SPEEDTRONIC™ Mark VI Turbine Control

Section Page

Introduction

With Mark VI, you receive the benefits of GE's unmatched experience with an advanced turbine control platform.

The SPEEDTRONIC™ Mark VI turbine control system is the current state-of-the-art control for GE turbines with a heritage of over 30 years of successful operation of electronic turbine control systems. It is designed as a complete integrated control, protection, and monitoring system for generator and mechanical drive applications of gas turbines and steam turbines. It is also an ideal platform for integrating all power island and balance of plant controls. Hardware and software are designed with close coordination between GE's turbine design engineering and controls engineering to insure that your control system provides the optimum turbine performance and you receive a true system solution.

Architecture

The heart of the control system is the control module, which is available in either a 13 or 21 slot standard VME board rack. Inputs are received by the control module through terminal boards with either barrier or box type terminal blocks and passive signal conditioning.

Each I/O board contains a TMS320C32 DSP processor to digitally filter the data before conversion to 32-bit IEEE-854 floating point format. The data is then placed in dual port memory, which is accessible by the on-board C32 DSP on one side and the VME bus on the other side.

In addition to the I/O boards, the control module contains an "internal" communication board, a main processor board, and sometimes a flash disk board. Each board takes one slot except for the main processor that takes two slots. Boards are manufactured with surface mounted technology and conformal coated per IPC-CC-830.

I/O data is transmitted on the VME backplane between the I/O boards and the VCMI board located in slot 1. The VCMI is used for "internal" communications between:

- I/O boards that are contained within its board rack
- I/O boards that may be contained in expansion I/O racks, called interface modules
- I/O in backup <P> protection modules
- I/O in other control modules used in triple redundant control configurations
- The main processor board

The main processor board executes the bulk of the application software at 10, 20, or 40ms depending on the requirements of the application. Since most applications require that specific parts of the control run at faster rates (servo loops, pyrometers) the distributed processor system between the main processor and the dedicated I/O processors is very important for optimum system performance. A QNX® operating system is used for real-time applications with multitasking, priority-driven preemptive scheduling, and fast context switching.

Communication of data between the control module and other modules within the Mark VI control system is performed on IONet. The VCMI board in the control module is the IONet busmaster communicating on an Ethernet® 10Base2 network to slave stations. A unique poling type protocol Asynchronous Drives Language (ADL) is used to make the IONet more deterministic than traditional Ethernet LANs.

The control module is used for control, protection, and monitoring functions, but some applications require backup protection. For example, backup emergency overspeed protection is always provided for turbines that do not have a mechanical overspeed bolt, and backup synch check protection is commonly provided for generator drives. In these applications, the IONet is extended to a backup protection module that is available in Simplex and triple redundant forms. The triple redundant version contains three independent sections (power supply, processor, I/O) that can be replaced while the turbine is running. IONet is used to access diagnostic data or for cross-tripping between the control module and the protection module, but it is not required for tripping.

Triple Modular Redundancy

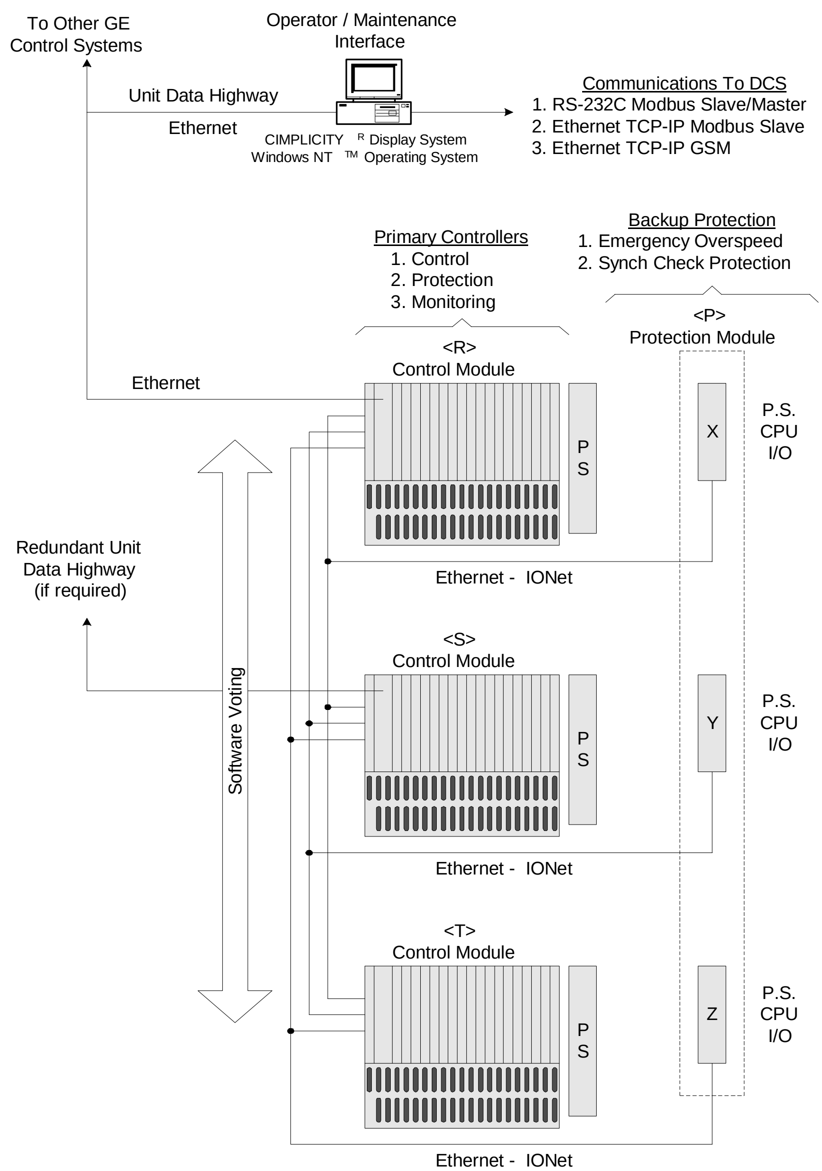
TMR interface has three completely separate and independent control modules, power supplies, and IONets.

Mark VI control systems are available in Simplex and Triple Modular Redundant (TMR) for small applications and large integrated systems with control ranging from a single module to many distributed modules. System throughput enables operation of up to nine, 21 slot VME racks of I/O boards at 40 ms including voting the data. Inputs are voted in software in a scheme called Software Implemented Fault Tolerance (SIFT). The VCMI board in each control module receives inputs from the control module back-plane and other modules through its own IONet.

Data from the VCMI boards in each of the three control modules is then exchanged and voted prior to transmitting the data to the main processor boards for execution of the application software. Output voting is extended to the turbine with three coil servos for control valves and 2 out of 3 relays for critical outputs such as hydraulic trip solenoids. Other forms of output voting are available including a median select of 4-20 mA outputs for process control and 0-200 mA outputs for positioners.

Sensor interface for TMR controls can be either single, dual, triple redundant, or combinations of redundancy levels. The TMR architecture supports riding through a single point failure in the electronics and repair of the defective board or module while the process is running. Adding sensor redundancy increases the fault tolerance of the overall system. Another TMR feature is the ability to distinguish between field sensor faults and internal electronics faults. Diagnostics continuously monitor the three sets of input electronics and alarm any discrepancies between them as an internal fault versus a sensor fault. In addition, all three main processors continue to execute the correct voted input data.

Note The diagram on the following page illustrates a typical Mark VI TMR configuration. A simplex configuration would not have the <S> and <T> control modules. The simplex <R> control module is also available in a dual redundant power supply configuration.



Mark VI TMR Control Configuration

I/O Interface

There are two types of terminal boards. One type has two 24 point, barrier type terminal blocks that can be unplugged for field maintenance These are available for Simplex and TMR controls. They can accept two 3.0 mm^2 (#12 AWG) wires with 300 V insulation. Another type of board used on Simplex controls is mounted on a DIN rail and has one, fixed, box type terminal block. It can accept one 3.0 mm^2 (#12 AWG) wire or two 2.0 mm^2 (#14 AWG) wires with 300 V insulation.

I/O devices on the equipment can be mounted up to 300 meters (984 feet) from the boards, and the boards must be within 15m (49.2 feet) from their corresponding I/O boards. Normally, the boards are mounted in vertical columns in terminal cabinets with pre-assigned cable lengths and routing to minimize exposure to emi-rfi for noise sensitive signals such as speed inputs and servo loops.

General Purpose I/O

Refer to the following tables for more information.

Discrete I/O is provided by a VCRC board with 48 digital inputs and 24 digital outputs. The I/O is divided between two terminal boards for the contact inputs and another two for the relay outputs.

Analog I/O is provided by a VAIC board with 20 analog inputs and four analog outputs. The I/O is divided between two boards. A VAOC is dedicated to 16 analog outputs and interfaces with one barrier type board or two box type boards.

Temperature Monitoring is provided by a VTCC board with interface to 24 thermocouples, and a VRTD board provides interface for 16 RTDs. The input boards interface with one barrier type board or two box type boards. Capacity for monitoring nine additional thermocouples is provided in the backup protection module.

Discrete I/O

Board	Type	I/O	Characteristics
TBCI	Barrier	24 CI	70-145 V dc, optical isolation, 1ms SOE 2.5 mA/point except last 3 input are 10 mA / point
DTCI	Box	24 CI	18-32 V dc, optical isolation, 1ms SOE 2.5 mA/point except last 3 input are 10 mA/point
TICI	Barrier	24 CI	70-145 V dc, 200-250 V dc, 90-132Vrms, 190-264 Vrms (47-63Hz), optical isolation 1ms SOE, 3 mA / point
TRLY	Barrier	12 CO	Plug-in, magnetic relays, dry, form “C” contacts 6 circuits with fused 3.2A, suppressed solenoid outputs Form H1B: diagnostics for coil current Form H1C: diagnostics for contact voltage Form H1D: 6 solenoid driver circuits only, with solenoid integrity monitoring Voltage / Resistive / Inductive 24 V dc / 3.0A / 3.0 A L/R = 7 ms, no suppression; 3.0 A L/R = 100 ms, with suppression 125 V dc / 0.6A / 0.2 A L/R = 7 ms, no suppression; 0.6 A L/R = 100 ms, with suppression 120/240 V ac / 6/3A / 2.0 A pf = 0.4
DRLY	Box	12 CO	Same as TRLY, but no solenoid circuits

Analog I/O

Board	Type	I/O	Characteristics
TBAI	Barrier	10 AI 2 AO	(8) 4-20 mA (250 Ω) or ±5,10 V dc inputs (2) 4-20 mA (250 Ω) or ±1 mA (500 Ω) inputs Current limited +24 V dc provided per input (2) +24 V, 0.2A current limited power sources (1) 4-20 mA output (500 Ω) (1) 4-20 mA (500 Ω) or 0-200 mA (50 Ω) output
TBAO	Barrier	16 AO	(16) 4-20 mA outputs (500 Ω)
DTAI	Box	10 AI 2 AO	(8) 4-20 mA (250 Ω) or ±5,10 V dc inputs (2) 4-20 mA (250 Ω) or ±1 mA (500 Ω) inputs Current limited +24 V dc available per input (1) 4-20 mA output (500 Ω) (1) 4-20 mA (500 Ω) or 0-200 mA (50 Ω) output
DTAO	Box	8 AO	(8) 4-20 mA outputs (500 Ω)

Temperature Monitoring

Board	Type	I/O	Characteristics
TBTC	Barrier	24 TC	Types: E, J, K, T, grounded or ungrounded H1A fanned (paralleled) inputs, H1B dedicated inputs
DTTC	Box	12 TC	Types: E, J, K, T, grounded or ungrounded
TRTD	Barrier	16 RTD	3 points/RTD, grounded or ungrounded 10 Ω copper, 100/200 Ω platinum, 120 Ω nick H1A fanned (paralleled) inputs, H1B dedicated inputs
DTAI	Box	8 RTD	RTDs, 3 points/RTD, grounded or ungrounded 10 Ω copper, 100/200 Ω platinum, 120 Ω nick

Application Specific I/O

In addition to general purpose I/O, the Mark VI has a large variety of boards that are designed for direct interface to unique sensors and actuators. This reduces or eliminates a substantial amount of interposing instrumentation in many applications. 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. A subtle benefit of this design is that spare parts inventories are reduced by eliminating peripheral instrumentation. The VTUR board is designed to integrate several of the unique sensor interfaces used in turbine control systems on a single board. In some applications, it works in conjunction with the I/O interface in the backup protection module described below.

Refer to the following tables for more information.

Speed (Pulse Rate) Inputs: Four speed inputs from passive magnetic sensors are monitored by the VTUR board. Another two speed (pulse rate) inputs can be monitored by the servo board VSVO, which can interface with either passive or active speed sensors. Pulse rate inputs on the VSVO are commonly used for flow divider feedback in servo loops. The frequency range is 2-14k Hz with sufficient sensitivity at 2 Hz to detect zero speed from a 60 toothed wheel.

Two additional passive speed sensors can be monitored by each of the three sections of the backup protection module used for emergency overspeed protection on turbines that do not have a mechanical overspeed bolt. IONet is used to communicate diagnostic and process data between the backup protection module and the control module(s) including cross-tripping capability; however, both modules will initiate system trips independent of the IONet.

VTUR I/O Terminations from Control Module

Board	Type	I/O	Characteristics
TTUR	Barrier	4 Pulse rate	Passive magnetic speed sensors (2-14k Hz)
		2 PTs	Single phase PTs for synchronizing
		Synch relays	Auto/manual synchronizing interface
		2 SVM	Shaft voltage / current monitor
TRPG*	Barrier	3 Trip solenoids	(-) side of interface to hydraulic trip solenoids
TRPS*		8 Flame inputs	UV flame scanner inputs (Honeywell)
TRPL*			
DTUR	Box	4 Pulse Rate	Passive magnetic speed sensors (2-14k Hz)
DRLY	Box	12 Relays	Form C contacts – previously described
DTRT			Transition board between VTUR & DRLY

VPRO I/O Terminations from Backup Protection Module

Board	Type	I/O	Characteristics
TPRO	Barrier	9 Pulse rate	Passive magnetic speed sensors (2-14k Hz)
		2 PTs	Single phase PTs for backup synch check
		3 Analog inputs	(1) 4-20 mA (250 Ω) or ±5,10 V dc inputs
			(2) 4-20 mA (250 Ω)
		9 TC inputs	Thermocouples, grounded or ungrounded
TREG*	Barrier	3 Trip solenoids	(+) side of interface to hydraulic trip solenoids
TRES*		8 Trip contact in	1 E-stop (24 V dc) & 7manual trips (125 V dc)
TREL*			

* There are several types of trip boards that are designed for the unique hydraulic trip circuit interface for different types of turbines.

Synchronizing: The synchronizing system consists of automatic synchronizing, manual synchronizing, and backup synch check protection. Two single phase PT inputs are provided on the TTUR terminal board to monitor the generator and line busses through the VTUR board. Turbine speed is matched to the line frequency, and the generator and line voltages are matched prior to giving a command to close the breaker through the TTUR.

Manual synchronizing is available from an operator station on the network or from a synchroscope.

An external synch check relay is connected in series with the internal K25P synch permissive relay and the K25 auto synch relay through the TTUR. Feedback of the actual breaker closing time is provided by a 52G/a contact from the generator breaker (not an auxiliary relay) to update the database. An internal K25A synch check relay is provided on the TTUR; however, the backup phase / slip calculation for this relay is performed in the backup protection module or through an external backup synch check relay.

Shaft Voltage & Current Monitor: Voltage can build up across the oil film of bearings until a discharge occurs. Repeated discharge and arcing can cause a pitted and roughened bearing surface that will eventually fail through accelerated mechanical wear. The VTUR / TTUR can continuously monitor the shaft to ground voltage and current and alarm excessive levels. Test circuits are provided to check the alarm functions and the continuity of wiring to the brush assembly that is mounted between the turbine and the generator.

Flame Detection: The existence of flame can either be calculated from turbine parameters that are already being monitored or from a direct interface to Reuter Stokes or Honeywell type flame detectors. These detectors monitor the flame in the combustion chamber by detecting UV radiation emitted by the flame. The Reuter Stokes detectors produce a 4-20 mA input. For Honeywell flame scanners, the Mark VI supplies the 335 V dc excitation and the VTUR / TRPG monitors the pulses of current being generated to determine if carbon buildup or other contaminates on the scanner window are causing reduced light detection.

Trip System: On turbines that do not have a mechanical overspeed bolt, the control can issue a trip command either from the main processor board to the VTUR board in the control module(s) or from the backup protection module. Hydraulic trip solenoids are wired with the negative side of the 24 V dc/125 V dc circuit connected to the TRPG which is driven from the VTUR in the control module(s) and the positive side connected to the TREG which is driven from the VPRO in each section of the backup protection module. A typical system trip initiated in the control module(s) will cause the analog control to drive the servo valve actuators closed to stop fuel or steam flow and de-energize (or energize) the hydraulic trip solenoids from the VTUR and TRPG. If cross-tripping is used or an overspeed condition is detected, then the VTUR/TRPG will trip one side of the solenoids and the VPTRO/TREG will trip the other side of the solenoid(s).

At least two LVDT/Rs are recommended for TMR applications because each sensor requires an ac excitation source.

Servo Valve Interface: A VSVO board provides four servo channels with selectable current drivers, feedback from LVDTs, LVDRs, or ratio metric LVDTs, and pulse rate inputs from flow divider feedback used on some liquid fuel systems. In TMR applications, three coil servos are commonly used to extend the voting of analog outs to the servo coils. Two coil servos can also be used. One, two, or three LVDT/Rs feedback sensors can be used per servo channel by selecting low, medium, or high in the software.

VSVO I/O Terminations from Control Module

Board	Type	I/O	Characteristics
TSVO	Barrier	2 channels	(2) Servo current sources (6) LVDT/LVDR feedback 0 to 7.0 Vrms (4) Excitation sources 7 Vrms, 3.2k Hz (2) Pulse rate inputs (2-14k Hz)*
DSVO	Box	2 channels	(2) Servo current sources (6) LVDT/LVDR feedback 0 to 7.0 Vrms (2) Excitation sources 7 Vrms, 3.2k Hz (2) Pulse rate inputs (2-14k Hz)*

* Only two per VSVO

Nominal Servo Valve Ratings

Coil Type	Nominal Current (mA)	Coil Resistance (Ω)	Mark VI Control
1	± 10	1,000	Simplex & TMR
2	± 20	125	Simplex
3	± 40	62	Simplex
4	± 40	89	TMR
5	± 80	22	TMR
6	± 120	40	Simplex
7	± 120	75	TMR

Faster shaft speeds may require faster sampling rates on the VVIB processor resulting in reduced vibration inputs from 16 to 8.

Vibration / proximitor inputs: The VVIB board provides a direct interface to seismic (velocity), Proximitor, velomitor, and accelerometer (through charge amplifier) probes. In addition, ac position inputs are available for axial measurements and keyphasor inputs are provided. Displays show the 1X and unfiltered vibration levels and the 1X vibration phase angle. –24 V dc is supplied from the control to each Proximitor with current limiting per point. The TVIB terminal board has active isolation amplifiers to buffer the sensor signals from BNC connectors. These connectors can be used to access real-time data by remote vibration analysis equipment. In addition, a direct plug connection is available from the board to a Bentley Nevada 3500 monitor. The 16 vibration inputs, eight dc position inputs, and two keyphasor inputs on the VVIB are divided evenly between two TVIB boards for 3,000 and 3,600 rpm applications.

VVIB I/O Terminations from Control Module

Board	Type	I/O	Characteristics
TVIB	Barrier	8 Vibrations	Seismic, Proximitor, velomitor, accelerometer
			charge amplifier
		4 Positions	dc inputs
		1 KP	Keyphasor
			Current limited -24 V dc provided per probe
DVIB	Box	same as TVIB	same as TVIB above

If a generator excitation system is controlling the generator, then 3-phase PT and CT data is communicated to the Mark VI on the network rather than using the VGEN board.

Three phase PT & CT monitoring: The VGEN board serves a dual role as an interface for 3-phase PTs and 1-phase CTs, as well as a specialized control for power load unbalance and early valve actuation on large reheat steam turbines. The I/O interface is split between the TGEN terminal board for the PT and CT inputs and the TRLY board for relay outputs to the fast acting solenoids. 4-20 mA inputs are also provided on the TGEN for monitoring pressure transducers.

VGEN I/O Terminations from Control Module

Board	Type	I/O	Characteristics
TGEN	Barrier	2 PTs	3-phase PTs, 115 Vrms
			5-66 Hz, 3 wire, open delta
		3 CTs	1-phase CTs, 0-5A
			(10A over range) 5-66 Hz
		4 AI	4-20 mA (250 Ω) or ±5,10 V dc inputs
			Current limited +24 V dc/input
TRLY	Barrier	12 CO	Plug-in magnetic relays previously described

Optical pyrometer inputs: The VPYR board monitors two LAND infrared pyrometers to create a temperature profile of rotating turbine blades. Separate, current limited +24 V dc and –24 V dc sources are provided for each Pyrometer which returns four 4-20 mA inputs. Two Keyphasors are used for the shaft reference. The VPYR and matching TPYR support 5,100 rpm shaft speeds and can be configured to monitor up to 92 buckets with 30 samples per bucket.

VPYR I/O Terminations from Control Module

Board	Type	I/O	Characteristics
TPYR	Barrier	2 Pyrometers	(8) 4-20 mA (100 Ω)
			(2) Current limited +24 V dc sources
			(2) Current limited -24 V dc sources
			(2) Keyphasor inputs

Dynamic pressure inputs: The VAMA board monitors two combustion acoustic or pressure wave sensors to monitor vibration in the turbine combustion section. Separate current limited +24 V dc and –24 V dc sources are provided for each charge amplifier, which returns two ac inputs superimposed on a dc bias. The inputs are specifically designed for use on GE5 and GE10 engines built by GE Nuove Pignone and LM2500 and LM6000 engines built by GE Aircraft Engines. The VAMA and matching DDPT support FFT analysis and RMS rectifier circuits for both inputs.

VPYR I/O Terminations from Control Module

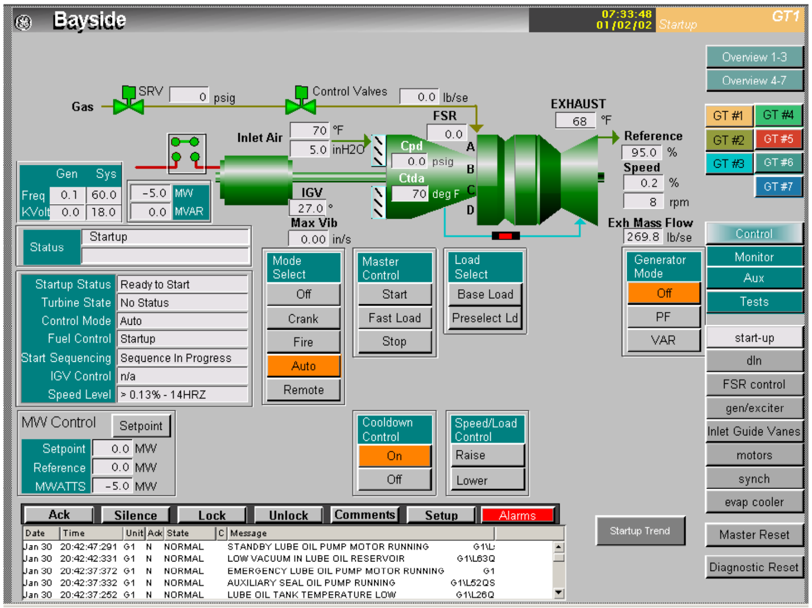
Board	Type	I/O	Characteristics
DDPT	Box	2 Dynamic Pressure	Simplex only Frequency range: 5 – 3000 Hz
			(2) Current limited +24 V dc sources
			(2) Current limited -24 V dc sources

Disconnect switch terminal blocks: The TBSW provides box type terminations with an individual disconnect switch for each of the 48 termination points on the Mark VI barrier-type terminal boards. It is intended to be used for circuit continuity testing when de-energized. The TBSW is rated for 5 A rms at 300 Vrms.

Operator Interface

The operator interface is commonly referred to as the Human-Machine Interface (HMI). It is a PC with a Microsoft® Windows® operating system supporting client/server capability, a CIMPLICITY® graphics display system, a Control System Toolbox (toolbox) for maintenance, and a software interface for the Mark VI and other control systems on the network. It can be applied as:

- Primary operator interface for one or multiple units
- Gateway for communication links to other systems
- Maintenance station
- Engineer's workstation



Operator Graphic Interface

The HMI can be reinitialized or replaced with the process running with no impact on the control system. The HMI communicates with the main processor board in the control module through the Ethernet-based Unit Data Highway (UDH). All analog and digital data in the Mark VI is accessible for HMI screens, including the high resolution time tags for alarms and events.

System (process) alarms and diagnostics alarms for fault conditions are time tagged at frame rate (10/20/40ms) in the Mark VI control 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 1ms on the contact input board in the control module. 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.

Refer to GEI-100487 for product functions of the HMI.

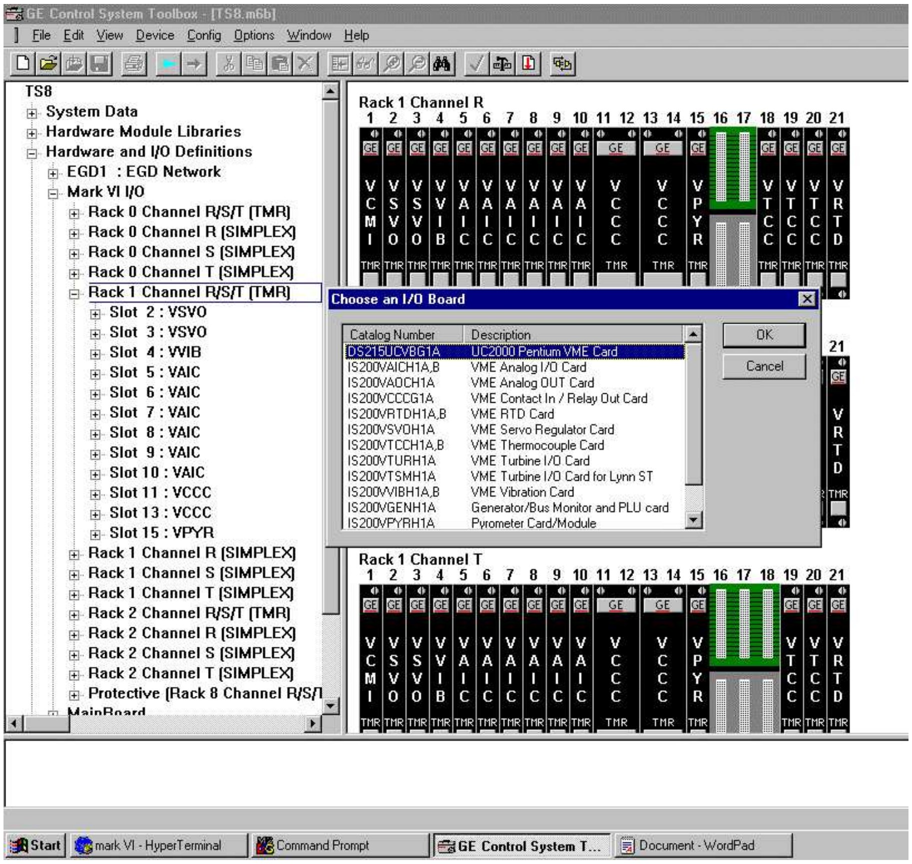
Data is displayed in either English or Metric engineering units with a one second refresh rate and a maximum of one second to repaint a typical display graphic. Operator commands can be issued by incrementing/decrementing a setpoint or entering a numerical value for the new setpoint. Responses to these commands can be observed on the screen one second from the time the command was issued. Security for HMI users is important to restrict access to certain maintenance functions, such as editors and tuning capability, and to limit certain operations.

Software Maintenance Tools

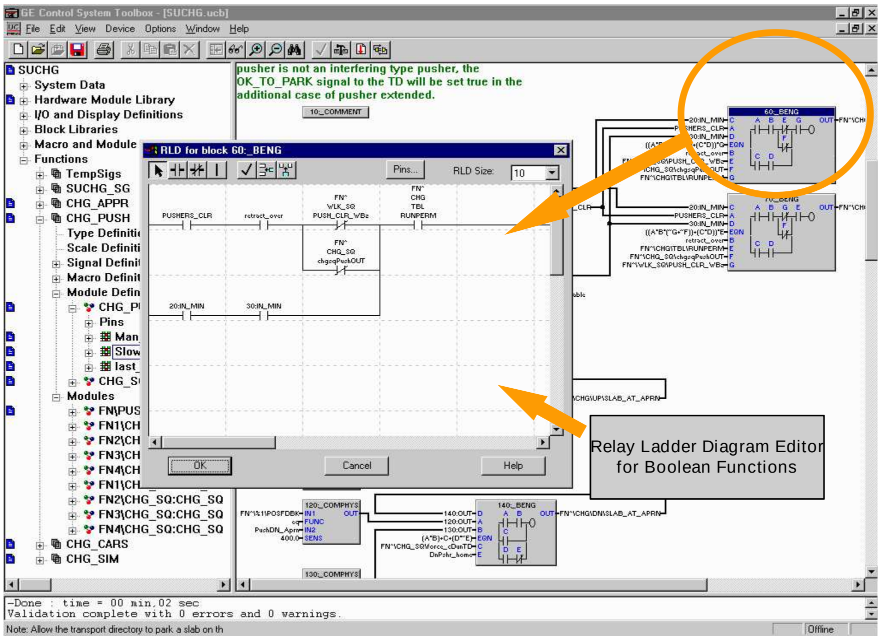
The Mark VI is a fully programmable control system. Application software is created from in-house software automation tools which select proven GE control and protection algorithms and integrate them with the I/O, sequencing, and displays for each application. A library of software is provided with general-purpose blocks, math blocks, macros, and application specific blocks. 32-bit floating point data (IEEE-854) is used in a QNX operating system with real-time applications, multitasking, priority-driven preemptive scheduling, and fast context switching.

Software frame rates of 10, 20, and 40 ms are supported. This is the elapsed time that it takes to read inputs, condition the inputs, execute the application software, and send outputs. Changes to the application software can be made with password protection (5 levels) and downloaded to the control module while the process is running. All application software is stored in the control module in non-volatile flash memory.

Application software is executed sequentially and represented in its dynamic state in a ladder diagram format. Maintenance personnel can add, delete, or change analog loops, sequencing logic, tuning constants, and such. To simplify editing, data points can be selected and drag-and-dropped on the screen from one block to another. Other features include logic forcing, analog forcing, and trending at frame rate. Application software documentation is created directly from the source code and printed at the site. This includes the primary elementary diagram, I/O assignments, the settings of tuning constants, and such. The software maintenance tools (Turbine Control System Solutions CD) are available for use in the HMI or as a separate software package on a Windows-based pc. The same tools are used for Generator Excitation Systems and Static Starters.



Software Maintenance Tools – Board Configuration



Software Maintenance Tools – Editors

Communications

Communications are provided for internal data transfer within a single Mark VI control, communications between Mark VI controls and peer GE control systems, and external communications to remote systems such as a plant distributed control system (DCS).

A variety of other proprietary protocols are used with EGD to optimize communication performance on the UDH.

The Unit Data Highway (UDH) is an Ethernet-based LAN with peer-to-peer communication between Mark VI controls, Generator Excitation Controls, Static Starters, the GE PLC-based controls, HMIs, and Historians. The network uses Ethernet Global Data (EGD), a message-based protocol with support for sharing information with multiple nodes based on the UDP/IP standard (RFC 768). Data can be transmitted unicast, multicast or broadcast to peer control systems. Data can be shared at 25 Hz (40 ms). Forty milliseconds is fast enough to close control loops on the UDH; however, control loops are normally closed within each unit control. Variations of this exist such as transmitting setpoints between turbine controls and generator controls for voltage matching and var/power factor control. All trips between units may be hardwired even if the UDH is redundant.

Refer to GEI-100487 for product functions of the HMI.

The UDH communication driver is located on the main processor board in a Mark VI control module. This is the same board that runs the turbine application software. Therefore there are no potential communication failure points between the main turbine processor and other controls or monitoring systems on the UDH. In TMR systems, there are three separate processor boards executing identical application software from identical databases. Two UDH drivers are normally connected to one switch, and the other UDH driver is connected to the other switch in a star configuration.

Communication links from the Mark VI to remote computers can be implemented from optional Ethernet or RS-232C Modbus® slave ports on the main processor board or from a variety of communication drivers from the HMI. Communication link options include RS-232C port or Ethernet TCP/IP with Modbus Slave RTU or ASCII communications from the main processor board.

Time Synchronization

Time sources that are supported include IRIG-A, IRIG-B, 2137, NASA-36, and local signals.

Time synchronization is available to synchronize all controls and HMIs on the UDH to a Global Time Source (GTS). Typical GTSs are Global Positioning Satellite (GPS) receivers such as the StarTime GPS Clock or other time processing hardware. The preferred time sources are Universal Time Coordinated (UTC) or GPS; however, the time synchronization option also supports a GTS using local time as its base time reference. The GTS supplies a time link network to one or more HMI's with a time/frequency processor board. When the HMI receives the time signal, it is sent to the Mark VI(s) using Network Time Protocol (NTP) which synchronizes the units to within ±1 ms time coherence.

Diagnostics

Each circuit board in the control module contains system (software) limit checking, high/low (hardware) limit checking, and comprehensive diagnostics for abnormal hardware conditions. System limit checking consists of two limits for every analog input signal, which can be set in engineering units for high/high, high/low, or low/low with the I/O configurator. In addition, each input limit can be set for latching/non-latching and enable/disable. Logic outputs from system limit checking are generated per frame and are available in the database (signal space) for control sequencing and alarm messages.

High/low (hardware) limit checking is provided on each analog input with typically two occurrences required before initiating an alarm. These limits are not configurable, and they are selected to be outside the normal control requirements 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 through the toolbox. A composite logic output is provided in the database for each board, and another logic output is provided to indicate a high/low (hardware) limit fault of any analog input or the associated communications for that signal.

The alarm system collects and time stamps the diagnostic alarm messages at frame rate in the control module and displays the alarms on the HMI. Communication links to a plant DCS can contain both the software (system) diagnostics and composite hardware diagnostics with varying degrees of capability depending on the protocol's ability to transmit the local time tags. Separate manual reset commands are required for hardware and system (software) diagnostic alarms assuming that the alarms were originally designated as latching alarms, and no alarms will reset if the original cause of the alarm is still present.

Each board front includes three LEDs: RUN-Green, FAIL-Red, STATUS-Yellow.

Each circuit board and terminal board in the system contains a serial number, board type, and hardware revision that can be displayed. Thirty seven pin D type connector cables are used to interface between the boards and the J3 and J4 connectors on the bottom of the control module. Each connector comes with latching fasteners and a unique label identifying the correct terminal point. One wire in each connector is dedicated to transmitting an identification message with a bar-code serial number, board type, hardware revision, and a connection location to the corresponding I/O board in the control module.

Power Requirements

In many applications, the control cabinet is powered from a 125 V dc battery system and short circuit protected external to the control. Both sides of the floating 125 V dc bus are continuously monitored with respect to ground, and a diagnostic alarm is initiated if a ground is detected on either side of the 125 V dc source.

For gas turbine applications, a separate 120/240 V ac source is required for the ignition transformers with short circuit protection of 20 A or less.

When a 120/240 V ac source is used, a power converter isolates the source with an isolation transformer and rectifies it to 125 V dc. A diode high select circuit chooses the highest of the 125 V dc busses to distribute to the Power Distribution Module. A second 120/240 V ac source can be provided for redundancy. Diagnostics produce an under-voltage alarm if either of the ac sources drop below the under-voltage setting.

Separate 120 V ac feeds are provided from the motor control center for any ac solenoids and ignition transformers on gas turbines.

The resultant internal 125 V dc is fuse isolated in the Mark VI power distribution module and fed to the internal power supplies for the control modules, any expansion modules, and the terminal boards for the field contact inputs and field solenoids. Additional 3.2 A fuse protection is provided on the board TRLY for each solenoid.

Power Requirements

Steady State Voltage	Frequency	Load	Comments
125 V dc (100 to 144 V dc)		10.0 A dc	Ripple <= 10V p-p (Note 1)
120 V ac (108 to 132 V ac)	47 - 63Hz	10.0 A rms	Harmonic distortion < 5% (Note 2)
240 V ac (200 to 264 V ac)	47 - 63Hz	5.0 A rms	Harmonic distortion < 5 % (Note 3)

1 - Add current load for each dc and ac solenoid powered from the control
2 - Add 6.0 A rms for a continuously powered ignition transformer
3 - Add 3.5 A rms for a continuously powered ignition transformer

Codes and Standards

Mark VI 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)	EN 50081-2 Generic Emissions Standards
Directive 89/336/EEC	EN 50082-2:1994 Generic Immunity Industrial Environment
	EN 55011 Radiated and Conducted Emissions
	IEC 61000-4-2:1995 Electrostatic Discharge Susceptibility
	IEC 6100-4-3: 1997 Radiated RF Immunity
	IEC 6100-4-4: 1995 Electrical Fast Transient Susceptibility
	IEC 6100-4-5: 1995 Surge Immunity
	IEC 61000-4-6: 1995 Conducted RF Immunity
	IEC 61000-4-11: 1994 Voltage Variation, Dips, and Interruptions
	ANSI/IEEE C37.90.1 Surge
Low-Voltage Directive 72/23/EEC	EN 61010, Safety of Electrical Equipment, Industrial Machines
	IEC 529, Intrusion Protection Codes/NEMA-1/IP/20

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

Reference GEH-6421, *Mark VI Systems Manual*, Chapter 5 for additional codes and standards.

Environment

The control is designed for operation in an air-conditioned equipment room with convection cooling. Special cabinets can be provided for operation in other types of environments.

The control can be operated at 50ºC during maintenance periods to repair air-conditioning systems. It is recommended that the electronics be operated in a controlled environment to maximize the mean-time-between-failure (MTBF) on the components.

Purchased commercial control room equipment such as PCs, monitors, and printers are typically capable of operating in a control room ambient of 0 to +40ºC with convection cooling.

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.

Environmental Requirements

Environmental requirements during operation:

Operating temperature 0 to 45ºC 32 to 113ºF

Storage temperature -40 to 70ºC -40 to 158ºF

Relative humidity 5 to 95% non-condensing

Seismic capability Designed to Universal Building Code (UBC- Seismic Code section 2312 Zone 4)

Elevation Exceeds EN50178: 1994

Gas Contaminants EN50178: 1994 Section A.6.1.4 Table A.2 (m)

Dust Contaminants Exceeds IEC 529: 1989-11 (IP-20)

Documentation

A subset of this documentation will be delivered with the control depending on the functional requirements of each system.

The following documentation is available for Mark VI turbine control systems.

Documents

- GEH-6421, Mark VI Turbine Control System Guide
- GEH-6403, Control System Toolbox for Configuring a Mark VI Controller
  - GEH-6408, Control System Toolbox for Configuring the Trend Recorder
  - GEI-100189, System Database (SDB) for Windows-Based Client/Server
  - GEI-100271, System Database (SDB) Browser
  - GEI-100278, Data Historian (used for trip history)
- GEH-6422, Turbine Historian System Guide

Communications to Remote Computers/Plant DCS

- RS-232C Modbus Slave From control module Modbus Communications Implementation UC/OC2000 - I/O Drivers, Chapter 2
- Communication Links From HMI: RS-232 Modbus Master/Slave, Ethernet Modbus Slave
- GEH-6126, HMI for SPEEDTRONIC™ Turbine Controls Application Manual, Chapter 7
- GEI-100165, GEDS Standard Message Format (GSM)

Operator/Maintenance Interface HMI

- GEH-6126, HMI for SPEEDTRONIC™ Turbine Controls Application Manual
- GFK-1396, CIMPLICITY®HMI CimEdit Operation Manual
- GFK-1180, CIMPLICITY® HMI Base System User's Manual
- GFK-1260, CIMPLICITY® HMI For Windows NT® Trending Operation Manual

Help Files

- SBLIB, Standard Blockware Library
- TURBLIB, Turbine Blockware Library

Drawings

- Equipment outline drawing (AutoCAD R14)
- Equipment layout drawing (AutoCAD R14)
- I/O termination list (Excel Spreadsheet)
- Network one-line diagram (if applicable)
- Application software diagram (printout from source code)
- Data list for communication link to DCS

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GE Industrial Systems

Issue date: 2002-01-10

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