDC

**UNIVERSAL DC INPUTS**

- MODE (3-wire)
  - Type: differential input
  - Range: 0VDC
  - Input impedance: 250kΩ
  - Accuracy: ±0.2% of 1mA or 0.2% of reading, whichever is greater
- **MODE**
  - Range: 0V to ±20 mA DC
  - Input impedance: 100kΩ
  - Accuracy: ±0.1% of 1mA or 0.2% of reading, whichever is greater
  - Conversion range: 1 to 0, 1 to 0, 1 to 0, 1 to 0, 1 to 0, 1 to 0, 1 to 0

**BRICK POWER SUPPLY**

- Nominal DC voltage: 110V to 250V
- Min/Max AC voltage: 88V to 300V
- Nominal AC voltage: 100 to 240V at 50/60Hz
- Min/Max AC voltage: 88V/240V at 25 to 100Hz
- Power consumption: <5W

**VOLTAGE INTERRUPTION**

- Hold-Up time*: 8 ms
- Brick recovery time**: 1 ms
- Voltage withstand: 2° Highest Nominal Voltage for 10ms, 2000VAC/3000VDC continuously

**BRICK OUTPUTS**

- **SOCKET/OUTPUT RELAY**
  - Release and operate time: <100us
  - Maximum voltage: 280VDC
  - Maximum continuous current: 5A
  - Maximum operating current: 10A
  - Make and Carry: 30A as per ANSI/IEEE C37.90
  - Breakdown capacity: IL=8ms

**FORM-C RELAY**

- Maximum voltage: 280VDC
- Maximum continuous current: 8A
- Make and carry: 30A as per ANSI/IEEE C37.90
- Breakdown capacity: IL=8 ms

**BIKE COMMUNICATIONS**

- Brick transceiver: 1310nm Tx/1550 nm Rx, 100Mbps, bi-directional 1-Fiber 50/125µm, complies with IEEE 802.3 100Base-BX-U

**MULTI-MODE MODULE**

- Optical transmittance: 14dBm—88dBm
- Maximum continuous power: Optical
- Received sensitivity: -30dBm

**BRICK LIMITATIONS**

- Storage: -40 to +85°C
- Continuous Operating: up to 2000cm

**BRICK TYPE TESTS**

- Cold: IEC 60668-1, 16 h at -40°C
- Dry heat: IEC 60668-2-16, 6 h at 85°C
- Humidity: IEC 60668-2-30, 55%, >95% Variant
- Temperature/humidity: IEC 60668-2-38, -10°C to +65°C
- Cyclic: IEC 61000-4-11
- Shock: IEC 61000-4-2
- Vibration: IEC 61000-4-15
- Impulse: 2000VDC
- Dielectric strength: 3kVAC/1min for AC inputs, 2.3kVAC/1min for others
- Insulation resistance: 100MΩ at 500VDC
- Electrostatic discharge: ANSI/IEEE C37.90.3, IEC 61000-4-2, 2.5kV for common mode test, 1 kV for differential mode test

**ELECTRICAL PROPERTIES**

- Cable Type: Conductors
  - Wire Gauge: 18 AWG
- **CABLES**
  - Power Cables
    - Cables: 400V, 300°C, 10 kA (UL 1569, CSA-C22.2-93)
  - Cable Weight: 164 kg/km (110 lbs/1000 ft)

**INDOOR BICABLES**

- **CABLES**
  - Voltage Rating: 600V
  - Cable Type: Conductors
    - Wire Gauge: 18 AWG
  - **ENVIRONMENTAL**
    - Temperature: -40 to +85°C
    - Humidity: 0% to 95% RH, 35°C

**INDOOR JICABLES**

- **CABLES**
  - Voltage Rating: 600V
  - Cable Type: Conductors
    - Wire Gauge: 18 AWG
  - **ENVIRONMENTAL**
    - Temperature: -40 to +85°C
    - Humidity: 0% to 95% RH, 35°C
Product Dimensions

S-Brick

Surface Mount BRICK-4-HI-****-S-S-X-X

Flush Mount BRICK-4-HI-****-S-F-X-X

Panel Mount BRICK-4-HI-****-S-P-X-X
Product Dimensions

Brick

Outdoor Brick Cable

Cross Connect Panel
Ordering

**Brick**

<table>
<thead>
<tr>
<th>BRICK</th>
<th>****</th>
<th>Base Unit</th>
<th>Core</th>
<th>Power Supply</th>
<th>Case</th>
<th>CT/VT Inputs</th>
<th>Mounting</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRICK</td>
<td>****</td>
<td>Base Unit</td>
<td>4</td>
<td>125V/250V DC Power Supply</td>
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<td>CC55</td>
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<td>Standard kiosk case</td>
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<td>4 fiber optic cores</td>
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<td>Rugged case for outdoor mounting</td>
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<td>Eight 5A CT inputs</td>
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<td>CV10</td>
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<td>Four 5A CT, 4 VT inputs</td>
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</table>

Cable Length
- 001 1 meter to 500 meters (3 feet to 1650 feet)

**Cross Connect Panel**

To be used with rugged Brick-4-HI-R-****-R-X-X only

<table>
<thead>
<tr>
<th>XPC</th>
<th>16</th>
<th>HI</th>
<th>HardFiber Cross Connect Panel, 16 positions, 125/250 V DC Distribution</th>
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</thead>
</table>

**Fiber Cables**

To be used with rugged Brick-4-HI-R-****-R-X-X only

<table>
<thead>
<tr>
<th>FOA</th>
<th>0000</th>
<th>M***</th>
<th>Outdoor Brick connection cable, four fiber optic cores plus copper DC supply</th>
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<tbody>
<tr>
<td>Cable Length</td>
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<td>001 1 meter to 500 meters (3 feet to 1650 feet)</td>
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<th>FOR</th>
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<th>Indoor relay fiber cable, four fiber optic cores</th>
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<td>Cable Length</td>
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**Brick Copper Cables**

To be used with rugged Brick-4-HI-R-****-R-X-X only

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<thead>
<tr>
<th>CUB</th>
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<th>Contact Output Cable</th>
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<tbody>
<tr>
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<td>002 2 meters (6 feet)</td>
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<td>005 5 meters (16 feet)</td>
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<td>010 10 meters (32 feet)</td>
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<td>020 20 meters (64 feet)</td>
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<td>CC55 5A/5A 5A CT inputs</td>
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<td>CV50 5A 4A 4A CT &amp; 4A VT inputs</td>
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<td>CC11 1A 1A 1A 1A 8CT inputs</td>
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imagination at work