All diagnostic fault information is accessible by the control program and the operator. The program or the operator can use diagnostic data to modify control actions or direct maintenance procedures.

Other key features of the Tricon controller that ensure the highest possible system integrity are:

- No single point of failure
- Ability to operate with 3, 2 or 1 Main Processor before shutdown
- Fully implemented and transparent triplication
- Comprehensive system diagnostics
- Complete range of I/O modules
- Dual and single I/O modules for safety-critical points with a limited need for availability
- Remote I/O up to 7.5 miles (12 kilometers) away from MPs
- Simple, online module repair
- Unsurpassed reliability and availability

What are Typical User Applications?

Each day the Tricon supplies increased safety, reliability and availability to a worldwide installed base. The following are a few typical applications. For more information on how a Tricon controller can add value to your applications, ask your sales representative for additional documentation and customer references.

Emergency Safety Shutdown (ESD)

The Tricon provides continuous protection for safety-critical units in refineries, petrochemical/chemical plants and other industrial processes. For example, in reactor and compressor units, plant trip signals—for pressure, product feed rates, expander pressure equalization and temperature—are monitored and shutdown actions taken if an upset condition occurs. Traditional shutdown systems implemented with mechanical or electronic relays provide shutdown protection but can also cause dangerous nuisance trips.

The Tricon increases system integrity, providing automatic detection and verification of field sensor integrity, integrated shutdown and control functionality, and direct connection to the supervisory data highway for continuous monitoring of safety-critical functions.

Boiler Flame Safety

Process steam boilers function as a critical component in most refinery applications. Protection of the boiler from upset conditions, safety interlock for normal startup and shutdown, and flame-safety applications are combined by one integrated Tricon system. In traditional applications, these functions had to be provided by separate, non-integrated components. But with the fault-tolerant, fail-safe Tricon controller, the boiler operations staff can use a critical resource more productively while maintaining safety at or above the level of electromechanical protection systems.

Turbine Control Systems

The control and protection of gas or steam turbines requires high integrity as well as safety. The continuous operation of the fault-tolerant Tricon controller provides the turbine operator with maximum availability while maintaining equivalent levels of safety. Speed control as well as start-up and shutdown sequencing are implemented in a single integrated system. Unscheduled outages are avoided by using *hot-spares* for the I/O modules. If a fault occurs in a module, a replacement module is automatically activated without operator intervention.

Offshore Fire and Gas Protection

The protection of offshore platforms from fire and gas threats requires continuous availability as well as reliability. The Tricon provides this availability through *online replacement* of faulty modules. Faults in individual modules, field wiring and sensors are managed automatically by built-in diagnostics. Analog fire and gas detectors are connected directly to the Tricon, eliminating the need for trip amps. An operator interface monitors fire and gas systems as well as diagnostics for the Tricon controller and its attached sensors. Traditional fire and gas panels can bereplaced with a single integrated system, saving costly floor space while maintaining high levels of safety and availability.

What is TriStation?

TriStation 1131 Developer's Workbench is an integrated tool for developing, testing and documenting control programs that execute in the Tricon controller. TriStation 1131 complies with the IEC 61131 International Standard for Programmable Controllers and follows the Microsoft Windows guidelines for graphical user interfaces.

What about Communication Capabilities?

Optional modules enable the Tricon to communicate with other Triconex controllers and with other hosts such as:

- Modbus masters and slaves
- Distributed Control Systems (DCS)
- Operator workstations
- Host computers using Ethernet (802.3) protocol

For more information, see "Communication Capabilities" on page 59.

The Tricon is designed with a fully triplicated architecture throughout, from the input modules through the main processors (MPs) to the output modules.

Theory of Operation

Fault tolerance in the Tricon is achieved by means of a Triple-Modular Redundant (TMR) architecture. The Tricon provides error-free, uninterrupted control in the presence of either hard failures of components, or transient faults from internal or external sources.

The Tricon is designed with a fully triplicated architecture throughout, from the input modules through the main processors to the output modules. Every I/O module houses the circuitry for three independent channels, which are also referred to as legs. Each channel on the input modules reads the process data and passes that information to its respective main processor. The three main processors communicate with each other using a proprietary high-speed bus system called the TriBus.

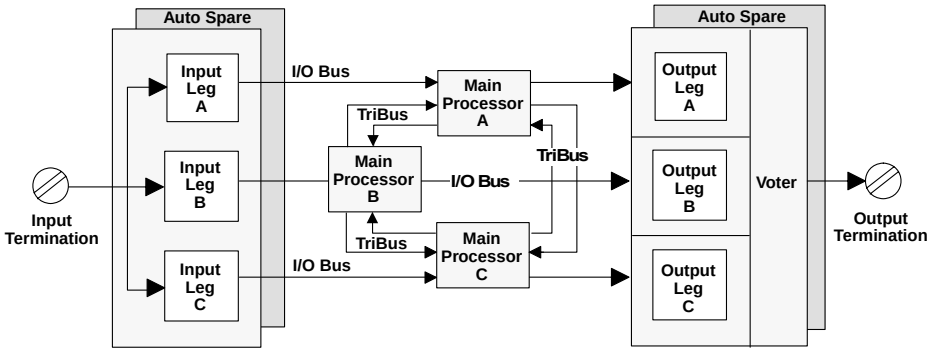
Once per scan, the three main processors synchronize and communicate with their two neighbors over the TriBus. The Tricon votes digital input data, compares output data, and sends copies of analog input data to each main processor.

The main processors execute the control program and send outputs generated by the control program to the output modules. The output data is voted on the output modules as close to the field as possible, which enables the Tricon to detect and compensate for any errors that might occur between the voting and the final output driven to the field.

For each I/O module, the system can support an optional hot-spare module which takes control if a fault is detected on the primary module during operation. The hot-spare position can also be used for online system repairs.

Main Processor Modules

A Tricon system contains three main processor (MP) modules to control three separate channels of the system. Each main processor operates in parallel with the other two main processors, as a member of a triad.



Simplified Tricon Architecture

A dedicated I/O and COMM processor on each main processor manages the data exchanged between the main processors and the I/O modules. A triplicated I/O bus is located on the chassis backplane and is extended from chassis to chassis by means of I/O bus cables.

As each input module is polled, the new input data is transmitted to the main processor over the appropriate channel of the I/O bus. The input data from each input module is assembled into a table in the main processor and stored in memory for use in the hardware voting process.

The individual input table in each main processor is transferred to its neighboring main processors over the proprietary TriBus. During this transfer, hardware voting takes place. The TriBus uses a direct memory access (DMA) programmable device to synchronize, transmit, vote and compare data among the three main processors.

If a disagreement is discovered, the signal value found in two out of three tables prevails, and the third table is corrected accordingly. One-time differences which result from sample timing variations can be distinguished from a pattern of differing data. The three independent main processors each maintain data about necessary corrections in local memory. Any disparity is flagged and used at the end of the scan by the built-in Fault Analyzer routines to determine whether a fault exists on a particular module.

After the TriBus transfer and input data voting have corrected the input values, these corrected values are used by the main processors as input to the user-written control program. (The control program is developed in the TriStation software and downloaded to the main processors.) The 32-bit main microprocessor executes the user-written control program in parallel with the neighboring main processor modules.

The user-written control program generates a table of output values based on the table of input values, according to the rules built into the control program by the customer. The I/O processor on each main processor manages the transmission of output data to the output modules by means of the I/O bus.

Using the table of output values, the I/O processor generates smaller tables, each corresponding to an individual output module in the system. Each small table is transmitted to the appropriate channel of the corresponding output module over the I/O bus. For example, Main Processor A transmits the appropriate table to Channel A of each output module over I/O Bus A. The transmittal of output data has priority over the routine scanning of all I/O modules.

The I/O and COMM processor manages the data exchanged between the main processors and the communication modules using the communication bus, which supports a broadcast mechanism.

The model 3008 Main Processors provide 16 megabytes of DRAM, which is used for the control program, sequence-of-events data, I/O data, diagnostics and communication buffers.

In the event of an external power failure, the integrity of the user-written program and the retentive variables is protected for a minimum of six months.

The main processor modules receive power from dual power modules and power rails in the main chassis. A failure on one power module or power rail will not affect the performance of the system.

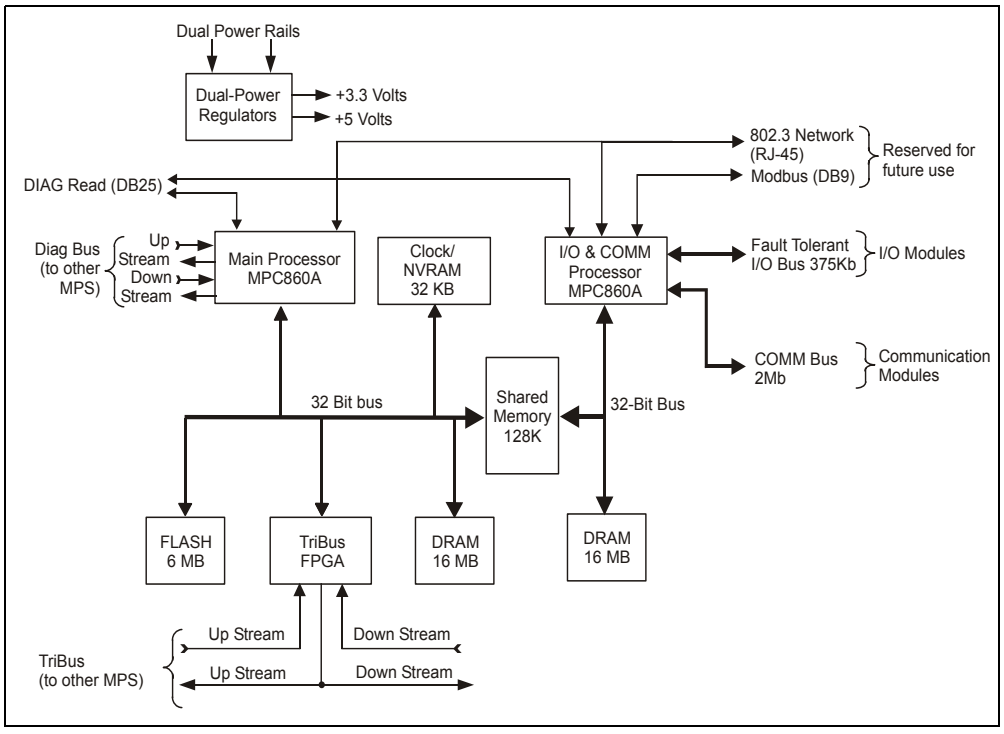
Bus Systems and Power Distribution

Three triplicated bus systems are etched on the chassis backplane: the TriBus, the I/O bus and the communication bus.

The TriBus consists of three independent serial links which operate at 25 megabits per second. The TriBus synchronizes the main processors at the beginning of a scan. Then each main processor sends its data to its upstream and downstream neighbors. The TriBus performs one of two functions with the data:

- Transfer of data only—for I/O, diagnostic and communication data.
- Comparing data and flagging disagreements—for the previous scan's output data and memory of user-written control program.

An important feature of the Tricon's fault-tolerant architecture is the use of a single transmitter to send data to both the upstream and downstream main processors. This ensures receipt of the same data by the upstream processor and downstream processor.



Main Processor (Model 3008) Architecture