GE Energy

Mark* VIe Control
Product Description

GEI-100600C

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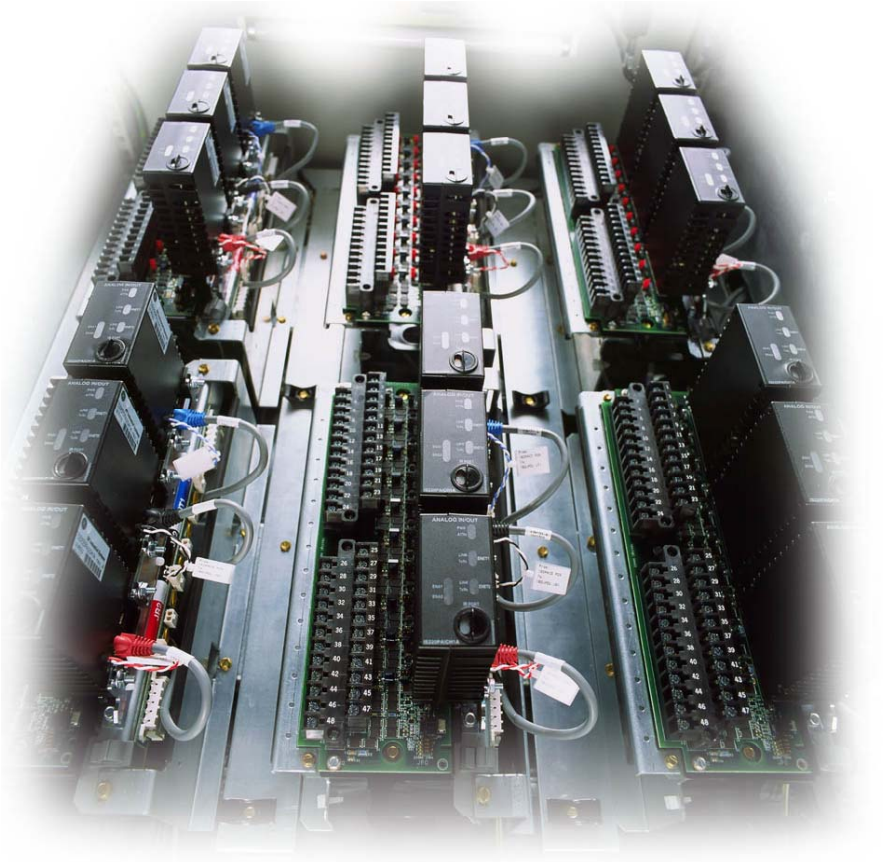


imagination at work

Introduction

Mark* VIe is a flexible control system for multiple applications. It features high-speed, networked I/O for simplex, dual, and triple redundant systems. Industry-standard Ethernet communications are used for I/O, controllers, and supervisory interface to operator and maintenance stations, and third-party systems.

ToolboxST* is used for Mark VIe and related controls as a common software platform for programming, configuring I/O, trending, and analyzing diagnostics. It provides a single source of quality, time-coherent data at the controller and plant level for effectively managing equipment assets.

Architecture

A single-board controller is the heart of the system. It includes the main processor and redundant Ethernet drivers for communicating with networked I/O and additional Ethernet drivers for the control network. A QNX® real-time, multitasking operating system is used for the main processor and I/O. Application software is provided in a configurable control block language, and is stored in non-volatile memory. It conforms to IEEE-854 32-bit floating-point format.

IONet is a dedicated, full-duplex, point-to-point protocol that provides a deterministic, high-speed 100 MB communications network suitable for local or remote I/O with a fiber interface. It provides communication between the main processor(s) and networked I/O blocks, called I/O packs.

100 MB Ethernet is used for communication to local and remote I/O packs. The IONet is available in single, dual, and triple configurations.

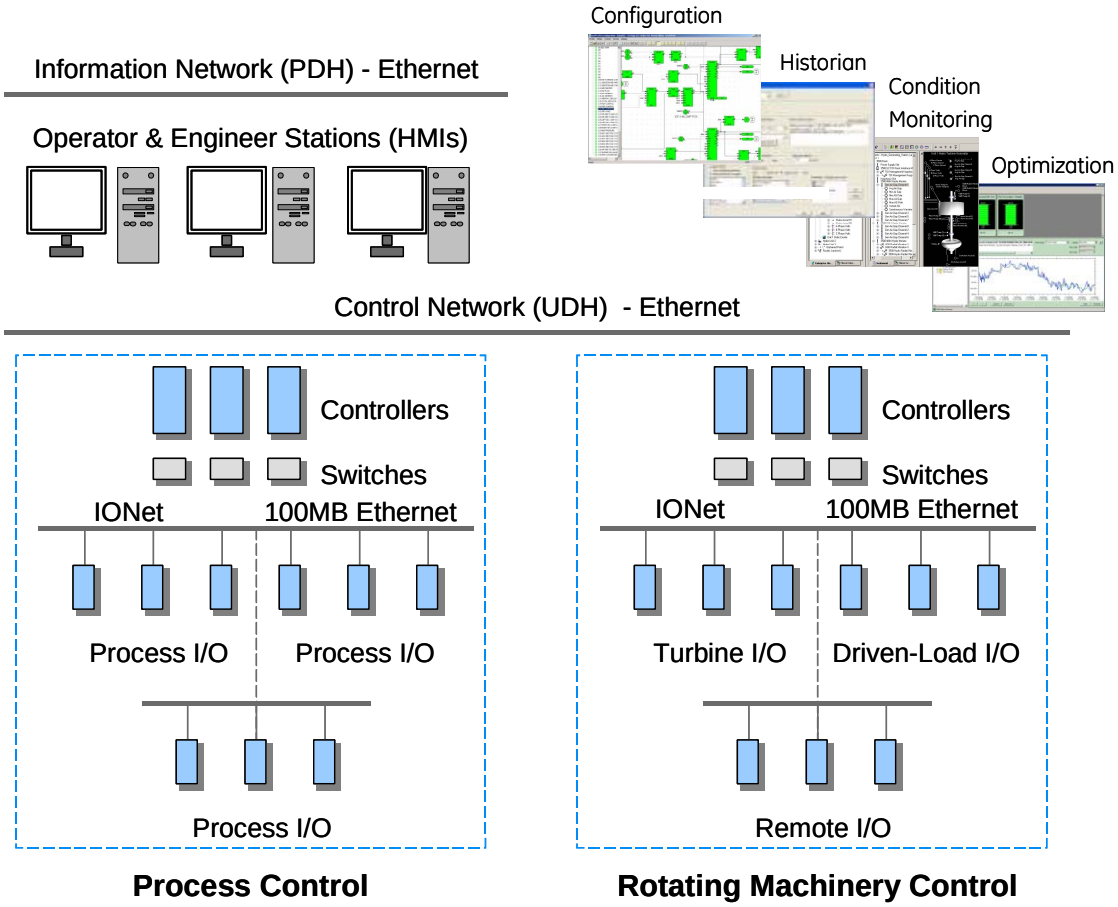
Each I/O pack is mounted on a board with barrier or box-type terminal blocks. The I/O pack contains two Ethernet ports, a power supply, a local processor, and a data acquisition board. Computation power grows as I/O packs are added to the control system, enabling an overall control system frame rate of 10 ms in simplex, dual, or triple redundant configuration. Some process sub-systems require even more performance; therefore, the local processors in each I/O pack run algorithms at higher rates as required for the application.

Redundancy

Every application has different requirements for redundancy depending on the importance of the process. Mark VIe provides a wide range of redundancy options that can be supplied in virtually any combination and mounted local or remote. Some of these redundancy options include:

- Power sources and supplies — single, dual, and triple
- Controllers (main processor) — single, dual, and triple
- I/O network redundancy — single, dual, and triple
- I/O packs per terminal board — single, dual, and triple
- Ethernet Ports / I/O pack — single or dual

System Architecture



Controllers are continuously online and read input data directly from IONet. Dual redundant systems transmit inputs from one or redundant I/O packs on dual IONets to dual controllers. Outputs are transmitted to an output I/O pack that selects either the first healthy signal or the signal of choice. Three output packs can be provided to vote output signals for mission-critical field devices.

Dual redundant systems can be configured for single, dual, and triple sensors. Their dual internal networks and controllers keep the process online if a controller or power supply fails. Triple redundant systems are available to protect against soft or partial failures of devices that continue to run but with incorrect signals/data.

These systems *out vote* a failed component with a 2-out-of-3 selection of the signal. Application software in all three controllers runs on the voted value of the signal while diagnostics identify the failed device. These sophisticated diagnostics minimize the mean-time-to-repair (MTTR) while the on-line repair capability maximizes the mean-time-between-forced-outages (MTBFO). Field sensors for these systems can be single, dual, or triple.

A second controller can be provided to separate the application software for different pieces of equipment. For example, a core engine control for an air-fuel governor can run in one controller while a second controller can be dedicated to auxiliary control.

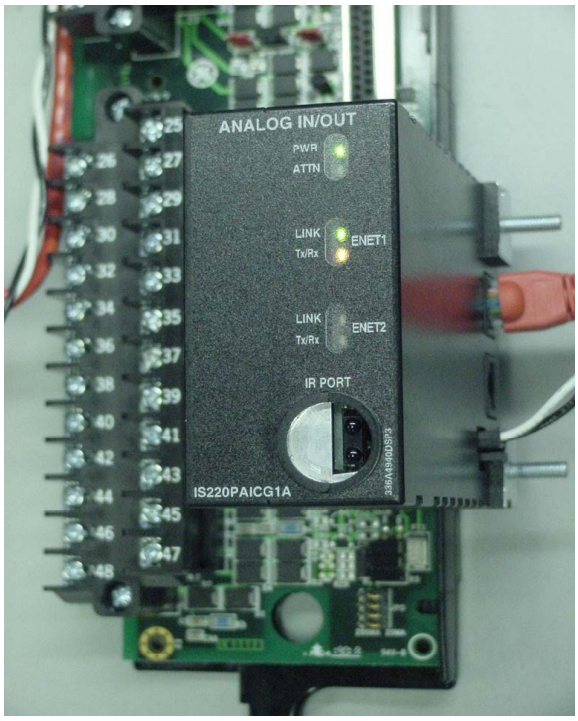
Note Every I/O pack communicates directly on IONet, which enables each I/O pack to be replaced individually without affecting any other I/O in the system. Also, the I/O pack can be replaced without disconnecting any field wiring.

I/O Interface

One or multiple I/O packs are mounted on each board to digitize the sensor signal, perform algorithms, and communicate with a separate controller that contains the main processor. I/O packs have a local processor board that runs a QNX operating system and a data acquisition board that is unique to the type of input device. Local processors run algorithms at faster speeds than the overall control system.

An infrared transceiver is useful for low-level diagnostics. I/O values can be monitored, I/O pack host/function names can be programmed, and error statuses can be checked. This requires a Windows®-based diagnostic tool on a laptop or a handheld computer.

An on-board temperature sensor provides continuous monitoring of the environment in remote locations.



- Dual 100 MB Ethernet ports
- 100 MB full duplex ports
- Online repair per I/O pack
- Operation -30°C to 65°C (-22 °F to 149 °F)
- Accuracy -30°C to 65°C (-22 °F to 149 °F)
- I/O packs rated Class 1, Div. 2
- Ambient temperature sensor
- LEDs: power status and attention
- LEDs: Ethernet link-connected and communication-active
- LEDs: application-specific
- Processor: 32-bit RISC CPU 266 mHz
- Infrared Transceiver: Low level diagnostics, monitor I/O, set host/function names, error status
- Power: 28 V dc (typical)
- Internal solid-state circuit breaker and soft start

The I/O Processor contains a temperature sensor that is accurate to within ±2°C (±3.6 °F). Detection of an excessive temperature generates a diagnostic alarm, and the logic is available in the database (signal space) to facilitate additional control action or unique process alarm messages. In addition, the temperature is continuously available in the database.

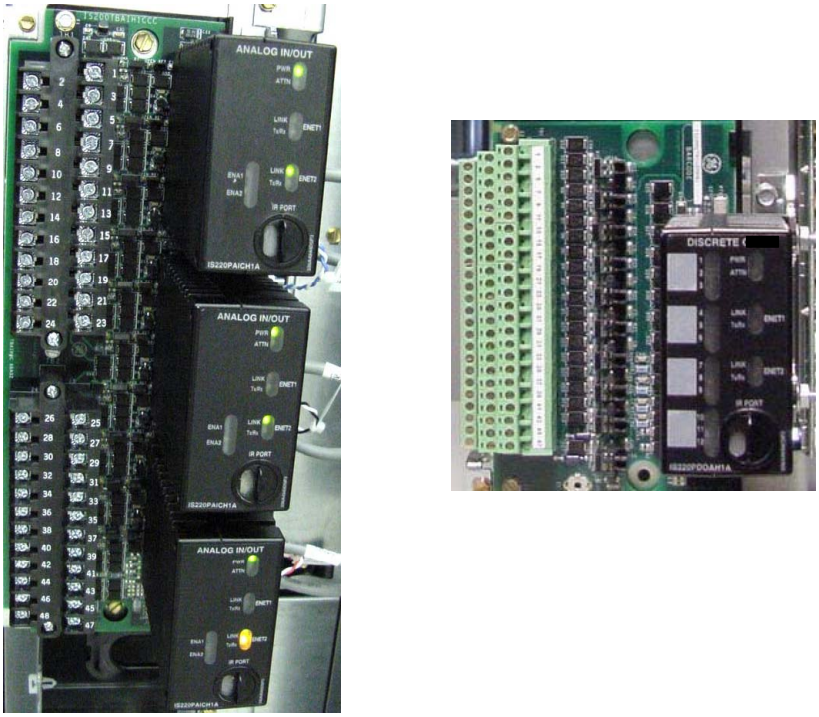
A power supply provides a regulated 28 V dc power feed to each I/O pack. The negative side of the 28 V dc is grounded through the I/O pack metal enclosure and its mounting base. The positive side has solid-state circuit protection built-into the I/O pack with a nominal 2 A trip point. Online repair is possible by removing the 28 V dc connector, replacing the I/O pack, reinserting the power connector, and downloading software from the software maintenance tools.

Note Every I/O pack communicates directly on IONet, which enables each I/O pack to be replaced individually without affecting any other I/O in the system. Also, the I/O pack can be replaced without disconnecting any field wiring.

Terminal Blocks

Signal flow begins with a sensor connected to a terminal block on a board. There are two types of boards available. T-type boards contain two 24 point, barrier-type, removable, terminal blocks. Each point can accept two 3.0 mm^2 (#12AWG) wires with 300 V insulation per point with spade or ring type lugs. In addition, *captive clamps* are provided for terminating bare wires. Screw spacing is 9.53 mm (0.375 inch) minimum, center-to-center.

A shield strip is provided next to each block, which is actually the left-hand side of the metal base where the board is mounted. Wide and narrow boards are arranged in vertical columns of high and low-level wiring that can be accessed from top and/or bottom cable entrances. An example of a wide board is a board that contains magnetic relays with fused circuits for solenoid drivers. T-type boards are normally surface mounted, but can also be DIN-rail mounted.



Barrier and Box Type Boards with I/O Packs

S-type boards have one I/O pack for simplex and dual redundant systems. They are half the size of T-type boards and are DIN-rail or surface mounted. Two versions of the boards are available, H1 and H3. H1 boards have fixed terminal blocks, and H3 boards have removable terminal blocks. A H2 version is available for mounting of custom blocks such as spring-cage or insulation displacement.

S-type boards have box type terminal blocks that accept one 3.0 mm^2 (#12AWG) wire or two 2.0 mm^2 (#14AWG) wires with 300 V insulation per point. Screw spacing is 5.08 mm (0.2 inch) minimum, center-to-center. A shield strip is provided to the left of each block. It can be connected to a metal base for immediate grounding or floated to allow individual ground wires from each board to be wired to a centralized, cabinet ground strip.

I/O Types

General purpose I/O is used for both turbine applications and process control. Turbine-specific I/O is used for direct interface to the unique sensors and actuators on turbines. This reduces or eliminates a substantial amount of interposing instrumentation. As a result, many potential single point failures are eliminated in the most critical area for improved running reliability and reduced long-term maintenance. Direct interface to the sensors and actuators also enables the diagnostics to directly interrogate the devices on the equipment for maximum effectiveness. This data is used to analyze device and system performance. Also, fewer spare parts are needed.

I/O Type - General Purpose	Board	Redundant Packs/Boards
24 DI (125 V dc, group isolated) 1 ms SOE	TBCIH1	1 or 2 or 3
24 DI (24 V dc, group isolated) 1 ms SOE	TBCIH2	1 or 2 or 3
24 DI (48 V dc, group isolated) 1 ms SOE	TBCIH3	1 or 2 or 3
24 DI (115/230 V ac, 125 V dc, point isolated) 1 ms SOE on 125 V dc	TBCIH1	1 or 2 or 3
24 DI (24 V dc, point isolated)	TBCIH2	1 or 2 or 3
24 DI (24 V dc, group isolated)	STCIH1	1
12 C mechanical relays w/6 solenoids, coil diagnostics (115/230 V ac, 24/125 V dc)	TRLYH1B	1 or 3
12 C mechanical relays w/6 solenoids, voltage diagnostics (115/230 V ac, 125 V dc)	TRLYH1C	1 or 3
12 C mechanical relays w/6 solenoids, voltage diagnostics (24 V dc)	TRLYH2C	
6 A mechanical relays for solenoids, solenoid impedance diagn. (24/125 V dc)	TRLYH1D	1 or 3
12 A solid-state relays/inputs (115/230 V ac)	TRLYH1E	1 or 3
12 A solid-state relays/inputs (125 V dc)	TRLYH2E	1 or 3
12 A solid-state relays/inputs (24 V dc)	TRLYH3E	1 or 3
36 mechanical relays, 12 voted form A outputs	TRLYH1F	3
12 fused branches	WPDFH1A	
36 mechanical relays, 12 voted form B outputs	TRLYH2F	3
12 fused branches	WPDFH2A	
10 AI (V/I inputs) and (2AO (4-20/0-200 mA outputs)	TBAIH1C	1 or 2 or 3
10 AI (V/I inputs) and (2AO (4-20/0-200 mA outputs)	STAIH1A	1 or 2 or 3
16 AO (4-20 mA outputs) 8 per I/O pack	TBAOH1C	1 or 2
8 AO (4-20 mA outputs)	STAOH1A	1
12 thermocouples	TBTCH1B	1 or 2 or 3
24 thermocouples (12 per I/O pack)	TBTCH1C	1 or 2
12 thermocouples	STTCH1A	1
16 RTDs 3 wires/RTD (8 per I/O pack)	TRTDH1C	1 or 2
8 RTDs 3 wires/RTD	SRTDH1A	1
6 serial ports for I/O drivers RS-232, RS422, RS485	SSCAH1A	1
10/2 analog I/O - HART communications	SHRAH1A	1
PROFIBus communications	SPIDH1A	1

I/O Type - Turbine	Board	Redundant Packs/Boards
Mixed I/O: 4 speed inputs/pack, synchronizing, shaft V/I monitor	TTURH1C	1 or 3
2 servo channels: up to 3 coils, 4 LVDTs/channel, includes excitation	TSVCH1A	1 or 3
8 vibration (seismic, proximity, accel.), 4 position, 1 reference probe, buffered out	TVBAH1A	1 or 2 or 3

Controller

Features

- Single board including:
  Main Processor
  Control Network Communications - Ethernet
  IO Network Communications – Ethernet
  USB and COM ports
- Processor: Freescale 8349, 667MHz
- Operating system: QNX
- Base mounting
- Status LEDs

Environment

- Operating temperature 0°C to +65 °C
- No fans required

Mark VIe Controller

The single-board controller is a compact and flexible design for processing and network communications.

The controller is a single board, which is base-mounted in the cabinet. For dual and triple redundant systems, a second and third board can be mounted adjacent for a compact packaging arrangement. An 8349, 667 MHz processor is provided with a QNX operating system. The board is powered by 18-36 V dc, 12 watt source.

This rugged design is rated for an operating range of 0 to 65°C (32 to 149 °F) to match the maximum operating temperature of the I/O modules. Also, it does not require any cooling fans even at maximum temperature, and is suitable for NFPA Class 1, Div. 2 applications.

Each controller has three 100 MB Ethernet drivers for the IONet, so that each controller can communicate with up to three network switches. In redundant systems, this allows each controller to monitor redundant inputs directly and compare them for any potential discrepancies. Connectors are color-coded and labeled to simplify maintenance.

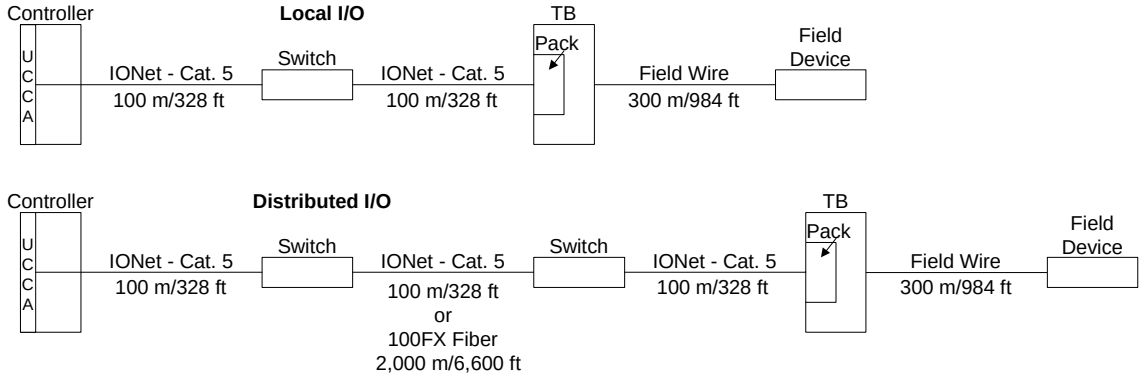
Controllers also have two Ethernet drivers for the control network to communicate peer-to-peer with other Mark VI, Mark VIe, and EX2100 generator excitation controls, as well as operator and maintenance stations. Controllers can be synchronized between units or to a local or remote time source for accurate plant-wide sequence of events monitoring.

I/ONet

Switches manage the communication traffic to eliminate collisions and increase network determinism

Communication between the controller and the I/O packs is performed with the internal IONet. This is a 100 MB Ethernet network available in non-redundant, dual redundant, and triple redundant configurations. Ethernet Global Data (EGD) and other protocols are used for communication. EGD is based on the UDP/IP standard (RFC 768). EGD packets are broadcast at the system frame rate from the controller to the I/O packs, which respond with input data.

IONet conforms to the IEEE 802.3 standard. It is supplied as 100BaseTx and 100BaseFx (fiber) for greater distances, noise rejection, lightning immunity, and ground immunity. A star topology is used with the controller on one end, a network switch in the middle, and I/O packs at the end.



Maximum IONet Distances Including Field Devices

Industrial grade switches are used for the IONet that meet the codes, standards, performance, and environmental criteria for industrial applications including an operating temperature of -40°C to 85°C (-40 °F to 185 °F) and Class 1, Div. 2. Switches have provision for redundant 10 to 30 V dc power sources (200/400 mA) and are mounted on a DIN-rail. LEDs indicate the status of the IONet link, speed, activity, and duplex.

	100BaseTx	**100BaseFx**
IEEE specification	802.3u	802.3u
Wire speed	100 Mbps	100 Mbps
Cable type	UTP Cat. 5	Fiber (multi-mode)
Connector type	RJ-45	SC
Maximum length of a segment at full-duplex	100 m/328 ft	2 km/6,600 ft
Maximum taps per segment	2	2
Maximum I/O packs per network	199	199
Maximum number of switches	2	2
Topology	Star	Star

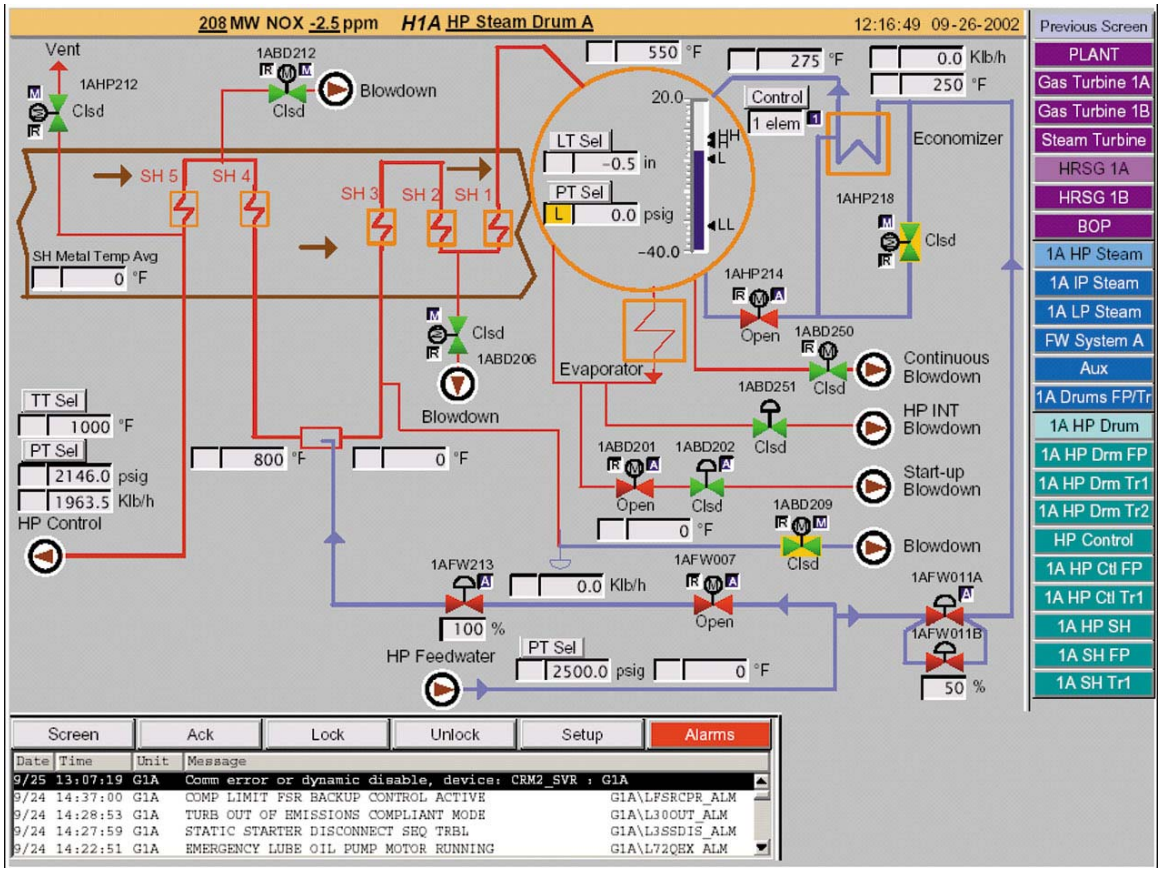
Operator Interface

The operator interface is commonly referred to as the Human-Machine Interface (HMI). It is a computer with a Microsoft® Windows-based operating system, client/server capability, a CIMPLICITY® graphics display system, and software maintenance tools (ToolboxST). It can be applied as:

- Primary operator station for one unit or the entire plant
- Maintenance station gateway
- Engineers station
- Gateway for communications

All local and remote data in the Mark VIe is accessible for screens with high-resolution time tags for alarms and events.

The HMI can be re-initialized or replaced with the process running with no impact on the control system. It communicates with the main processor board in the Mark VIe controller(s) through the control network Unit Data Highway (UDH) and to third-party control and monitoring systems through the information network Plant Data Highway (PDH).



Typical Operator Screen

System (process) alarms for fault conditions are time-tagged at frame rate in the controller(s) and transmitted to the HMI alarm management system. System events are time-tagged at frame rate, and sequence of events (SOE) for contact inputs are time-tagged at 1 ms in the I/O packs. Alarms can be sorted according to ID, Resource, Device, Time, and Priority. Operators can add comments to alarm messages or link specific alarm messages to supporting graphics.

A standard alarm/event log stores data for 30 days and can be sorted in chronological order or according to the frequency of occurrence. In addition, a trip history is provided that stores the key control parameters and alarms/events for the last 30 trips. This includes up to 200 alarms, 200 events, 200 SOE messages, and analog data before and after the trip.

Data is displayed in English or Metric engineering units with a one-second update rate and one second to repaint a typical display graphic. Operator commands can be issued to increment/decrement a setpoint, or a numerical value can be entered for a new setpoint.

Security for HMI users is important to restrict access to certain maintenance functions, such as editors and tuning capability, and to limit certain operations. A system called *User Accounts* is provided to limit access or use of particular HMI features.

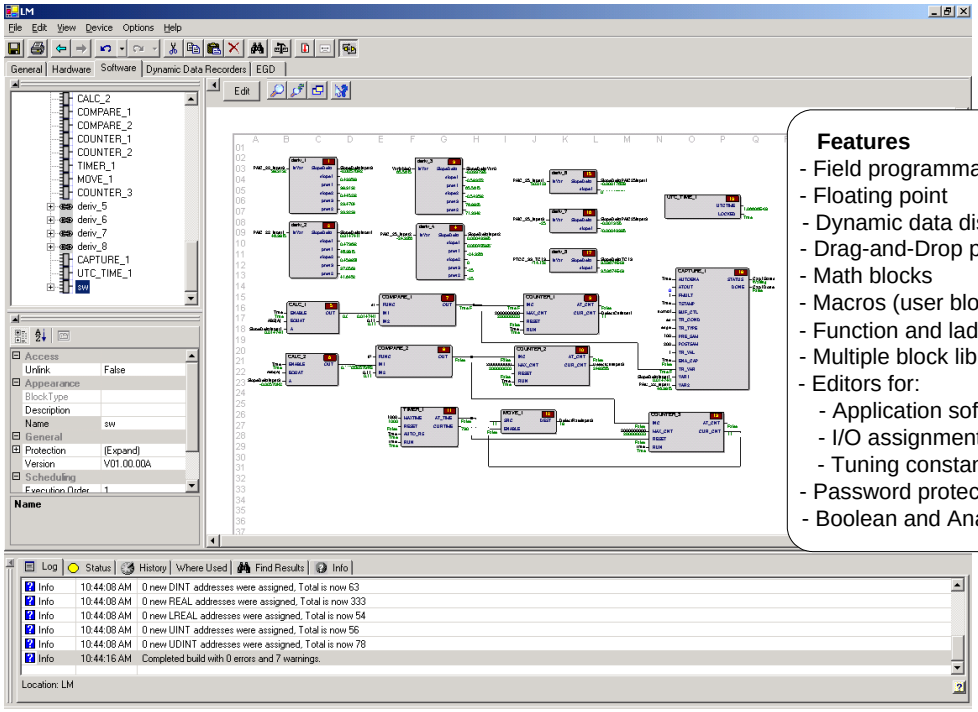
Software Maintenance Tools (ToolboxST)

The Mark VIe is a fully programmable control system. Application software is maintained by factory software automation tools that select proven GE control and protection algorithms and integrate them with the I/O, sequencing, and displays for each application. Multiple block libraries are provided with general-purpose blocks, math blocks, macros (user blocks), and application-specific blocks.

Changes to the application software can be made with multi-level password protection and downloaded to the controller(s) while the system is running without rebooting the main processors. In redundant control systems, the application software in each controller is identical, and is represented as a single program to maintenance personnel. Downloads of changes are automatically distributed to the redundant controllers by the control system, and any discrepancies between the controllers are monitored by diagnostics. All application software is stored in the controller(s) in non-volatile memory.

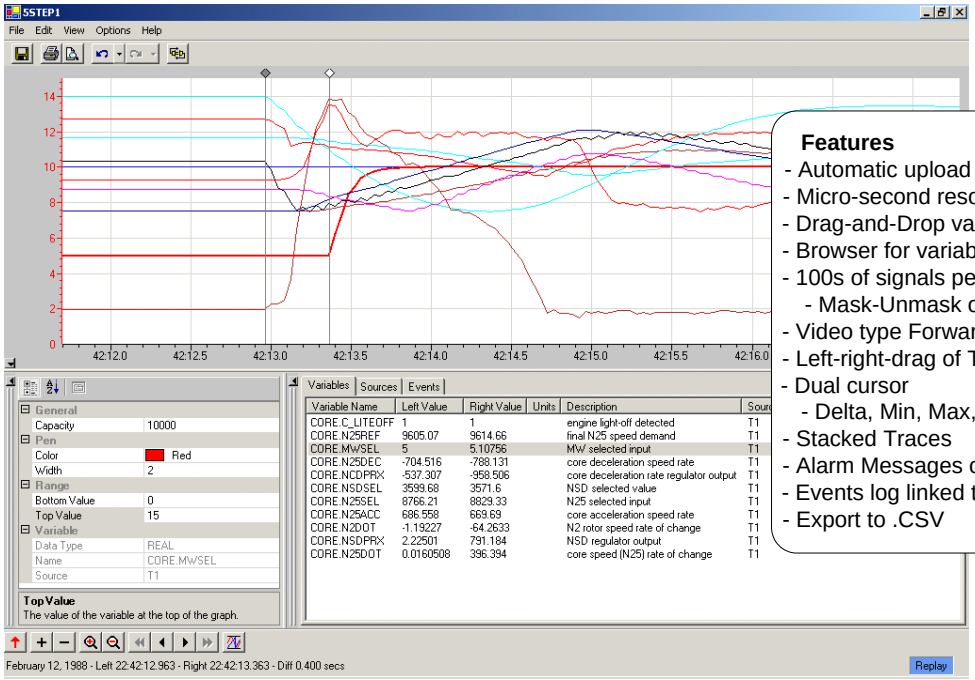
Application software is run sequentially, and dynamic data displays in function block and ladder diagram formats. Maintenance personnel can add, delete, or change analog loops, sequencing, I/O assignments, and tuning constants. To simplify editing, data points can be selected, dragged, and dropped on the screen from one block to another. Points can also be dragged from the application software diagrams onto trends. Other features include Boolean (digital) forcing, analog forcing, and trending at the rate the application software is running, frame rate.

Application software documentation is created directly from source code and can be compiled and printed at the site. This includes the application software diagram, I/O assignments, the settings of tuning constants, and such. The software maintenance tools are available for use in the HMI or as a separate software package on a Windows-based computer.



Features
- Field programmable
- Floating point
- Dynamic data display
- Drag-and-Drop points
- Math blocks
- Macros (user blocks)
- Function and ladder blocks
- Multiple block libraries
- Editors for:
  - Application software
  - I/O assignments
  - Tuning constants
- Password protection
- Boolean and Analog forcing

ToolboxST Editing Tools



Features
- Automatic upload of Capture Blocks
- Micro-second resolution
- Drag-and-Drop variables to Trender
- Browser for variables selection
- 100s of signals per Trend
  - Mask-Unmask of selected variables
- Video type Forward-reverse
- Left-right-drag of Time Axis
- Dual cursor
  - Delta, Min, Max, Average
- Stacked Traces
- Alarm Messages on Trip Trend
- Events log linked to Trend
- Export to .CSV

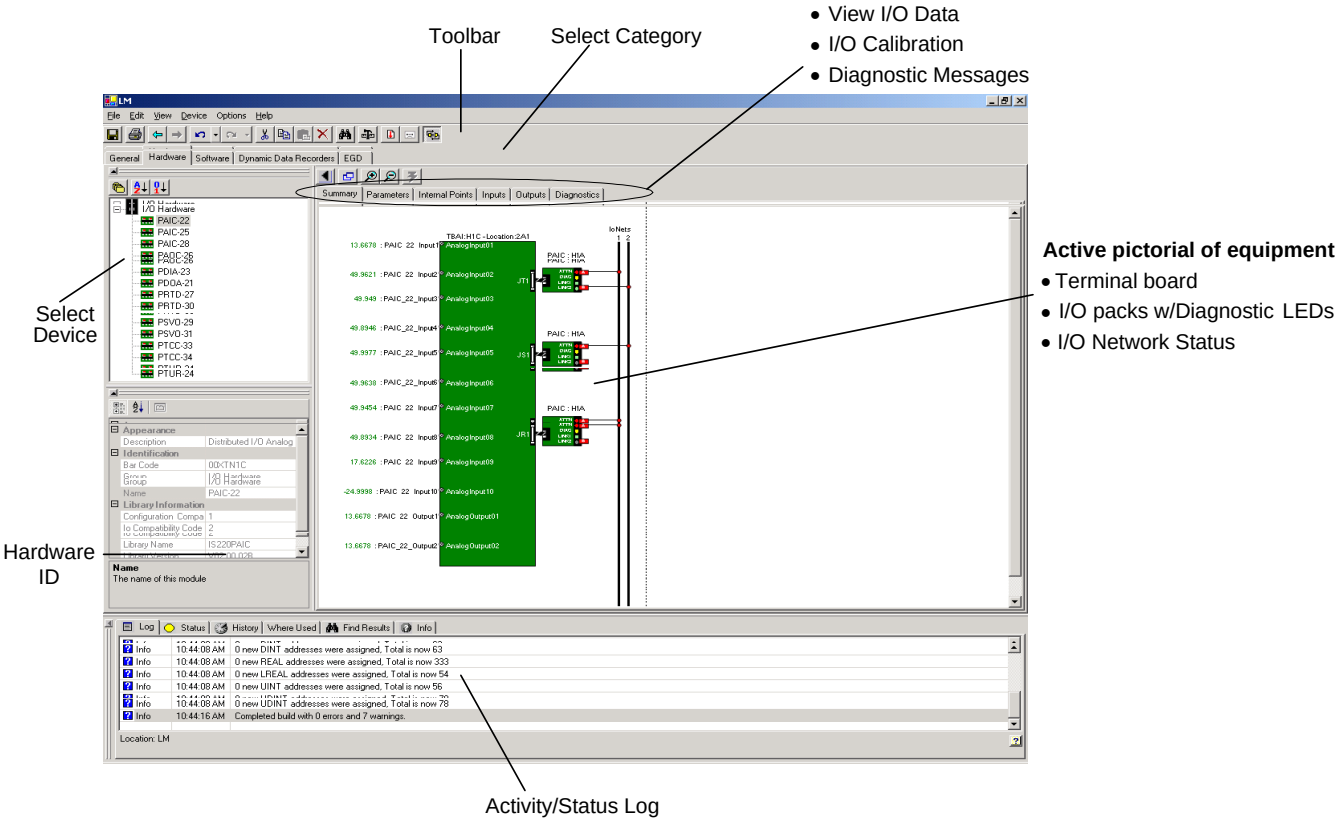
ToolboxST Trending Tools

Diagnostics

High/low (hardware) limit checking is provided for each analog input. These limits are not configurable, and are selected to be outside the normal operating range but inside the linear hardware operational range (before the hardware reaches saturation). Diagnostic messages for hardware limit checks and all other hardware diagnostics for the board can be accessed with the software maintenance tools. A composite diagnostic alarm state is provided in the database for each I/O pack, and a separate logic state is provided to indicate a high/low (hardware) limit fault of any analog input or the associated communications for that signal.

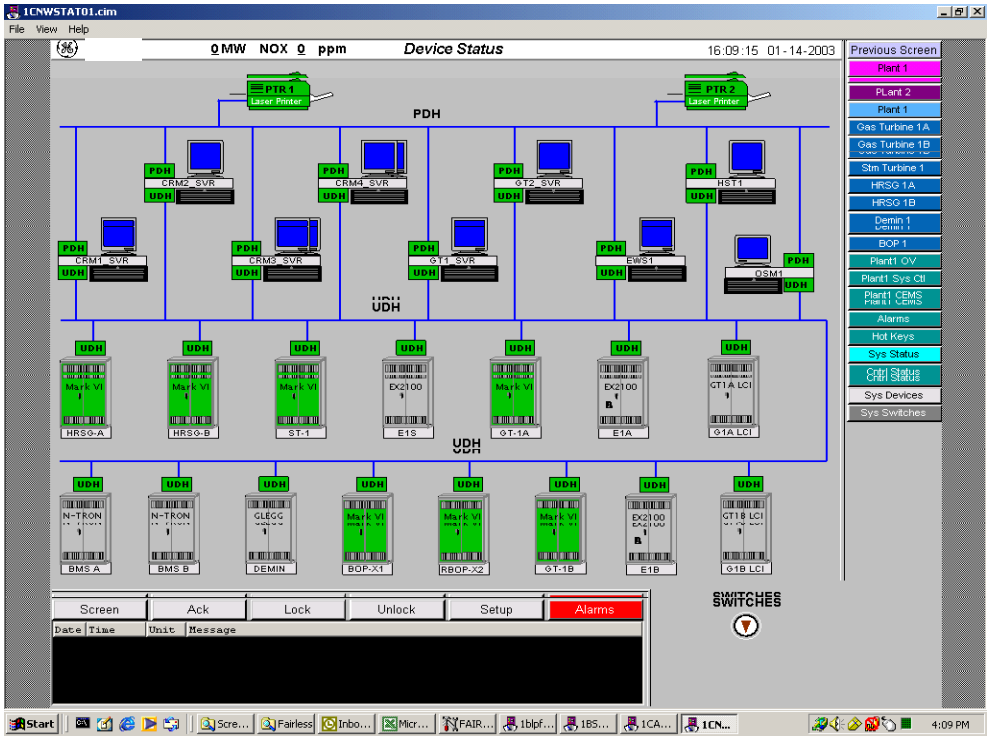
Diagnostic and system (process) alarms are time-stamped in the controller(s) and transmitted to operator and maintenance stations. Communication links to a plant-distributed control system (DCS) can contain both the software (system) diagnostics and composite hardware diagnostics.

Diagnostic LEDs are provided on I/O packs as previously shown for the Analog I/O pack. Standard LEDs indicate: power status, attention (abnormality detected), Ethernet link connected, and Ethernet link communicating. LEDs on discrete I/O packs also indicate the status of each point. All boards feature an electronic ID that contains the board name, revision, and a unique serial number. When power is applied to the I/O processor, it reads the ID of the terminal board, application board, and itself. It then uses this information for a start permissive, diagnostics, and system asset management. Since the terminal boards can be mounted remote at the equipment, local temperature sensors monitor the temperature at each I/O pack. Excessive temperature causes an alarm message. The alarm state and current temperature value are available for display and for use in the application software.



I/O Pack Diagnostics

Plant level control systems integrate the diagnostic data from the individual turbine and generator controls with the overall plant. This allows maintenance personnel to quickly identify the defective control node, switch, or station and locate the particular device needing service.



Plant Network Diagnostics

Network Diagnostics for:

- Operator Stations
- Maintenance Stations
- Engineers Stations
- Switches on:
  - Plant Data Highway
  - Unit Data Highway
  - IONet
- Control Nodes
  - Boards Within Nodes
  - I/O Packs

Codes and Standards

Safety Standards	EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements CAN/CSA 22.2 No. 1010.1-92 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements ANSI/ISA S82.02.01 1999 Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment – General Requirements
Printed wire board assemblies	UL 796 Printed Circuit Boards ANSI IPC Guidelines ANSI IPC/EIA Guidelines
Electromagnetic Compatibility (EMC) EMC Directive 89/336/EEC as amended by 92/31/EEC and 93/68/EEC	EN 55081-2 General Emission Standard EN 50082-2 Generic Immunity Industrial Environment EN 55011 Radiated and Conducted Emissions IEC 61000-4-2 Electrostatic Discharge Susceptibility IEC 61000-4-3 Radiated RF Immunity IEC 61000-4-4 Electrical Fast Transit Susceptibility IEC 61000-4-5 Surge Immunity IEC 61000-4-6 Conducted RF Immunity IEC61000-4-11 Voltage Variation, Dips and Interruptions ANSI/IEEE C37.90.1 Surge
Low-Voltage Directive 72/23/EEC	EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements
ATEX Directive 94/9/EC	EN 50021 Electrical Apparatus for Potentially Explosive Atmospheres

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