

GE Oil & Gas

# Compact Control System

Highly flexible & reliable solution for  
GE's PGT25+/G4 family of aeroderivative gas turbine drives  
(centrifugal compressors & electric generators)

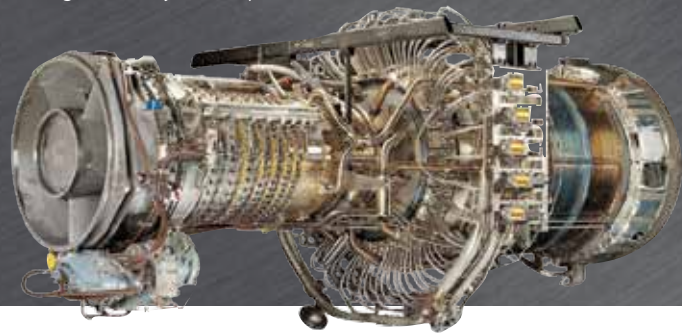


# Smallest design makes Biggest difference

When GE Oil & Gas engineers set out to design a more streamlined PGT25+ turbine package, the control system architecture quickly became the focus and springboard for some of the most beneficial installation and operational advances in recent history.

- fewer external auxiliary skids and interconnecting cables
- simplified installation and commissioning
- improved gas turbine enclosure ergonomics
- increased maintainability and machine availability
- lower total cost

The turbine is shipped as a pre-assembled, pre-wired, fully tested package to simplify installation and commissioning – with all required turbine instrumentation wired to the on-skid I/O boards during assembly at our plant.

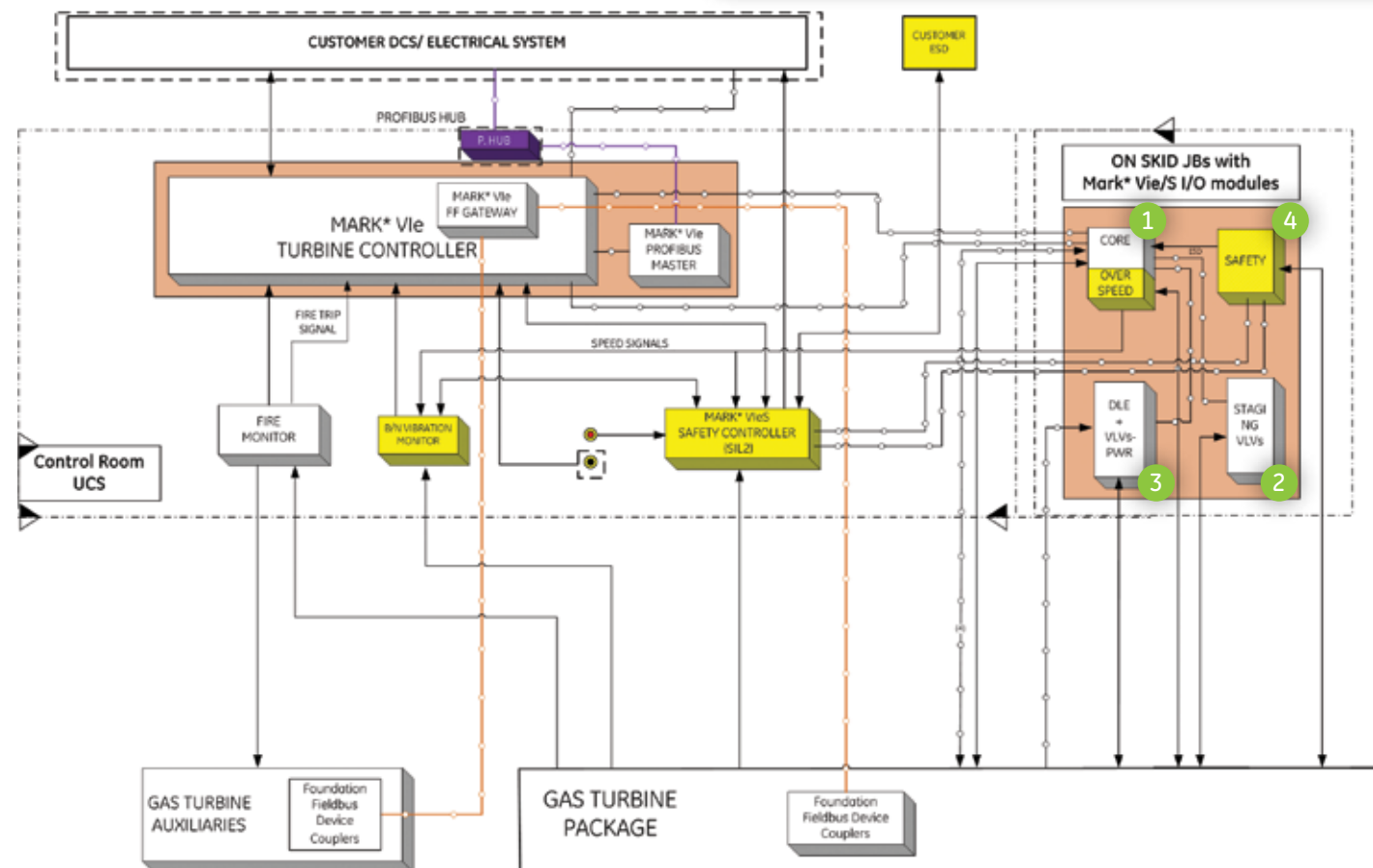


## Advanced turbine control

GE's latest Mark VIe\* and Mark VIeS\* family of turbine controls is the ideal choice for such a distributed system design. Proven in a variety of energy industries, this advanced system provides enhanced remote I/O capability over previous Mark VI controllers, as well as increased computing power, smaller footprint for control room panel, improved application development tools, and lower cost. Rugged industrial-type network switches are used in both the control-room and skid panels, enabling interconnection of the distributed control system via standard copper ethernet or fiberoptic cable, depending on distance.

## Innovative split architecture

The overarching design principal of GE's Compact Control system is a split architecture in which most primary signal acquisition and processing equipment is on the turbine skid. Vibration monitoring, computing, interfacing and networking systems are hosted in a conventional control room panel.



# Compact Control advantages

## Safety

The Compact Control system has a network of redundant interconnected Mark VIeS dual controllers, certified for use in applications up to and including SIL3. The typical PGT25 family safety-critical loops included are:

- Explosive gas leakage protection
- Exhaust duct purging
- Loss of flame protection
- Excessive fuel at startup protection
- Vibration trip management
- Overspeed

The skid-mounted panels with all the components assembled inside (Mark VIe/S, ethernet switches, power supplies, etc.) are certified for use in potentially explosive atmosphere (ATEX Zone 2 for EU and Class1 Div 2 for USA/Canada). In addition, the I/O cards, power distribution and loads power distribution are designed to allow maintenance in hazardous area without requiring a hot-work permit.

## Certifications include

- ATEX Zone 2 (EU), Class1 Div 2 (NA) and IECEx
- ABS certification for marine installation
- Designed to meet regulations in Europe, United States, Canada, Australia, Brazil, Russia and China

## CANOpen communication fieldbus for DLE controls

This new communication module extends the range of compatible fieldbuses to provide the digital connectivity required to control the high accuracy multivalve metering system used in the DLE application.

## Temperature & environmental conditions

Specially designed IP66 enclosures with embedded thermal management system allow for extended range of operation from -40°C to +49°C. The uniquely designed thermoelectric system with heat exchangers maintains internal temperature without an external air supply. The boxes are designed for 5-90% (±10%) relative humidity and are suitable for marine and desert conditions.

## Speed & vibration protection

The Mark VIe board currently used for speed detection (PPRA) is located in the core box and certified by EXIDA as a stand-alone SIL3-rated overspeed protection module.

## Reliability

Although simplex can be offered as an option, the jet engine instrumentation is by nature dual redundant. The PGT25+ redesigned control system takes this into account and implements dual redundancy in its architecture at the CPU, I/O, and power supply level in all its subsystems.

The Mark VIeS controllers are programmed according to IEC61508 rules and have full control of all safety-relevant instrumentation, including shut-off valves, block and vent valves, gas detectors, flame detectors and transmitter for enclosure differential pressure. Fire protection logic is hosted in the control room in order to guarantee proper intervention in the most adverse conditions.

## Designed for hazardous areas

Conventional enclosures for classified areas tend to be 'over designed' in order to protect equipment that would otherwise not be suitable for hazardous-area installation. Their bulky designs increase overall weight and cost, while inhibiting operation and maintenance activities.

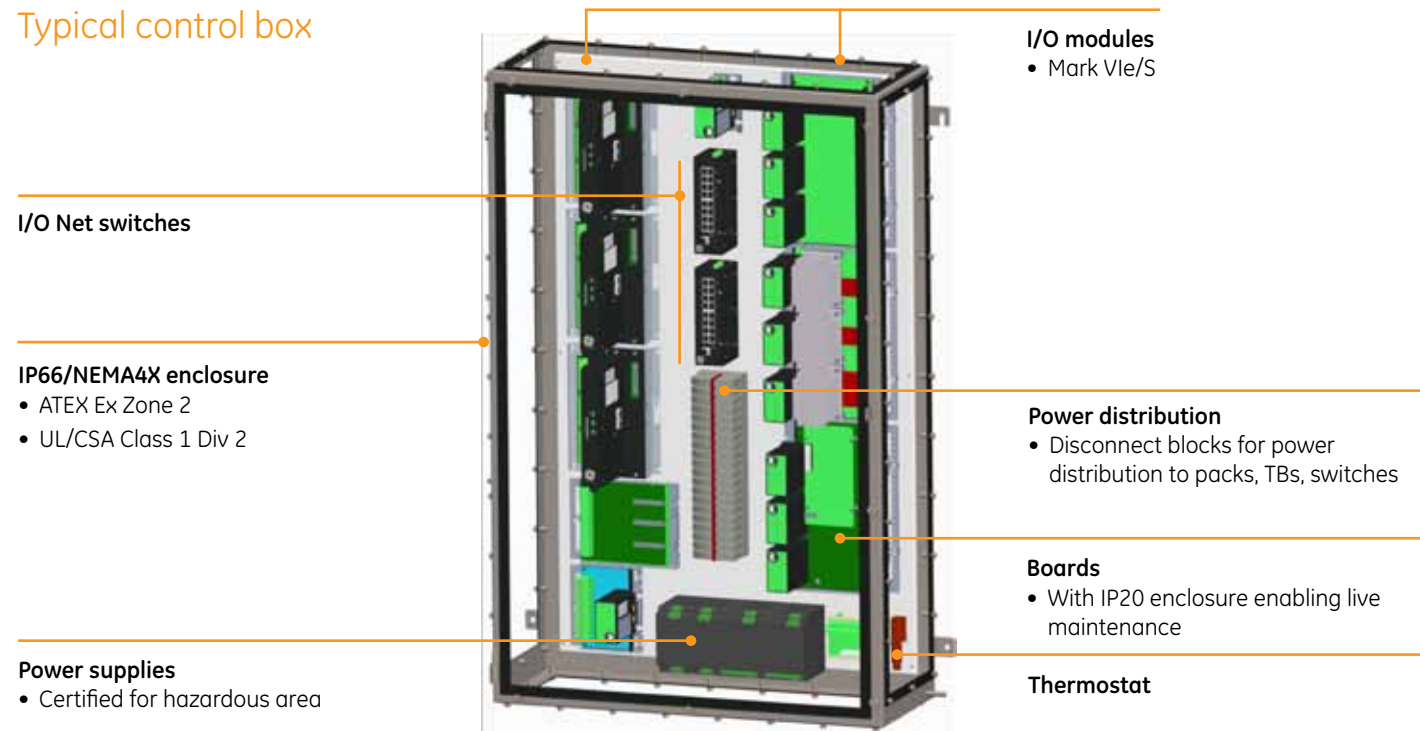
By contrast, our Compact Control skid-mounted panel includes only those components suitable for installation in Class 1 Div 2 or Zone 2. This applies to major equipment (I/O boards, I/O switches, power supplies) as well as to the various assembly components such as fuses, terminals, relays, breakers, lamps and heaters.



# Standardized skid panels

## Customized control room

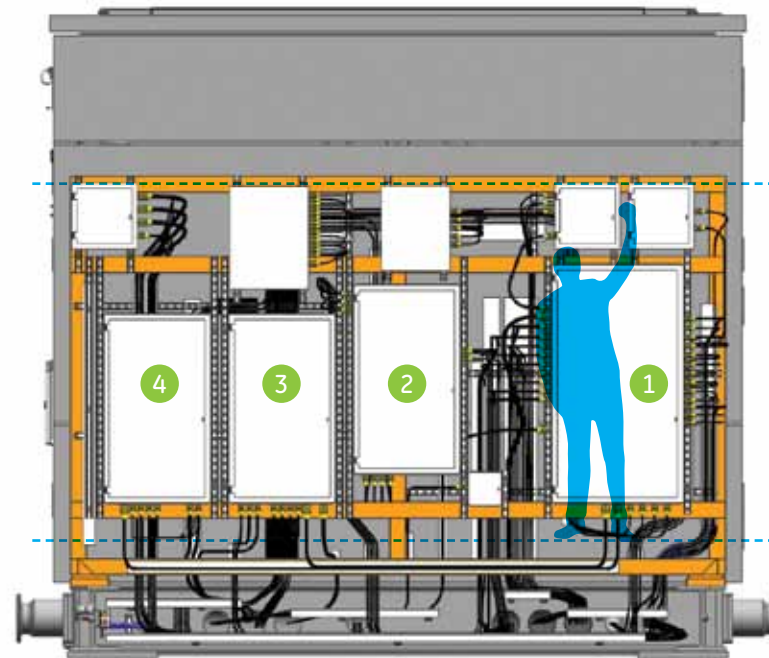
### Typical control box



### Compact Control RIO

#### Advantages over traditional control room setup

- Significant savings in cost and effort due to the reduced amount of cables as compared to a traditional control setup where typical cabling expense can be upwards of \$250,000
- Startup/commissioning is streamlined since on-site wiring checks are no longer needed between the control room and engine. All wiring is now completed at the GE plant along with the gas turbine assembly.
- Maintenance and diagnostics are greatly simplified since all activities related to control and IO cards can be done close to the skid by one person instead of two.
- Compact Control enables much greater online maintenance benefits, cost saving and simplified operation since it does not require shutdown or hotwork permits in order to replace cards
- The Compact Control boxes are thermally controlled for extreme ambient conditions and designed for temperature control without additional cooling or instrument air



### The skid at a glance

#### Key safety & control features

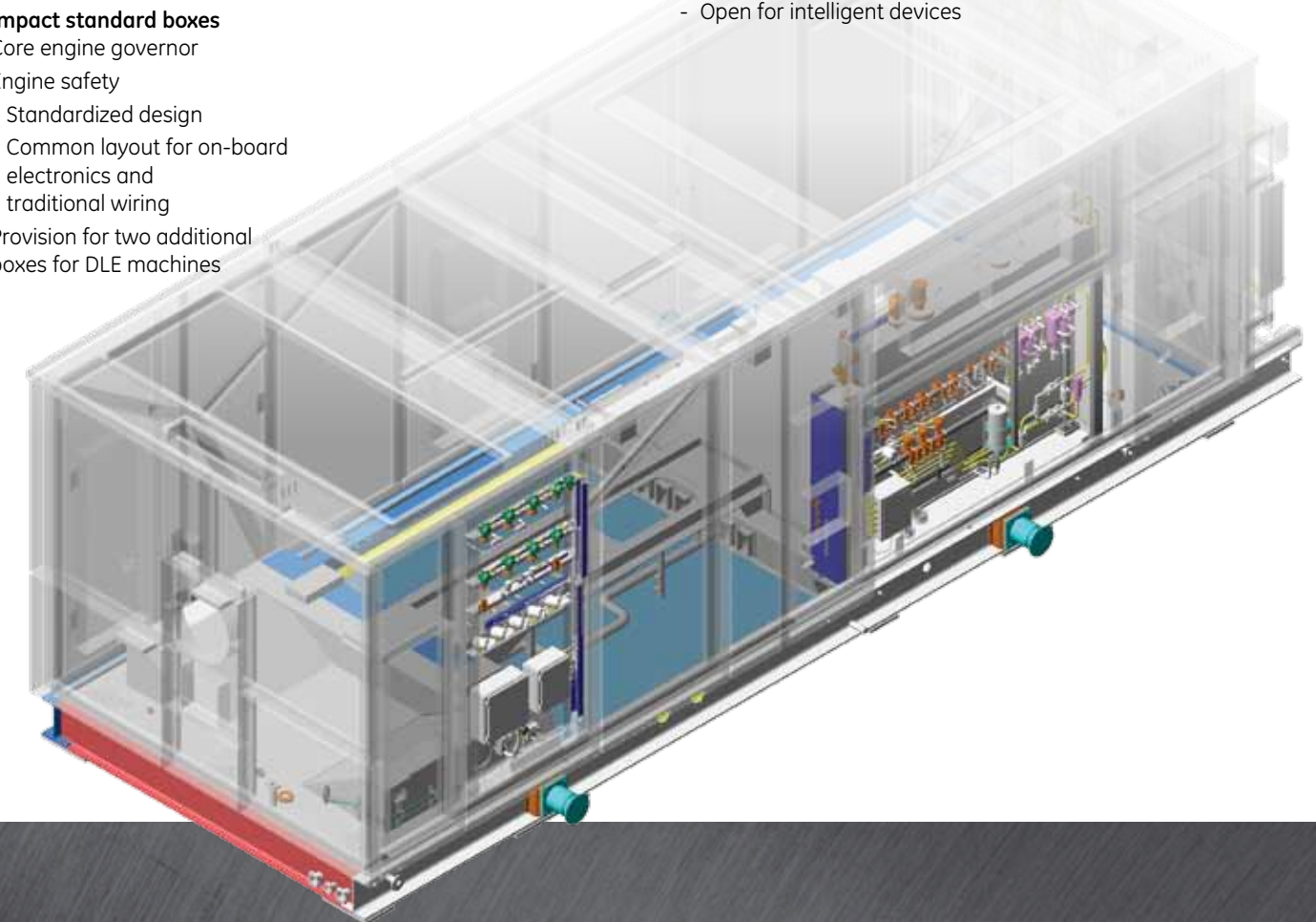
- Compact skid-mounted boxes for I/O related to core turbine control
- Digital networked instrumentation (Foundation Fieldbus) for auxiliary and balance of plant
- Safety system I/O is provided in the dedicated junction box
- Integral thermal management, eliminating external air requirement
- Designed for live maintenance in hazardous areas

#### Compact standard boxes

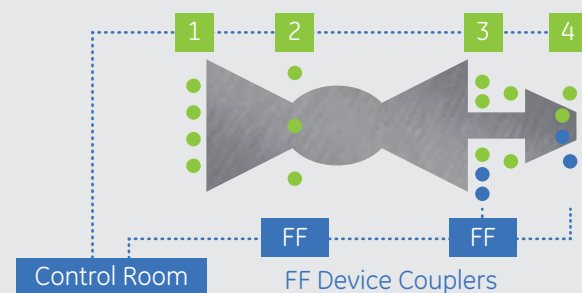
- Core engine governor
- Engine safety
  - Standardized design
  - Common layout for on-board electronics and traditional wiring
- Provision for two additional boxes for DLE machines

#### Networked sensors (Foundation Fieldbus)

- Auxiliary systems, package and external skids
- Balance of plant (BOP) and compressor auxiliaries
  - Move customization from hardware to software
  - Plug & Play: reduced wiring, installation and commissioning costs
  - Advanced diagnostic for trouble-shooting and preventive maintenance
  - Improved plant asset management and data visualization
  - Open for intelligent devices



The Compact Control System comes in two configurations: 2 standard boxes for SAC machines and 4 standard boxes for DLE machines. The standardized enclosures with integrated Mark VIe I/O hardware are suitable for installation in hazardous areas and harsh/marine environments. These self-contained enclosures include all elements needed to enable full plant-specific customization through the linked control room panel.



#### Box 1

Core junction box containing redundant Mark VIe cards for core control of the PGT25+/G4 and related power supplies.

#### Box 2

Staging valves box with redundant Mark VIe cards and power supplies for operation of the DLE valves (required for DLE machines).

#### Box 3

DLE box with redundant Mark VIe I/O cards for instrumentation required for DLE machines and instrumentation to drive the valves.

#### Box 4

Safety box with redundant Mark VIeS I/O cards and power supplies required to manage the engine safety loops for SIL3 certification.

# Foundation Fieldbus

A system – not just a bus

The transition to open and standardized fieldbus systems, such as Profibus DP, had a significant positive impact on decentralized architecture, improving diagnostic capabilities and availability.

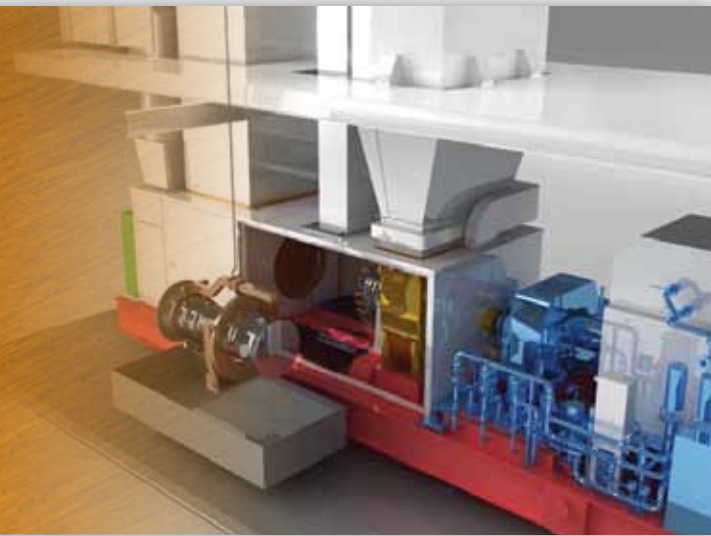
We've now taken these benefits to an even higher level with the adoption of the more robust Foundation Fieldbus system.

This has extended digital communication strengths to all plant devices, even further increasing availability of the entire plant. The benefit is simple and significant – minimized lost production time by proactively avoiding device failures that were common in the past.

## At a glance

- Preventive maintenance of instruments
- Early prediction of sensor failures and damages to equipment
- Fast and precise error recognition of the field devices
- Predictable outages to increase in-market availability

The improved availability extends plant lifecycle, with increased performance and quality, and is therefore instrumental in reducing total ownership cost.



## Lifecycle advantages

### Faster installation

- Ease of engineering and installation as a result of less wiring
- Faster assembly and fewer faults
- 90% less time required by customer crew since far less cable work
- Lower material costs

### Faster commissioning

- More than 100 devices can be commissioned per day
- One person can complete instrumentation commissioning – no need for a second person to find and activate instruments for the loop check
- Communication faults can be located from the control room
- No 4-20 mA calibration is required since the digital device measures the full range of process values
- Instrument settings can be downloaded from the control room; no need for separate connection of a handheld to each transmitter
- A calibration pressure source is not required

### Improved engine & BOP operation

- High resolution of the measured value
- The original signal is not altered by analog-digital conversion
- Higher transmission reliability
  - Digital communication is not subject to noise
  - Plausibility checks confirm the quality of the signal
- Communication of measurement value and device status from field instruments to DCS
- Fewer and predictable outages

## Key design features

### Robust communications

Foundation Fieldbus is a deterministic, peer-to-peer protocol with individual devices communicating control information on a very precise schedule without the need for a host to initiate communications. Message retries and other statistics enable users to identify communication difficulties and easily help isolate problems either at individual nodes or in the communication system.

### Alarms and alerts

With Foundation Fieldbus, each device is an independent processing node and can process alarms and alerts independent of other devices. Each device has a real-time clock that is synchronized with other devices on that segment, and that can be synchronized with other segments through high-speed ethernet. Highly accurate alarm processing and time stamping are communicated to the host, so that later analysis of the alarm sequence is not altered by the host scan order or frequency of updates. Foundation Fieldbus supports alerts the same way it supports alarms. Individual devices time stamp alert or diagnostic conditions, and both the alert and time are available to the host for later diagnostic processing.

### Real-time diagnostics

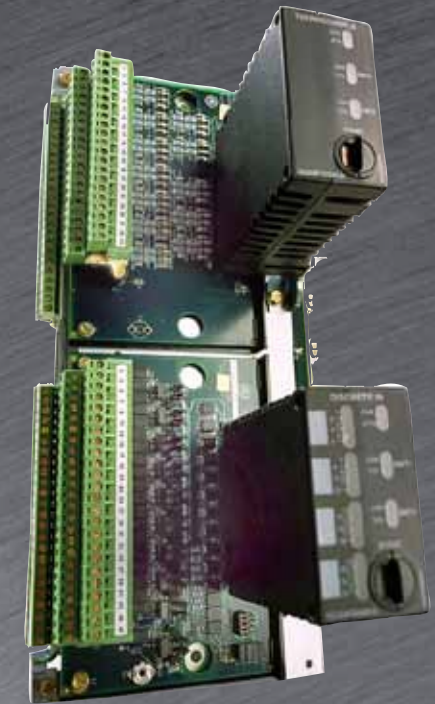
Each device proactively time stamps and reports diagnostic conditions when they occur, not only when requested by the host. Time stamping allows synchronization of diagnostics and process information for precise analysis. Foundation Fieldbus diagnostics can therefore be used proactively to improve both process performance and asset reliability and life.

### Redundancy

For reliability, two linking devices can be connected with a RS-232C null modem cable to form one logical linking device (a redundant set) in a primary-secondary configuration. Both linking devices are connected to the same H1 components and HSE subnet. Should the primary device fail, the secondary device provides a timely backup. The original primary could then be replaced and automatically reconfigured to match the new primary device. The power conditioners and the trunks can be offered in a redundant configuration for enhanced reliability.

### Optimized maintenance

- Diagnostic information for predictive maintenance – maintenance is performed only when scheduled or required
- Determination of process or instrument faults
- Easy and fast troubleshooting from the control room
  - No need to physically locate instrument in the plant
  - Fewer trips to the field
- Self-test and corrective functions in the field device
- No periodic 4-20 mA calibration
- Plug and play by downloading updated settings to the new instrument



### I/O flexibility

In addition to built-in module redundancy, one of the major advantages of GE's Mark family of turbine controls has always been the availability of dedicated I/O cards for acquisition of specific turbine instruments (e.g., thermocouples, LVDTs, servovalves, seismic probes, etc.) that are at the very heart of turbine dynamics and combustion control.

Compact Control's core analog module combines all the I/O capabilities required by an aeroderivative core engine control into a single, compact acquisition module featuring native input and output redundancy. All remaining auxiliary instrumentation is Digital (Foundation Fieldbus) Intrinsically Safe type. The auxiliary instrumentation can therefore be maintained in a hazardous area without a hot work permit procedure in place – allowing live work on energized equipment.

The Foundation Fieldbus network is implemented with a tree-type topology: high current trunk cables (Type A per IEC61158-2) run from control room power supplies to the field junction box where Foundation Fieldbus device couplers are installed. Starting from each junction box, several individual spur cables interconnect each Foundation Fieldbus instrument to any available device coupler input. The Foundation Fieldbus network solution is available for Zone 1, Zone 2, Division 1 and Division 2 Hazardous Area classifications. This type of circuit can be worked on while energized without a hot work permit.

### Connectivity

The Foundation Fieldbus network is interconnected to Mark VIe through several linking devices that comply with Class 42c of the HSE profile. Each linking device manages four H1 ports with galvanic isolation (transformer). Linking devices are connected on the Mark VIe I/O control network like standard I/O modules and communicate to a network switch and then to both Mark VIe redundant controllers. They are fully compatible with all controllers and I/O modules in the Turbine Control software suite, which configure and monitor the linking devices along with all devices at the I/O and supervisory levels. Field device data is combined with other unit, plant process and diagnostic data in a common time-coherent database to simplify operations, provide better data quality and reducing troubleshooting time.

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