



SPEEDTRONIC™ Mark V

These instructions do not purport to cover all details or variations in equipment, nor to provide every possible contingency to be met during installation, operation, and maintenance. If further information is desired or if particular problems arise that are not covered sufficiently for the purchaser's purpose, the matter should be referred to GE Industrial Systems.

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Product Description

Introduction

The SPEEDTRONIC™ Mark V is a fully programmable turbine control system designed to meet the needs of today's power generation industry for the complex, dynamic behavior of gas and steam turbines. It is a flexible control system that delivers state-of-the-art control, monitoring, and protection.

The Mark V utilizes GE's extensive turbine control application and design experience with modern electronic hardware and software. This allows operators immediate access to all major control functions, extensive monitoring capabilities, and many built-in features that automatically protect the turbine-generator from a variety of abnormal operating conditions, such as overspeed, loss of oil, and overheating.

Features of Mark V include:

- software-implemented fault tolerance
- triple modular redundant (TMR) architecture
- online maintenance
- direct sensor interface
- built-in diagnostics
- common hardware platform for gas and steam applications

Control Modules

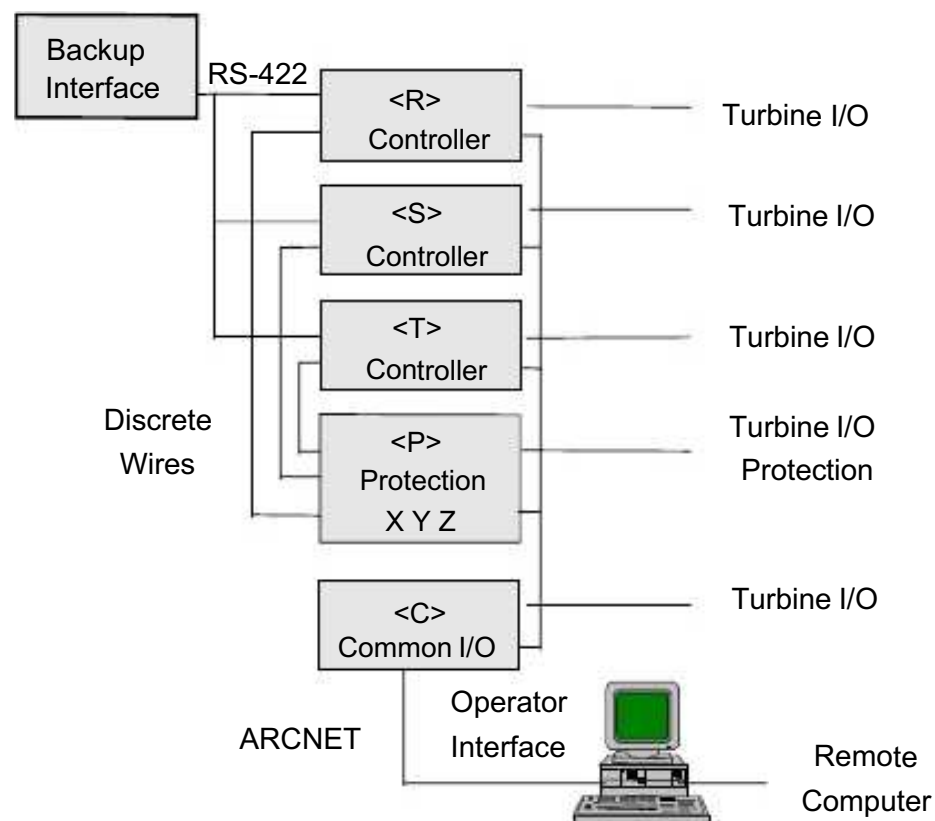
The extremely high system reliability achieved with the TMR control systems is due considerably to the use of triple sensors for all critical parameters.

The identical controllers, <R>, <S>, and <T>, in a Mark V TMR configuration perform all the critical control algorithms, protective functions, and sequencing. They also acquire the data needed to generate outputs to the turbine. Protective outputs are routed through the <P> module consisting of triple redundant processors X, Y, and Z, which also provide independent protection for certain critical functions such as overspeed.

All three controllers acquire data from triple-redundant sensors as well (as from dual or single sensors). The actual number of sensors will depend on the turbine type. All critical sensors for continuous controls, as well as protection, are triple-redundant.

The <C> controller is the interface for non-critical and non-trip I/O, and provides operator-maintenance interface through two ARCNET® ports. All operator commands and monitoring are performed from this interface, and all maintenance functions, including changing control constants, editing application software, changing I/O assignments and editing displays.

All of the microprocessor-based controllers have a modular design for ease of maintenance. Each module or controller contains up to five boards, including a power supply. Multiple microprocessors residing in each controller distribute the processing for maximum performance. Individual microprocessors are dedicated to specific I/O assignments and application software. The communication processing is performed in a real-time, multi-tasking operating system. The controller boards use ribbon cables and gas-tight connectors. Communication between individual controllers is performed on high-speed ARCNET links.



Mark V Control TMR Configuration

Protection Module

Three speed sensors are connected to sections X, Y, and Z for emergency overspeed protection. If desired, this replaces the traditional mechanical overspeed bolt.

The protection module, <P> provides a second level of protection for critical functions. It contains three sets of identical boards (X, Y, and Z) each with its own power supply and processor. These are used to provide separate relay drivers and relays for each of the <R>, <S>, and <T> controllers prior to interfacing with the hydraulic trip solenoids. The <P> module also provides flame detection and automatic synchronization functions.

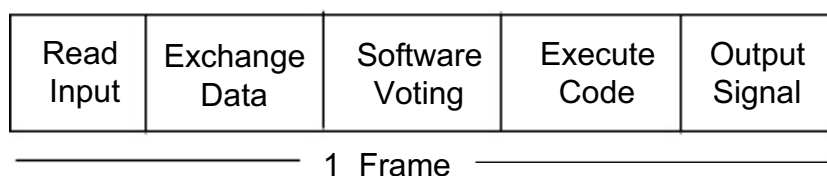
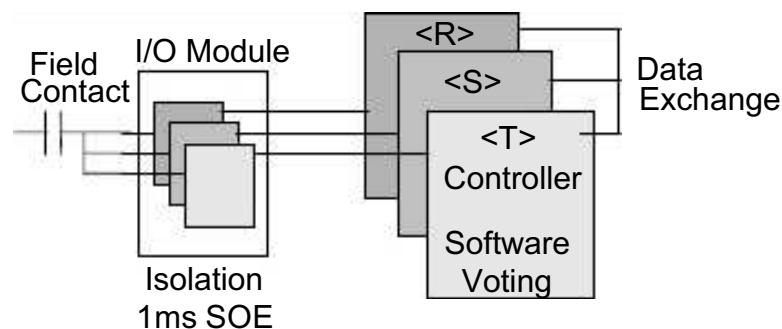
Software Voting

Software Implemented Fault Tolerant (SIFT) and hardware voting are used by the Mark V control system. At the beginning of each computing time frame, each controller independently reads its sensors and exchanges this data with the data from the other two controllers. The median values of each analog input is calculated in each controller and then used as the resultant control parameter for that controller. The diagnostic algorithm monitors a predefined deadband for all analog inputs to each controller. If one of the analog inputs deviates from this deadband, a diagnostic alarm is activated to alert maintenance personnel.

This technique eliminates any single point failure in the software voting system.

Contact inputs are voted in a similar manner. Each of the contact inputs is connected to a single terminal point and is parallel wired to three contact input boards. Each board optically isolates the 125 or 24 V dc input. A dedicated 80196 processor, located in each board, time stamps the input to within one millisecond resolution. These signals are then transmitted to the <R>, <S>, and <T> controllers for voting and execution of the application software. Redundant contact inputs for functions such as low lube oil pressure, are connected to three separate terminal points and then voted individually. The SIFT technique enables the control system to accept multiple failures of contact or analog inputs without causing an erroneous trip command from any of the three controllers as long as the failures are not from the same circuit.

Another form of voting is accomplished through hardware voting of analog outputs. Three coil servos on the valve actuators are separately driven from each controller, and three LVDTs provide the position feedback. The normal position of each valve is the average of the three commands from <R>, <S>, and <T>. The resultant averaging circuit has sufficient gain to override a gross failure of any controller, such as a controller output being driven to saturation. Diagnostics monitor the servo coil currents and the D/A converters in addition to the LVDTs.



Mark V TMR Control Sequence

Built-in Diagnostics

The Mark V has extensive built-in diagnostics, including power up, background and manually initiated diagnostic routines. These routines are capable of identifying both control panel, sensor, and output device faults. These faults are identified down to the board level for the panel, and to the circuit level for the sensor or actuator component. Online replacement of boards is possible with the Mark V triple redundant design and is also available for those sensors where physical access and system isolation are feasible.

Backup Interface

If the operator interface becomes unavailable, a small backup interface is provided on the Mark V cabinet door. It has a liquid crystal display (LCD) with two lines of 40 characters per line to display essential control parameters and alarms. The Mark V accepts operator commands from this backup interface.

Memory

Memory is located in the individual controllers and in the personal computer (PC) used by the operator interface. Controllers have electrically/erasable programmable read only memory (EPROM) for fixed memory, random access memory (RAM) for volatile memory, and electrically erasable programmable read-only memory (EEPROM) for permanent storage of up-to-date application software. Changes to sequencing, I/O assignments, gains, and such can be made from the operator interface and stored in the individual controller's EEPROM. All sequencing can be edited in ladder diagram format through the operator-maintenance interface. Changes to control constants such as gains and offsets can be made while the turbine is online by entering a security code.

The hard disk of the PC has a copy of all application software and display programming. Alarm messages can be added and changed. Text for existing displays can be changed or new displays can be created. The I/O tag names can be added or changed in standard 12-character lengths as well as descriptive 40-character fields. These changes are stored on the hard disk.

Application Software

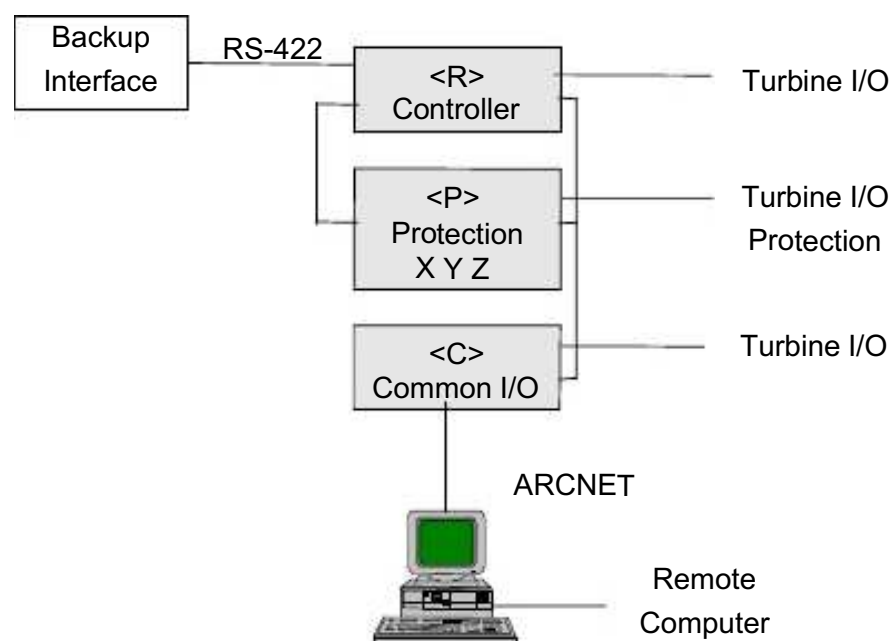
Application software is created from in-house software automation tools that select proven GE control and protection algorithms and integrate them with the I/O, sequencing, and displays for each application. Fixed-point data can be run at a frame of 62.5 ms (16 Hz). The frame rate is the elapsed time it takes to read control inputs, condition the inputs, execute the application software, and send output commands to the control valves.

Changes to the application software can be made with password protection and downloaded to the control module while the turbine is running. All application software is stored in the control module in nonvolatile EEPROM memory. Application software is executed sequentially and is represented in a ladder diagram format.

A library of software building blocks allows maintenance personnel to add or change analog loops and sequencing logic. Math blocks are also available. Application software documentation, including the primary elementary diagram, I/O assignments, and the settings of tuning constants is created directly from the source code and can be printed at the site.

Simplex Applications

Mark V Simplex control panels have only one controller, <R>, but still have three protective processors (<X>, <Y>, and <Z>) in the <P> protection module.



Mark V Simplex Control Configuration

Power Load Unbalance Module

The Power Load Unbalance (PLU) option is used on large steam turbines to protect the machine from overspeed under load rejection. It looks for an unbalance between mechanical and electrical power. This function initiates Control Valve (CV) and Intercept Valve (IV) fast closing actions under load rejection conditions where rapid acceleration could lead to an overspeed event. Valve actuation does not occur under stable fault conditions that are self-clearing (such as grid faults). The <PLU> module contains three sets of identical boards, the U, V, and W. Each has its own power supply and processor.

Hardware Inputs and Outputs

Directly monitoring these sensors eliminates the cost and potential reliability factors associated with interposing transducers and instrumentation.

The Mark V I/O is designed for direct interface with the following turbine and generator devices:

- magnetic speed pickups
- servos and LVDT/Rs
- vibration sensors
- thermocouples
- Resistive Temperature Devices (RTDs)

Contact Inputs: The Mark V uses the 125 V dc bus from the internal power distribution core to provide a fuse isolated and current limited interrogation voltage for the contact inputs. Other input voltages between 24 V dc and 125 V dc can be used, however, they may require a power source external to the Mark V. Jumpers on the terminal boards can be used to isolate field grounds by disconnecting the interrogation voltage from the contact inputs in groups of eight.

Every contact input is optically isolated and receives a time stamp within 1 ms of a status change. The Mark V printer can log each contact input status change with the time stamp, if that input is selected for sequence of events (SOE) logging. Diagnostic circuitry tests the internal electronics of each contact input every 1 ms and initiates an alarm if the circuitry fails.

Contact and Solenoid Outputs: The Mark V exclusively uses plug-in type magnetic relays for contact outputs (no solid state outputs). All contacts are form C; three wire; one normally open and one normally closed contact with a common center conductor. In a TMR system, the three controllers <R>, <S>, and <T> separately determine the contact output status and the *two out of three* voting takes place at the relay driver. If the three controllers do not agree, a diagnostic alarm is annunciated.

These internally powered outputs are also called solenoid outputs.

By selecting jumpers on the terminal boards, certain outputs can be internally powered by 125 V dc or 115 V ac. Elector-mechanical relay contacts are factory rated at:

Volts	Inductive	Resistive	Other
120 ac	2 A	3 A	10 A in-rush
220-240 ac	2 A	3 A	10 A in-rush
125 dc	0.2 A (no suppression)	0.5 A	0.5 A (with suppression)
28 dc	2 A	3 A	

Temperature Monitoring: The Mark V control can monitor grounded and ungrounded thermocouples and RTDs with linearization for various sensor types provided in software.

The Mark V supports the following types:

Thermocouple	RTD
E	10 Ω copper
J	100 Ω platinum
K	120 Ω nickel
T	200 Ω platinum

Analog Inputs and Outputs: Most of the analog inputs to the Mark V come directly from transducers on the turbine such as vibration or speed sensors however, 4-20 mA and 0-1 mA inputs are provided for other types of transducers. Each analog input can receive isolated 21 V dc excitation power for the transducer from the Mark V. Jumpers are provided for such selections as current or voltage input, burden resistor size, and grounding options.

Some inputs can be used as either voltage or current inputs by selection of a jumper. In *current input* mode, a burden resistor produces a voltage from the transducer current. This voltage is then internally parallel wired with ribbon cables to the <R>, <S>, and <T> controllers or just <R> in Simplex applications. Any discrepancy between the three controller inputs is annunciated as an internal diagnostic fault while the control and protection system continues to perform their normal calculations based on the median signal. Additional diagnostics monitor the inputs to insure that they are within their proper range.

Both 4-20 mA (500 Ω max burden) and 0-200 mA (40 Ω max burden) analog current outputs are available. These outputs can be independently configured from the Mark V operator interface, and are typically used for driving remote instrumentation for monitoring.

Pulse Rate Inputs: The most common application for the pulse rate inputs is monitoring the turbine shaft speed with magnetic speed sensors. These sensors fall into three categories:

- sensors which feed <R>, <S>, and <T> (or just <R> in Simplex application)
- TTL type inputs which feed <R>, <S>, and <T>
- sensors which feed <P>

Simplex can also have three speed sensors.

The Mark V can interface with the standard passive or the optional active speed sensors with an effective frequency range of 2 to 10,000 Hz. Circuit sensitivity allows detection of a two-rpm speed on a 60-tooth wheel to determine whether the turbine is stopped or on turning gear. Six magnetic speed sensors can be monitored by each of the <R>, <S>, and <T> controllers. One additional magnetic pickup is paralleled to all three controllers. A typical application has three speed sensors wired independently to each <R>, <S>, and <T> controller. The voting software then selects the median value for the governing speed parameter and the primary overspeed trip signal in the TMR systems.

Turbines which do not have a mechanical bolt for the backup emergency overspeed protection require a totally separate and independent set of electronics for emergency trip protection. This is provided by the three boards in the <P> module which has independent power supplies and processors. Each board can interface with two speed sensors, and the overspeed trip settings are adjustable.

These relays are energized during normal operation by 125 V dc from the power distribution core.

The PTRs and ETRs are located on a board specifically designed for a particular turbine application (gas, medium or large steam).

Each sensor terminates on one set of terminal board points and is then parallel wired through ribbon cables to each of the three control processors.

Master Trip Circuit: Turbine protection in the Mark V control system is performed by multiple cores within the control panel. There are two parts to the Master Trip Circuit: the inputs to the Mark V and the outputs from the Mark V. The *hardwired* or remote trip inputs to the Mark V (contact open to trip) connect to the 4's relay coils (known as the 4's for the ANSI standard device number). This circuit has redundant relay coils connected to the positive dc bus in series with the external trip contact inputs and another set of redundant relay coils connected to the negative bus. A failure of any one of the 4's relay coils will not accidentally trip the turbine because the resultant hardware contact will *out vote* the failed relay. Only de-energizing both relays connected to the same (positive or negative) dc bus will trip the turbine.

If an external trip signal is received, the 4's trip circuit will de-energize and the voting contacts circuit will de-energize the internal 24 V dc protective bus. The 24 V dc protective bus then supplies all the primary trip relays (PTRs), emergency trip relays (ETRs), and other relays, which interface with the turbine trip solenoids. These PTRs and ETRs comprise the output portion of the Master Trip Circuit. The microprocessors on these protection boards monitor the status of the *hardwired* or remote trip inputs, however, the actual tripping is independent of any processors.

Servo Valve Interface: The Mark V can control servo valves with up to three coils. In a typical TMR system, <R> is connected to one coil, <S> is connected to the second coil, and <T> is connected to the third coil of a three-coil servo valve. Bipolar current outputs are provided for 10, 20, 40, 80, and 120 mA ranges. The current of each servo valve output is the result of the comparison of a reference value and a feedback value by a digital control regulator defined for that output. The three currents through three coils wound around one steel laminated core produce one magnetic field. This magnetic field moves a valve that control the flow of high pressure oil to the actuator. This is a form of *hardware voting*, where the individual outputs of the redundant control processors are voted (summed) by the action of the servo valve's coils. This avoids a potential single point failure within the electronics from tripping the turbine. A failure of a controller, its output port, or the physical connection to the output coil will result in the other two servo drivers compensating for the failed channel and keeping the valve properly positioned.

LVDT or LVDR position feedback, flow-rate feedback and pressure feedback are the different types of feedback signals that are used by the control regulators. The Mark V control provides the excitation signals for the LVDTs and monitors their feedback.

Vibration Measurement and Protection: Three different types of vibration sensors can be directly connected to the Mark V: seismic (velocity) inputs, accelerometer inputs, and proximity transducer inputs. In TMR systems, a discrepancy between the three control processors inputs is alarmed as an internal diagnostic fault message while the vibration protection system continues to perform its normal calculations based on the median vibration signal.

Proximity transducers include vibration, position, and key phasor inputs. The 1X and unfiltered vibration levels and the 1X vibration phase angle are displayed on the operator interface's monitor. An optional module is available with buffered, BNC type of connectors for remote monitoring with Bentley Nevada's vibration analysis equipment.

The Mark V system has powerful features for customizing control strategy for each site. For example, one operator interface can interface to multiple systems or more than one operator interface can communicate to a single Mark V. A hierarchy of control can be programmed on-site when multiple operator interfaces are used. Communication links to a Distributed Control System (DCS) or remote computers are available. These links include a Modbus™ link or an Ethernet™ TCP/IP link using GE Standard Messages as the application protocol.

Flame Detection: Ultraviolet (UV) flame detectors monitor flame in the combustion chamber by detecting UV radiation emitted by the flame. The flame detection takes place in the <P> protection module utilizing the three independent, identical processors. The flame intensity information is then sent to the control processors <R>, <S> and <T> so that an operator can determine if carbon buildup or other contaminants on the scanner window are causing reduced light detection. The Mark V provides the 335 V dc excitation for the detectors; thus avoiding the need for interposing transducers and separate 335 V excitation supplies.

Synchronization Interface: Automatic synchronization is available by way of single-phase PT inputs from the generator and line. The control matches the turbine speed to the line frequency and the generator and line voltages. Three Mark V internal functions must be satisfied before a breaker close command is issued:

- synchronize permissive or complete sequence from <R>, <S>, and <T> (25P)
- sync check from <R>, <S> and <T> (25X)
- automatic synchronization signal from <X>, <Y>, and <Z> in <P> (25)

A normally open contact on the breaker (not an auxiliary relay) is monitored to measure the actual time it takes to close the breaker. This time is used for self-adaptive adjustments of the breaker closure anticipation time constant and diagnostics. A maximum of two breakers can be controlled.

Shaft Voltage and Current Monitor: Can accept voltage inputs from shaft voltage and current circuits that monitor ac/dc voltages and currents, which might be present or develop on the turbine and/or generator shaft(s). The control can continuously monitor the shaft-to-ground voltage/current and alarm excessive levels. Test circuits check the alarm functions and the continuity of wiring to the brush assembly mounted between the turbine and the generator.

Operator-Maintenance Interface

The operator interface is a technician's interface to the Mark V control with which it communicates.

The Mark V system's primary operator interface consists of an IBM-compatible PC, color monitor, keyboard, cursor positioning device (either touch screen and/or trackball or mouse) and a printer. The operator interface is used to issue commands to start/stop the unit, load/unload the unit, manage and log alarms, and monitor unit operation. With the exception of the Plant Load Control option, no control or protection of the unit is accomplished by the operator interface.

The operator interfaces are connected to a Mark V panel(s) with coaxial cable using ARCNET Local Area Network (LAN) communication. This connection between the operator interfaces and Mark V control panel(s) is called the Stage Link. In some cases, the Stage Link may include fiber optic cables and repeaters in order to accommodate long distances between the operator interface computers and the turbine control panel.

The operator interface can also be used to configure or modify the control, protection, monitoring, and logging functions of the Mark V using programs supplied on the interface computer. The ability to modify or configure these functions is password protected. Options available for the interface include monitor sizes, color printers, laser printers and audible alarm horn.

Time Synchronization

Typical sources of a GTS are global-positioning satellite (GPS) receivers or other time-processing hardware.

Time synchronization allows synchronization of all Mark V control panels on the Stagelink with a global time source (GTS), such as an IRIG-B time code signal or periodic pulse inputs with limited loss of accuracy. This permits setting the time clocks of all computers with operator interfaces in conjunction with the GTS. The remainder of plant equipment, including the DCSs, should be synchronized with this common GTS.

Multi-Unit Control and Monitoring

The Mark V system has powerful features for customizing control strategy to each site. One or more operator interfaces can control and monitor up to eight turbines. It is possible to program a hierarchy of control by using multiple operator interfaces.

Log Functions

Log functions include:

Up to 63 turbine parameters can be logged.

Alarms are logged as they occur and as they clear with a 62ms resolution.

Events (turbine operation) such as engaging the turning gear or closing the generator breaker are logged on the printer, with an individual time tag resolution of 62 ms. Events are user definable and can be edited in the field.

Events (contact inputs) are logged on the printer with individual time tags of 1ms. All contact inputs to the Mark V are included in the event log. In the field, logging can be turned on or off and individual contact inputs can be deleted from the event log.

The trip log contains up to 60 alarms captured at the time of the trip.

Trip log provides a record for the turbine trip analysis. Up to 63 parameters can be included in each sample, with 38 pre-trip samples spanning 5 hours and 3 post-trip samples spanning 3 seconds. This information is available on the display or can be printed. The freeze on the trip log is released when the unit is restarted, and samples begin to overwrite the memory locations in the log.

Enclosures and Packaging

The standard turbine control enclosure is a NEMA-1, convection-cooled cabinet with front access and top or bottom cable entrances. Panel material consists of hot-rolled, low carbon, 12-gauge steel (.105 in) with one exception, the access plates use thicker gauge (.187 in) steel. The paint build thickness for E-coat and powder painted parts is approximately 1.5 mils. The color of the exterior and interior is ANSI-70 (light) gray. It is rated for continuous operation in a 0° – 45°C ambient and operation up to 50°C during maintenance periods.

Note GE recommends locating this microprocessor-based product in an air-conditioned environment. Other types of enclosures are available with built-in cooling and purification systems as required by specific applications.

Printed circuit boards and terminal boards in a Mark V control panel are contained in, or are mounted on cores. Cores are sheet metal housings that can have stationary and moveable printed circuit board holders called board carriers. The cores have a maximum of five printed circuit boards mounted on the carriers. As many as four I/O terminal boards can also be mounted on a single core. Terminal boards are high-density compression-type terminals.

Panel Specifications

Panel Type	Simplex	TMR	Large Steam TMR
Weight	800 lbs (362.9 kg)	1000 lbs (453.6 kg)	2000 lbs (907.2 kg)
Heat Dissipation	500 W	700 W	1000 W
Dimensions	36 in x 20 in x 90 in (914 mm x 508 mm x 2286 mm)	54 in x 20 in x 90 in (1372 mm x 508 mm x 2286 mm)	108 in x 20 in x 90 in (2744 mm x 508mm x 2286 mm)

Environmental Requirements

Environmental requirements during operation:

Ambient temperature	0 to 45 °C
Relative humidity	5 to 95% non-condensing
Seismic capability	Designed to Universal Building Code (UBC- Seismic Code section 2312 Zone 4)
Vibration	1.0 G horizontal, 0.5 G vertical at 15 to 120 Hz
Surge	Designed to ANSI C37.90.1
Radio interference	Operation of a 5 W radio transmitter at 27 MHz, 150 MHz, and 480 MHz will not disrupt operation. Note: Panel doors must be closed.
Altitude	2000 m maximum

Power Requirements

Diagnostics monitor each voltage source and each feeder, including the fuses in each solenoid circuit on the relay terminal board.

Mark V panel can accept power from multiple power sources. Each power input source (dc and two ac sources) should be fed through its own external 30 A 2 pole thermal magnetic circuit breaker before entering the Mark V panel. Power sources can be any combination of a 125 V dc source and/or up to two 120/240 V ac sources. Each core within the panel has its own power supply board all of which operate from a common 125 V dc panel distribution bus.

Power Source Requirements

Voltage	Frequency	Current Draw
		(measured at nominal voltage)
Nominal (Tolerance range)	Nominal (Tolerance range)	Typical
125 V dc (100 to 144 V dc) (Note 5)	N/A	7.0 A dc (Note 1)
120 V ac (108 to 132 V ac) (Note 6)	60 Hz (47 to 63 Hz)	7.0 A RMS (Notes 2 and 4)
240 V ac (216 to 254 V ac) (Note 6)	50 Hz (47 to 63 Hz)	3.5 A RMS (Notes 3 and 4)

- 1 - Add 0.5 A dc continuous for each dc solenoid powered
- 2 - Add 6.0 A RMS for a continuously powered ignition transformer (2 maximum)
- 3 - Add 3.5 A RMS for a continuously powered ignition transformer (2 maximum)
- 4 - Add 0.5 A RMS continuous for each ac solenoid powered (inrush 3.0 A)
- 5 - Ripple not to exceed 10 V peak-to-peak
- 6 - Total Harmonic Distortion not to exceed 7.0%

Codes and Standards

Mark V General Standards

Standard	Description
Safety Standards	UL 508A Safety Standard, Industrial Control Equipment CSA 22.2 No. 14, Industrial Control Equipment
Printed wire board assemblies	UL 796 Printed Circuit Boards UL-Recognized PWB Manufacturer, UL file no. E110691 ANSI IPC Guidelines ANSI IPC/EIA Guidelines
Electromagnetic Compatibility (EMC) Directive 89/336/EEC	EN6100-4-2, Electrostatic Discharge Susceptibility ENV 5014:1993, Radiated RF Immunity EN 50082-2:1994, Generic Immunity Industrial Environment EN 6100-4-4, Electrical Fast Transient Susceptibility EN 6100-4-5, Surge Immunity EN 50141, Conducted RF Immunity EN 50081-2, Generic Emissions Standards EN 55011:1991, ISM Equipment Emissions (CISPR-11)
Low-Voltage Directive 72/23/EEC	EN 61010, Safety of Electrical Equipment, Industrial Machines IEC 529, Intrusion Protection Codes/NEMA-1/IP/20
Machinery Directive 89/392/EEC	EN 60204-1, Electrical Equipment for Machines EN 292-1, Basic Terminology, Methodology EN 954-1, General Design Principles PrEN 50100-1, ESPD General Requirements

ISO Certifications

Standard	Description
ISO 9001	In accordance with Tick IT by Quality Management Institute (QMI)
ISO 9000-3	Software certified to Quality Management and Quality Assurance Standards, Part 3: Guidelines for the Application of ISO 9001 to Development Supply and Maintenance of Software

Documentation

Documentation for the Mark V turbine control system consists of unit-specific drawings and general documents. A unique set of requisition-specific documentation is supplied with each control system. Instruction books are available for the specific needs of each customer.

Unit-Specific Drawings

Each Mark V control system includes the following unit-specific documents:

- **I/O Report** contains the unit-specific assignment of I/O terminations in the Mark V control panel. This report also has I/O related information such as the signal names.
- **Control Sequence Program Printout** is a unit-specific printout that shows a functional representation the Big Blocks and sequencing of a particular requisition. Software on the operator interface allows editing and printing of this document from any location.
- **Outline Drawings** provide an external view of the control panel and primary operator interface. The drawings furnish information needed for handling and installing the equipment.
- **Case Layout Drawing** supplies an internal view of the control panel. The primary purpose of this drawing is to furnish information needed to route interconnect cables.
- **Case Wiring Drawing** defines the factory cabling internal to the control panel case. The drawing's primary purpose is to document the internal wiring for maintenance use.
- **Core Drawings** provide an isometric drawing of the core depicting the boards and their respective locations within the core. For each board, the physical location and identification of removable parts, such as connectors and hardware jumpers, are highlighted. The core drawing is placed in a pocket on the inside of the core door.

Related Publications

The following instructional books are available:

- GEH-5979, *Mark V User's Manual* (operator)
- GEH-5980, *Mark V Maintenance Manual* (maintenance technician)
- GEH-6195, *Mark V Application Manual* (application engineer)
- GEH-6370, *Mark V Time Synchronization*
- GEI-100165, *GEDS Standard Message Format* (GSM)

Mark V I/O Capacity

I/O Type	Minimum	Optional	Comments
Contact inputs	96	96	96 paralleled to <R><S><T> and 96 to <C>
		96	Paralleled to <R><S><T> (TMR only) 125 / 24 V dc, optical isolation
Contact outputs	60	60	60 from <R><S><T> and 60 from <C>
		60	From <R><S><T> (TMR only) Magnetic relays, dry contacts, form C
		16	Fast acting solenoids from <PLU>
Pulse rate inputs	19	4	Magnetic pickups: 6 to each of <R><S><T>, 5 par
	4		TTL
	6		Magnetic pickups: 2 to each of X Y Z in <P>
LVDT/R position inputs	16	8	7 V rms, 3 kHz 70 mA
Servo value inputs	4		±10, 20, 40 mA
	4		±10, 20, 40, 80, 120, 240 mA
		4	±10 mA
Vibration - seismic	12		Paralleled to <R><S><T>
		3	Paralleled to <R><S><T>
Proximitors - vibration		28	18 paralleled to <R><S><T>, 10 par to <U>, <V>, <W>
		19	10 paralleled to <R><S><T>, 9 par to <U>, <V>, <W>
		3	2 paralleled to <R><S><T>, 1 par to <U>, <V>, <W>
Thermocouple inputs	87		15 to each of <R><S><T> and 42 to <C>
		15	15 paralleled to <R><S><T>
RTD inputs	30	14	To <C>
4 – 20 mA inputs	29	14	15 paralleled to <R><S><T> and others to <C>
		15	15 paralleled to <R><S><T>
4 – 20 / 0-1 mA inputs	1	8	1 paralleled to <R><S><T> and 8 to <C>
4 – 20 mA outputs	16	4	16 from <C>, 4 from <R><S><T>
4 – 20 mA / 0-200 mA outputs	2	2	Valve positioners from <R><S><T>
±10 V dc inputs	8		2 to each of <R><S><T>, 2 paralleled to <R><S><T>
±10 V dc or 4-20 mA inputs		2	2 paralleled to <R><S><T>
0 – 5 V dc inputs	6		2 to each of <R><S><T>
Flame scanners	8		Paralleled to X Y Z in <P> w/ 335 V dc supply
Shaft voltage and current	1		To <C>
PT inputs		6	120 V ac open delta
CT inputs		3	5 A ac



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