P40 Agile Enhanced

Utility and Industrial Feeder Management Relay

The P40 Agile Enhanced feeder management relay delivers highly-adaptable protection and control for utility and industrial feeders alike. It can be applied for primary (main) or backup protection of underground cable and overhead line circuits. Fast overcurrent, ground fault, voltage and frequency elements form the central core of key performance. Advanced functionality includes extensive programmable logic and flexible configuration capabilities, plus support for industry-leading communication protocols. P40 Agile Enhanced provides easy integration into new or existing SCADA or DCS for real time situational-awareness.

P40 Agile Enhanced offers comprehensive power quality monitoring, plus extensive data-logging capabilities, oscillography and events capture. Such measurement and recording features empower users to arrive at power network decisions quickly and effectively, thereby improving service reliability and availability levels.

Key Benefits

- Advanced protection with integrated communications
- Condition monitoring of the relay and health of substation equipment in the bay/cell
- Compact design for power distribution applications featuring universal communications, ideal for on-switchgear installation
- High I/O density – up to 11 inputs / 11 outputs or 14 inputs / 9 outputs - in a case as small as 20TE (4 inch) width
- Extensive recording – 2048 events, 25 fault records, disturbance recording up to 128 s/c
- Embedded suite of serial and Ethernet protocols for ease of integration
- Choice of copper or fiber Ethernet interfaces
- CyberSentry™ Advanced Security including features such as AAA, Radius, RBAC, and Syslog helps enable NERC® CIP compliance
- Designed with an IEC62443-4-1:2018 certified secure development lifecycle process
- Draw-out design for simplified testing, commissioning and maintenance

Applications

- Deploy at distribution voltage levels (as primary protection) up to transmission (as back-up)
- Solidly-grounded, through to systems with constrained fault currents, such as resistance/impedance grounded systems.
- Networks with connected renewables requiring advanced harmonic monitoring and accurate recording
- Fast protection pass enables load-shedding schemes
- Advanced synchronization and autoreclose schemes
- Standard, coastal, industrial and polluted environments thanks to harsh environmental coating of PCBs as standard

Protection & Control

- Comprehensive current, voltage, power and frequency protection functions
- Fast protection execution, scan rate 8 times / cycle
- Advanced protection functions including rate of change, autoreclose, synchrocheck and fault location

Advanced Monitoring & Metering

- Harmonics and THD up to the 21st order
- Up to 128 samples/cycle oscillography
- Flexible elements for building customized functions

Advanced Communications

- Supports IEC 61850 Ed. 2, IEC 62439 (PRP/HSR), Modbus RTU, Modbus TCP, IEC 60870-5-103, DNP 3.0 serial and DNP 3.0 Ethernet protocols
- IEEE 1588 (PTP), IRIG-B and SNTP time synchronization
- Ethernet and serial protocols can operate concurrently

Ease-of-Use

- Compact and withdrawable
- Low depth design (<155 mm)
- Universal voltage binary inputs, universal 1 A / 5 A CTs and universal power supply
- Single setting file for relay configuration
- No internal battery, for UN3091 air transit compliance

Intuitive User Interface

The front HMI (shown in Figure 1) allows direct device interaction. A USB front port offers simple PC access without requiring special leads. Tricolor, programmable LEDs provide a cost-effective solution for annunciation. Smart dependencies within the menu ensure that settings for unused elements are hidden and do not complicate viewing by the user.
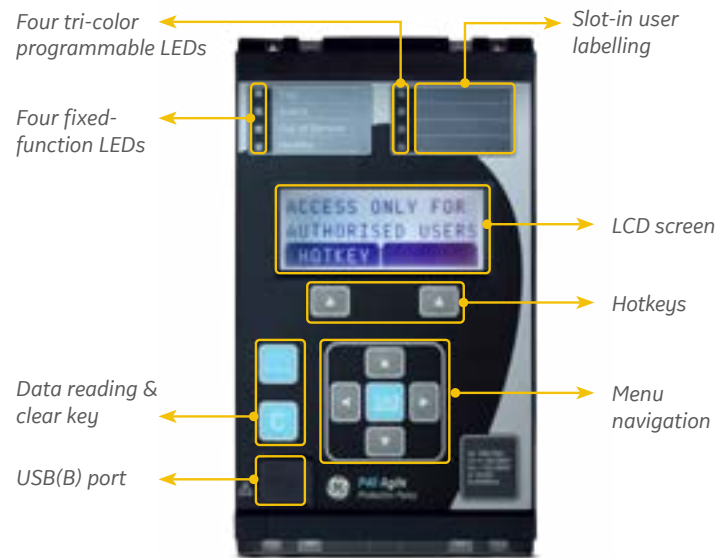
Four tri-color programmable LEDs

Four fixed-function LEDs

Data reading & clear key

USB(B) port

Slot-in user labelling

LCD screen

Hotkeys

Menu navigation

Figure 1 – Front panel interface 20TE (MIDOS SIZE 4)

Environmental Responsibility

The relays are manufactured in a lead-free soldering process using lead-free components. Power dissipation is very low, minimizing the burden on station batteries and keeping the internal electronics cooler to prolong service life. Even the product weight (including packaging) has been optimized to lessen the transit carbon footprint. All such actions boost the eco-responsibility demonstrated in the Product Environment Profile (PEP). The product does not require any resident battery.

The PEP shows claims for raw material depletion, energy depletion, water depletion, global warming potential, ozone depletion, photochemical ozone creation, air acidification, and hazardous waste production.

Quality Built-in

Quality Built-In methodology is applied throughout the development and manufacturing processes. Parts stress analysis in R&D, rigorous component supplier selection, and a shipping carton compliant with ISTA protection requirements all are examples of best-practice to maximize long-life reliability. All circuit boards have harsh environmental coating, to resist moisture, salt, corrosive atmosphere and industrial ambient pollution as standard. Circuit board production uses in-circuit tests, boundary scanning, built-in self-test, automated optical inspection, and X-ray scanning to achieve 100% test coverage.

Manufacturing of the product is at an ISMS 27001 certified plant.

Retrofitting

In addition to new-build, P40 Agile Enhanced can be used to refurbish legacy protection schemes. Having lower depth than most 4U relays or electromechanical disk relays in the installed base makes retrofitting within the existing footprint and AC/DC schematic an easy task.

All models offer:

• Space-saving 4U height (177 mm) and 20TE (4") width case size

• Terminals with IP20 protection, safer within the panel

• A front USB port and rear RS485 and RJ45 ports

• Power-up diagnostics and continuous self-monitoring

• Freely-programmable opto-isolated binary inputs and output relays

• Watchdog health contact

• Field upgradeable via firmware upgrade to change the relay model avoiding costly hardware change

20TE Models

20TE models can accommodate:

• 1 x RS485/IRIG-B interface

• 1 x RS485 additional interface

• Up to 3 x RJ45/FO ports for single and redundant Ethernet plus additional engineering access

• Up to 11 binary inputs and 11 binary outputs or 14 binary inputs and 9 binary outputs, depending on the order code
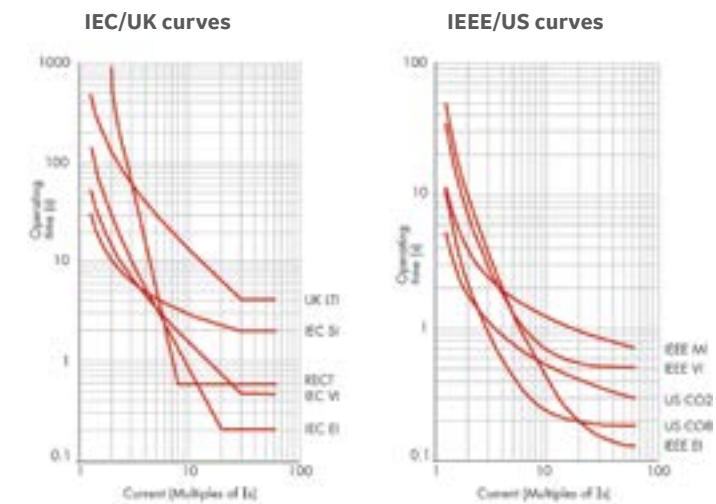
Feeder Protection

Ethernet, graphical programmable logic and field-proven protection, measurement and control algorithms are native in this enhanced range.

Phase and Ground Fault Overcurrent

Six independent stages are available for each phase overcurrent element. Additional to the definite time and predefined IDMT curve selection, programmable curves for customized operation and resetting are available. The profile can be chosen to optimize the protection without constraining the feeder's loadability. If a standard curve is not suitable for the application, the user can program and upload a custom variant.

Standard ground fault elements are available, with four independent stages. Typically, these operate from the quantity flowing directly in to the relay's ground (IN) input. The sensitive ground fault (SEF) order option allows application on systems whose ground fault currents are constrained, achieving pickup sensitivities as low as 2 mA. A core balance CT should be used to drive this SEF CT input.

IEC/UK curves   **IEEE/US curves**

IEC and ANSI/IEEE inverse-time curve profiles

Special Applications

Cold load pickup, second harmonic inrush blocking, broken conductor protection, RMS thermal overload protection, fault location, autoreclose, switch on to fault, rate of change of frequency elements and check synchronizing are built-in depending on the selected model number.

Distributed Generation Protection

Voltage Controlled and Voltage Restrained Overcurrent

Voltage-dependent protection boosts sensitivity and reduces tripping times for faults on weaker systems, such as those with a high prevalence of distributed generation. The timing characteristics can be set as either definitive time or IDMT inverse.

Power

The relay provides four stages of directional power protection per setting group. The two stages of underpower and overpower elements are available which can be configured to operate as forward or reverse directional and active or reactive.

The directional power element responds to three-phase directional power and can be used for reverse power and low forward power applications for synchronous machines or interconnections involving co-generation.

Under / Over voltage

Under/over voltage protection may be configured to operate from either phase-phase or phase-neutral quantities. Four independent stages are available, which can be configured for definite time, inverse time or user defined characteristics.

Check Synchronizing

The check synchronizing feature ensures that the CB contacts touch at the instant of synchronism, minimizing the stress on plant assets when paralleling.

Transformer Protection

P40 Agile Enhanced offers the required current protection with second harmonic blocking, thermal overload protection and instantaneous restricted ground fault element (REF). REF detects transformer winding ground faults, and may be configured as high impedance or low impedance biased differential. Negative sequence overcurrent protection can be set non-directional or directional (forward/reverse) and offers detection of remote phase-phase and phase ground faults.

Load Shedding

Nine stages each of frequency protection are available (except P14N). Each may measure in over-, under-, rate of change, and frequency supervised rate of change modes.

The wide range of setting options permits application of any frequency-based load shedding or islanding scheme.

EnerVista Flex Toolsuite

All aspects of P40 Agile Enhanced configuration are managed using the EnerVista Flex software.

• IED Engineer
• System Integration
• Firmware & License
• Product Selection

• Data Model Management
• Tests & Commissioning
• Maintenance & Monitoring
• Network/Fault Analysis

Single Tool for IED Lifecycle

• IED configure
• Scheme logic design
• Digital substation management
• Product selector
• Data model management

• Firmware download management
• Troubleshoot & diagnostics management
• Fault analyzer
• Simulation management

Advanced Logic and Control Capabilities

P40 Agile Enhanced incorporates advanced automation capabilities which exceed those found in most feeder protection relays. This reduces the need for additional programmable controllers or discrete control relays by including programmable logic, communication, and HV bay / MV cell monitoring. Advanced automation also enables seamless integration into other protection or process systems (SCADA or DCS).

FlexElements™

FlexElement is a universal comparator, that can be used to monitor any (analog) value measured or calculated by the relay, or a net difference of any two analog values of the same type. The element can be programmed to respond either to a signal level or to a rate-of-change (delta) over a pre-defined period of time. FlexElements can be used to generate special protection or monitoring functions, allowing the user to flag a user-defined abnormality for better visibility. The relay supports up to 8 FlexElements.

Digital Counters

P40 Agile Enhanced provides sixteen identical digital counters. A digital counter counts the number of state transitions from logic 0 to logic 1. The counters are generally used to count operations such as the pickups of an element, the changes of state of an external contact (e.g. breaker auxiliary switch), or the pulses from a watt-hour meter.

Programmable Scheme Logic (PSL)

Programmable Scheme Logic (PSL) is the powerful programming logic engine that provides the ability to create customized protection and control schemes, minimizing the need for and the associated costs of auxiliary components and wiring.

It is also used to program the optically isolated inputs, relay outputs and LEDs. The logic includes up to 500 OR, AND or majority gates, timers, and set/reset latch functions, with the ability to invert the inputs and outputs, and provide feedback. The relay has 32 PSL timers, where time-slugged operation or coordination is required.

Circuit Breaker Control

Circuit breaker control is available from the front panel user interface, optically isolated inputs and remotely via the substation communications.

Switch Status and Control

This feature provides status monitoring and control for up to eight switchgear elements. It allows double point status and control over the IEC 61850 protocols for various types of switches and disconnectors.
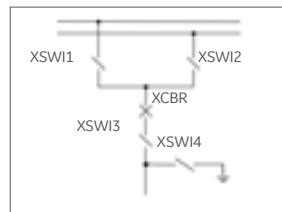
Supervisory and Condition Monitoring Functions

Depending on the hardware base, two stage circuit breaker failure protection, CT/VT supervision, circuit breaker condition monitoring and trip circuit supervision are available. Supervision of the trip circuit in both circuit breaker open and closed states can be realized using the optically isolated inputs and programmable scheme logic. Full compliance to the benchmark H7 supervision scheme is claimed.
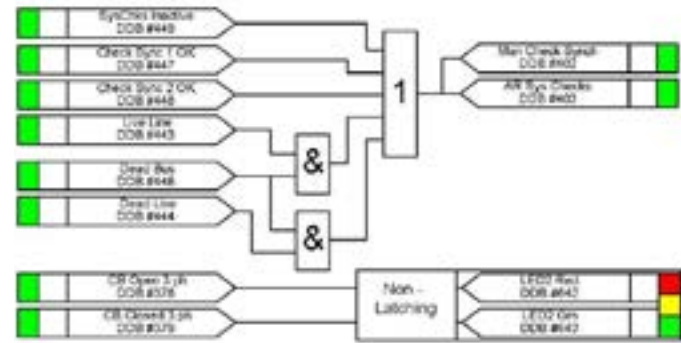
PSL example

Breaker Health Monitoring

The breaker is monitored by the relay not only for detection of breaker failure, but also for the overall "breaker health" which includes:

• Breaker close and breaker open times

• Trip circuit monitoring

• Spring charging time

• Per-phase arcing current

• Trip counters

DC Supply Monitoring

P40 Agile Enhanced measures the DC auxiliary supply infeed to the device, to determine whether the supply is within acceptable operational limits. Three DC supply monitoring zones are available, for under and overvoltage alarming. The DC auxiliary supply value can be displayed on the front panel LCD. This measurement also assists in configuration of binary input pickup thresholds to provide accurate pickup and drop-off.

Active Impedance Binary Inputs

P40 Agile Enhanced binary inputs comply to the ESI 48-4 EB2 standard which are immune to inductive fields created in substations where wiring runs for hundreds of meters in the yard and neighboring wires, busbars and power conductors create strong fields. The inputs support programmable pickup and drop-off and no spurious pickup during battery ground faults or capacitive discharges, thereby making them perfect for plant status monitoring.


Binary inputs immunity to Inductive fields

Measurement, Recording and Post-Fault Analysis

The P40 Agile Enhanced offers unmatched power system analytics through the advanced features, monitoring and recording tools.

Up to 2048 time-tagged event records are stored in non-volatile memory and can be extracted using the communication ports or viewed on the front panel display. Records of the last 25 faults are stored, and fault data is also available via the IEC 61850 protocol.

The internal disturbance recorder has up to 16 analog oscillograph channels and 64 digital channels, with a 30 second capacity. A longer duration transient recorder record ranges from 31 to 1549 cycles (typically half a second to half a minute).

P40 Agile Enhanced offers comprehensive Power Quality metering by measuring up to the 21st harmonic for currents including total harmonic distortion (THD). This feature is an ideal fit for monitoring utility, industrial and commercial feeders supplying non-linear loads.
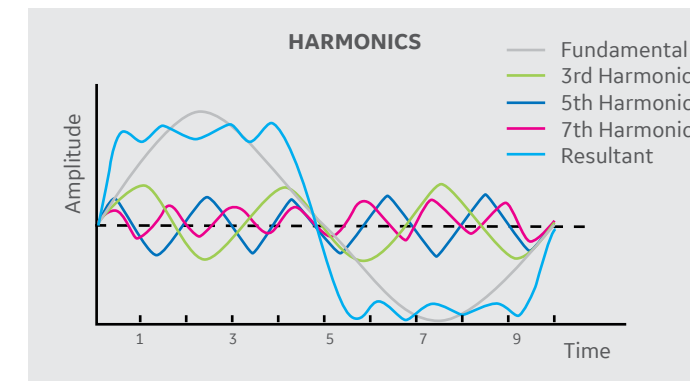
Power Quality Monitoring & Custom Schemes

P40 Agile Enhanced provides a comprehensive datalogging facility where the average values of analog metering values can be recorded at a user selectable interval. The datalogger can store information from up to 16 analog channels, selected from any analogue values calculated by the relay. Capture rates range from once per nominal power system cycle, up to once per hour storage.

Local and Remote Communication

P40 Agile Enhanced provides advanced communications technologies for remote data and engineering access, making it easy and flexible to use and integrate into new and existing networks. Providing several Ethernet and serial port formats and supporting a wide range of industry standard protocols, the relay can be integrated directly into DCS and SCADA systems.

The following protocols are supported:

• Modbus (RS485 serial and Ethernet)

• IEC 61850 Ed. 2

• IEC 60870-5-103 serial

• DNP3.0 (RS485 serial and Ethernet)

• IEC62439 (PRP/HSR) redundancy protocol

• IEEE 1588 (PTP) for time synchronization

All of the serial protocols - Modbus, IEC 60870-5-103 and DNP 3.0 - are switchable in settings and site-selectable for customer use. Similarly,

once the Ethernet interface is ordered, all the Ethernet protocols (Modbus RTU, IEC 61850 and DNP 3.0) are available for selection.

The concurrent Ethernet protocol feature allows customers to future-proof their investment by applying this option for applications requiring support of multiple Ethernet protocols in a single device. Similarly, ordering the Ethernet option in a device initially connected with a serial protocol can provision for a future communications upgrade to Ethernet.

P40 Agile Enhanced offers 128 virtual inputs, and superior GOOSE performance.
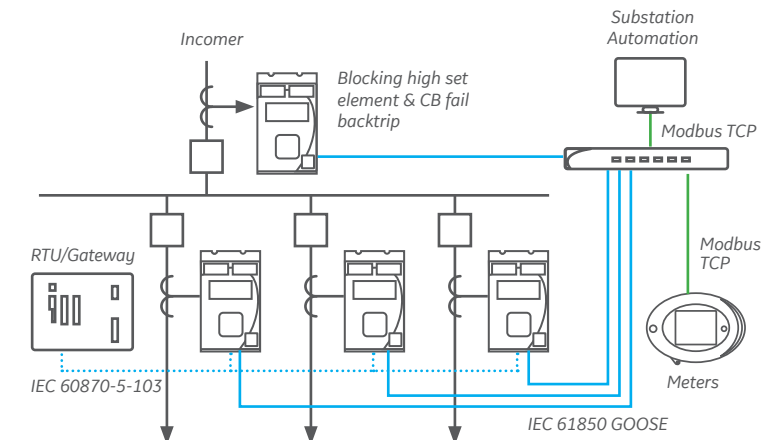
Mixed Communication Protocols: Application Example

Cybersecurity

P40 Agile Enhanced delivers a host of cybersecurity features that help operators to comply with NIS and NERC CIP guidelines, or other security regulations.

• Authentication/authorization/accounting server support (AAA - Radius)

• Role Based Access Control (RBAC)

• Non-erasable cyber event recorder (Syslog for SEM)
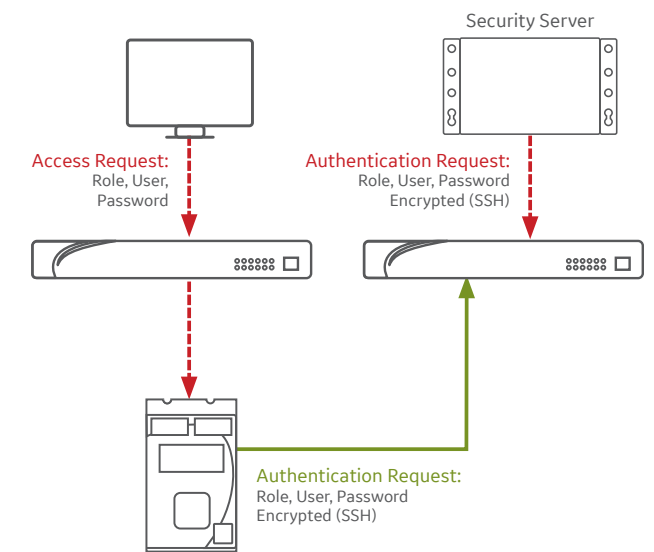
Cybersecurity with Radius Authentication

Testing and Simulation

P40 Agile Enhanced provides a facility to simulate current and voltage inputs. Other test operations are also possible such as the LED lamp test for each color, contact input states and testing of output relays.

The simulation feature tests the response to programmed conditions, without the need of external AC voltage and current inputs. First time users will find this to be a valuable training tool. System parameters such as currents, voltages and phase angles are entered as setpoints.

When placed in simulation mode, the relay suspends reading actual AC inputs, generates samples to represent the programmed phasors, and loads these samples into the memory to be processed by the relay. Normal (pre-fault), fault and post-fault conditions can be simulated to exercise a variety of relay features.

Model Variants and Intended Application

MODEL	HARDWARE BASE	INTENDED APPLICATION	CASE
P14NB	P14N	Non-directional feeder	20TE
P14NL	P14N	Non-directional feeder with autoreclose	20TE
P14DB	P14D	Directional feeder	20TE
P14DL	P14D	Advanced directional feeder with autoreclose and check synchronizing	20TE
P94VB	P94V	Voltage and frequency	20TE
P94VP	P94V	Voltage and frequency with autoreclose and check synchronizing	20TE

		NON-DIRECTIONAL		DIRECTIONAL		VOLTAGE & FREQUENCY	
ANSI CODE	FUNCTION	P14NB	P14NL	P14DB	P14DL	P94VB	P94VP
50	Definite time overcurrent protection	6	6	6	6		
50N/G	Neutral / Ground definite time overcurrent protection (Derived and Measured)	4	4	4	4		
51	IDMT overcurrent	3	3	3	3		
51N/G	Neutral / Ground IDMT overcurrent protection	2	2	2	2		
50/51SEF	Sensitive ground fault	4	4	4	4		
68	Inrush blocking	•	•	•	•		
	Cold load pick up	•	•	•	•		
46	Negative sequence overcurrent	4	4	4	4		
46BC	Broken conductor	4	4	4	4		
	Programmable curves	4	4	4	4		
67	Directional phase overcurrent			6	6		
67N/G	Directional neutral/ground overcurrent			4	4		
	Sensitive directional ground fault			4	4		
	Blocking scheme	•	•	•	•		
37	Undercurrent detection (loss of load)	•	•	•	•		
32	Phase directional power (Forward/Reverse/Under/Over)				4		
49	Thermal overload (current replica)	•	•	•	•		
64N	Restricted ground fault	•	•	•	•		
50BF	CB failure	•	•	•	•		
21FL	Fault locator				•		
27/59	Undervoltage/overvoltage			4/4	4/4	4/4	4/4
27V/59V	Positive sequence undervoltage/overvoltage			2/2	2/2	2/2	2/2
59N	Residual overvoltage			4	4	4	4
47	Negative sequence overvoltage			2	2	2	2
79	Autoreclose (number of shots)		4		4		4
25	Check synchronizing				•		•
81O	Overfrequency			9	9	9	9
81U	Underfrequency			9	9	9	9
81V	Undervoltage blocking of frequency protection			•	•	•	•
81 df/dt	Rate of change of frequency				9	9	9
64N	Restricted ground fault (REF)	•	•	•	•		
PSL	Programmable scheme logic	•	•	•	•	•	•
86	Latching output contacts (Lockout)	•	•	•	•	•	•
	Switch status control	•	•	•	•	•	•
VTS	VT supervision			•	•		
CTS	CT supervision	•	•	•	•		
	DC supply supervision	•	•	•	•	•	•
	CB condition monitoring	•	•	•	•	•	•
	Pole discrepancy	•	•	•	•		
	Setting groups	4	4	4	4	4	4

Wiring Diagram - Hardware Overview

	NON-DIRECTIONAL		DIRECTIONAL		VOLTAGE & FREQUENCY	
FUNCTION	P14NB	P14NL	P14DB	P14DL	P94VB	P94VP
Trip circuit supervision (H7 scheme)	Supported					
Rear communication port (software selectable to convert into demodulated IRIG-B)	RS485					
Rear communication port options	Additonal RS485 serial, 0 to 3 RJ45 Ethernet, 0 to 3 fiber Ethernet*					
Communication Protocols	IEC 103, Modbus, DNP3.0, Modbus TCP, DNP3 Ethernet, IEC 61850, IEC62439 (PRP/HSR) *					
Digital inputs min./max. hardware option	5/8/11/14					
Output relays min./max. hardware option	7/5/11/9					
CT (AC current) inputs : 1 and 5 A software selectable	3Ph + N					
VT (AC voltage) inputs : 100/120 V					4	

* Refer to cortec code for possible combinations
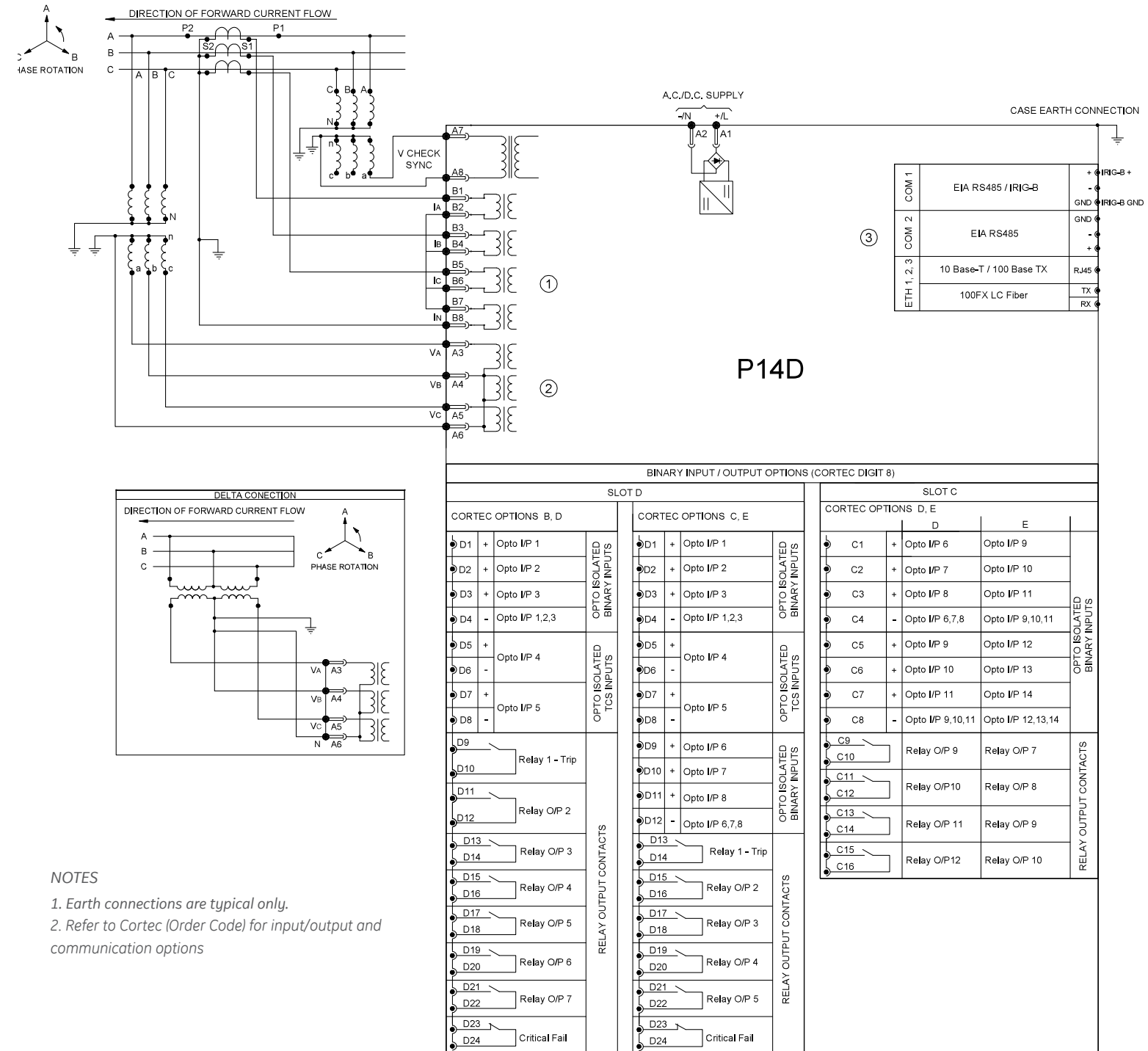
NOTES
1. Earth connections are typical only.
2. Refer to Cortec (Order Code) for input/output and communication options

GE

Worldwide Contact Center

Web: www.GEGridSolutions.com/contact
Email: contact.center@ge.com
Phone: +44 (0) 1785 250 070

GEGridSolutions.com

IEC is a registered trademark of Commission Electrotechnique Internationale. IEEE is a registered trademark of the Institute of Electrical Electronics Engineers, Inc. Modbus is a registered trademark of Schneider Automation. NERC is a registered trademark of North American Electric Reliability Council. NIST is a registered trademark of the National Institute of Standards and Technology.

GE and the GE monogram are trademarks of General Electric Company.

GE reserves the right to make changes to specifications of products described at any time without notice and without obligation to notify any person of such changes.