SPEEDTRONIC™ Mark VI Turbine Control System

Introduction

The SPEEDTRONIC™ Mark VI turbine control is the current state-of-the-art control for GE turbines that have a heritage of more than 30 years of successful operation. It is designed as a complete integrated control, protection, and monitoring system for generator and mechanical drive applications of gas 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. With Mark VI, you receive the benefits of GE's unmatched experience with an advanced turbine control platform. (*See Figure 1.*)

- Over 30 years experience
- Complete control, protection, and monitoring
- Can be used in variety of applications
- Designed by GE turbine and controls engineering

Figure 1. Benefits of Speedtronic™ Mark VI

Architecture

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

Each I/O card 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 that is accessible by the on-board C32 DSP on one side and the VME bus on the other.

In addition to the I/O cards, the Control Module contains an "internal" communication card, a main processor card, and sometimes a flash disk card. Each card takes one slot except for the main processor that takes two slots. Cards 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 cards and the VCMI card located in slot 1. The VCMI is used for "internal" communications between:

- I/O cards that are contained within its card rack
- I/O cards 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 card

The main processor card executes the bulk of the application software at 10, 20, or 40 ms depending on the requirements of the application. Since most applications require that spe-

cific parts of the control run at faster rates (i.e. servo loops, pyrometers, etc.), 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 multi-tasking, 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 card in the Control Module is the IONet bus master communicating on an Ethernet 10Base2 network to slave stations. A unique poling type protocol (Asynchronous Drives Language) is used to make the IONet more deterministic than traditional Ethernet LANs. An optional Genius Bus™ interface can be provided on the main processor card in Mark VI Simplex controls for communication with the GE Fanuc family of remote I/O blocks. These blocks can be selected with the same software configuration tools that select Mark VI I/O cards, and the data is resident in the same database.

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 Redundancy

Mark VI control systems are available in Simplex and Triple Redundant forms for small applications and large integrated systems with control ranging from a single module to many distributed modules. The name Triple Module Redundant (TMR) is derived from the basic architecture with three completely separate and independent Control Modules, power supplies, and IONets. Mark VI is the third generation of triple redundant control systems that were pioneered by GE in 1983. System throughput enables operation of up to nine, 21-slot VME racks of I/O cards at 40 ms including voting the data. Inputs are voted in software in a scheme called Software Implemented Fault Tolerance (SIFT). The VCMI card in each Control Module receives inputs from the Control Module back-plane and other modules via “its own” IONet.

Data from the VCMI cards in each of the three Control Modules is then exchanged and voted prior to transmitting the data to the main processor cards 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 4-20ma outputs for process control and 0-200ma 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 card or module while the process is running. Adding sensor redundancy increases the fault tolerance