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GMR Flex.Triple ModularRedundant (TMR) System Technical
Product Overview

GE Fanuc Automation

Programmable Control Products

Genius™ Modular Redundancy
Flexible Triple Modular Redundant (TMR) System

Technical Product Overview

Warnings, Cautions, and Notes as Used in this Publication

<div align="center">

Warning

</div>

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

<div align="center">

Caution

</div>

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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CIMPLICITY PowerTRAC	Genius PowerTRAC	PROMACRO	VuMaster
CIMPLICITY 90–ADS	Helpmate	Series Five	Workmaster
CIMSTAR	Logicmaster	Series 90	

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The GE Fanuc Genius Modular Redundancy (GMR) system combines the flexibility and power of the Series 90-70 PLC with the advanced functionality of Genius I/O.   The result: an excellent PLC-based, fault-tolerant, Triple-Modular Redundancy (TMR) choice for Critical Control Applications. GMR is GE Fanuc's sole offering for safety-critical applications.

Genius Modular Redundancy is an extremely flexible system that is able to provide variable redundancy from the input modules through one, two or three PLC CPU processors to the output modules. This flexibility means less-critical inputs and outputs may be configured for simplex or duplex operation while maintaining triplicated elements for critical control.

Depending upon the level of redundancy required, sensor signals are brought into isolated Genius input blocks. Isolated CPUs, located in separate racks, receive the input signals from each Genius I/O bus. The CPUs independently vote on the inputs, then execute the application program utilizing the voted results. Programs may be initially stored to one CPU for monitoring before storing to the other CPU(s).

In a GMR system, the CPUs provide optional data synchronization only at startup, not during normal operation. The need for repeated synchronization is avoided because GMR inputs are broadcast to all PLCs simultaneously. Other systems that require ongoing CPU synchronization risk a common point of system failure.

In its triplicated (TMR) configuration, GMR includes three isolated PLCs and extensive diagnostics which are integrated into a single system. Utilizing two-out-of-three voting, the GMR system provides high reliability and error-free operation. There are no hardware common failure modes due to GMR's physically uncoupled design and separate leg circuit protection.

In the TMR configuration, each of the three CPUs sends output state results of the logic to the output subsystem via triplicated Genius I/O busses. Genius output blocks perform output voting on the triplicated output data. Discrete output circuits incorporate current and voltage sensors that provide output and load state diagnostics.

Typical Operator Display Showing Basic System
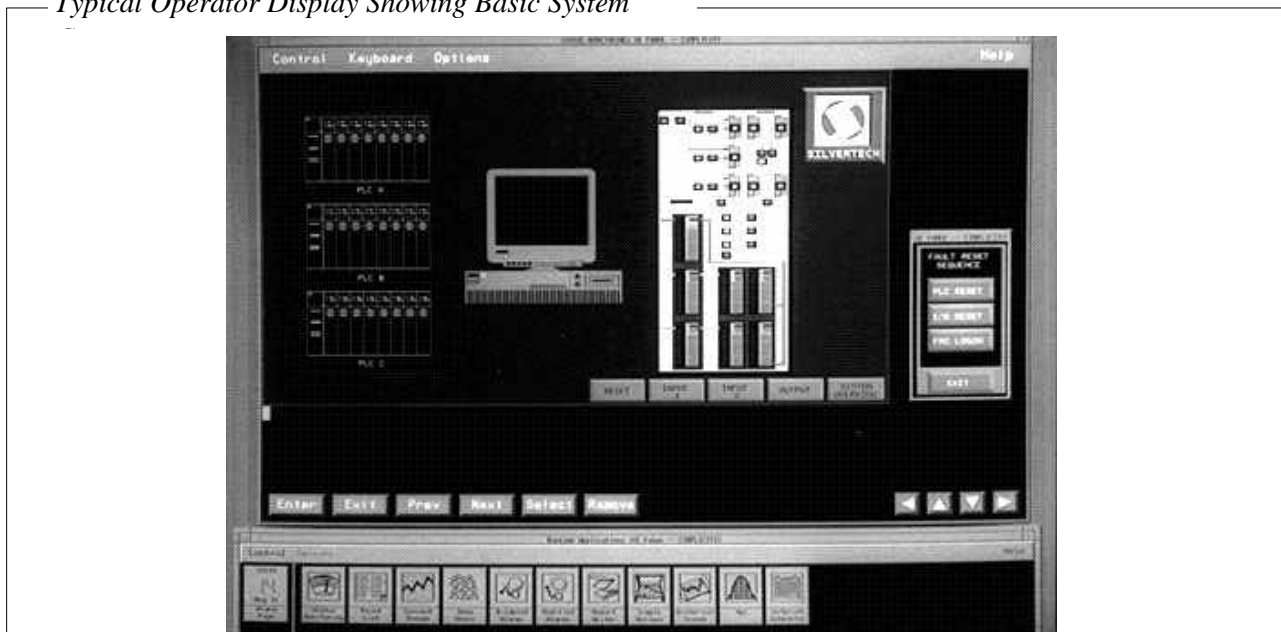
GMR identifies system faults, compensates for them automatically, and allows repair or replacement without interrupting system operations. Faults are handled by a software alarm processor function that time-stamps and logs I/O and system faults in two diagnostic tables that can be displayed by the programmer or uploaded to a host computer or other coprocessor.

Each PLC executes continuous diagnostics to detect overt and covert failures, reducing mean time to repair (MTTR) and generating automatic fault reports for maintenance or operations personnel. This fault information is readily available to the application program, making it possible to take appropriate control action and alerting maintenance personnel. Memory errors are detected via parity or checksum, along with data and address line testing.

Genius I/O, with its distributed design and technology, allows the I/O to monitor the actions of other intelligent devices in the system and provide automatic diagnostics without long wiring runs. Genius I/O accommodates both local and remote installation requirements and can reduce installation costs up to 50 percent.

Special Features of a GMR System

In addition to the normal features of typical TMR systems, such as fault tolerance, comprehensive diagnostics, remote I/O, online module repair, and high reliability and availability, GMR provides these benefits:

■ Application flexibility. Configurable per-point redundancy makes it possible to customize system hardware to specific application requirements, thereby saving money.

■ Genius I/O speeds startup and eliminates long wire runs, saving time and money.

■ Elimination of fuses. Temporary shorts are electronically cleared, reducing Mean Time To Repair (MTTR)

■ Fault identification to point level, further reducing MTTR. Ability to stage and debug input and output circuitry before CPU installation using a Hand-held Monitor.

■ Readily available modules through worldwide distribution channels.

■ Software driven and self-documenting configuration.

System Programming and Configuration

System configuration and programming are done using software that installs on an IBM®-PC or compatible computer. Configuration and programming can be done with the programming computer either online or offline from the PLC.

The software architecture provides a structured platform upon which to build application programs. An application program may be built of many smaller program blocks each related to a specific machine or process function. This approach makes it easier to isolate and associate control logic with machine and process functions.

GMR is shipped as a complete package providing all safety system functions such as voting, diagnostics, and startup control. A programmer macro allows all three PLCs to appear as one for the purpose of downloading and verification of the application program, saving time and increasing accuracy.

Communications

A variety of communications options make it possible to interface the GMR system to Distributed Control Systems (DCS), operator interfaces or workstations, host computers, and other devices which communicate using serial communications, either RTU MODBUS® or GE Fanuc protocols, Ethernet TCP/IP, or GE Fanuc's Genius LAN.

Quality is Built In

GE Fanuc has been awarded ISO 9001 certification, assuring built-in product quality. GMR products are built in our award-winning Charlottesville, Virginia manufacturing facility.

GMR is based on two thoroughly field-tested product families: the Series 90-70 PLC and the Genius I/O system. Both have demonstrated mean time between failure (MTBF) statistics that allow system designers to easily achieve the safety integrity level (SIL) required in critical applications. In addition, they are both approved for hazardous location, Class I, Division II installation.

TÜV has certified GMR for classification to these requirements: triplex Class 5, duplex Class 4 and 5 according to the DIN V19250/DIN V VDE 081 standards. Field data has been accumulated and submitted for Class 6 type approval, anticipated by the end of 1997. For information about using the GMR system in a TÜV approved safety critical installation, refer to information in the GMR User's Manual (GFK-1277).

Certificate #
FM13400

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GMR Applications

The GMR input subsystem, PLC subsystem, and output subsystem combine to provide a high-availability, high-reliability system.
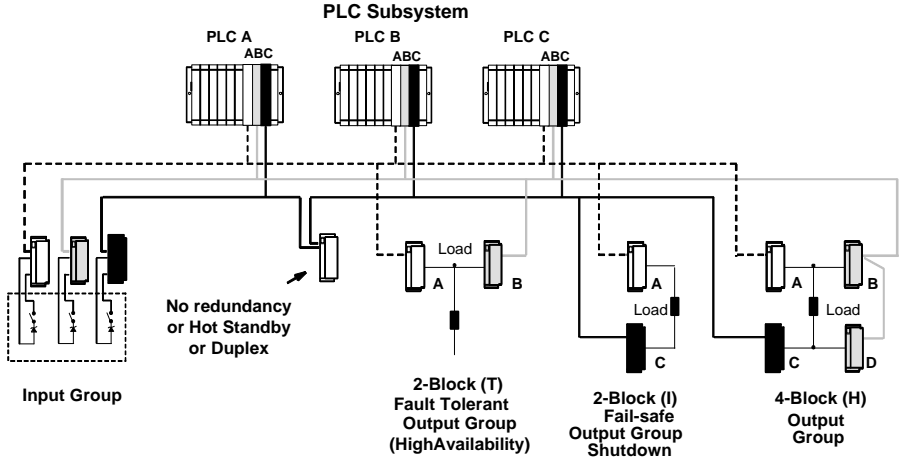
Typical uses of Genius Modular Redundancy technology are applications that require operation on demand—high system availability. These applications include equipment protection, environmental release protection, and safety-critical protection systems. For details of the following typical applications of the GE Fanuc Series 90-70 GMR system technology, please contact your local GE Fanuc distributor or sales representative.

Emergency Shutdown

The GMR system was specifically designed, tested, and certified to provide redundancy in both CPU and I/O subsystems, together with the latent fault diagnostic coverage required for Emergency Shutdown applications in refining, chemical manufacturing, and other continuous/batch operation environments.

Functions that cannot be implemented in traditional relay, DCS, or PLC-based systems are standard features of GMR. Typical factors that contribute to its reputation for operation on demand are High Availability (99.999%), fault coverage that extends to the field device, elimination of nuisance trips, and fail safe/fault tolerant design.

Environmental Protection Systems

Environmental Protection systems are becoming extremely important in many processing facilities. Uncontrolled events in chemical production centers can lead to release of toxic substances into the environment, exposing plant personnel and adjacent communities to materials now controlled by OSHA.

By monitoring critical variables on reactors, vapor recovery, and other potentially volatile process units, GMR can react to bring the unit back to a controlled

state, eliminating the unwanted activation of other levels of mitigation such as mechanical pressure-relief devices.

Boiler/Burner Management Systems

If a process boiler stops operating reliably, other parts of the system are soon affected, leading to loss of both quality and profits. With the fail-safe and fault-tolerant GMR system, operations such as purge sequencing, fuel control, burner ignition, and flame safety can also be cost-effectively integrated into a single system-meeting even the most stringent NFPA requirements.

Fire and Gas Detection Systems

Fire and Gas Detection systems require many of the same high-integrity considerations as Emergency Shutdown (ESD) applications. However, special design strategies must be integrated in a Fire and Gas Detection system for monitoring the field wiring of de-energized control devices and other functions specific to "energize-to-trip" systems.

GE Fanuc Genius I/O blocks are easily configured to meet these special application requirements. They can be certified by leading specification underwriters. In addition, reduction in spare parts costs can be achieved through commonality of component requirements for ESD and Fire & Gas systems, and through the availability of more than 250 stocking distributors around the globe.
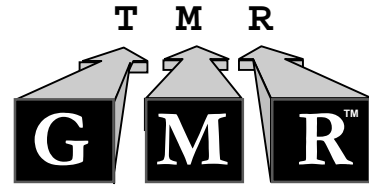
On-line Replacement of Modules

The reliability of GE Fanuc Series 90-70 products has been field-proven by millions of hours of operation. If a GMR system component should ever need repair, the faulty module can be replaced online. Process protection continues without interruption.

Section 2

Operation

The purpose of this section is to explain how a GMR system operates—how field inputs are gathered, stored, and processed, how field outputs are generated, how voting occurs, and how the extensive diagnostics capabilities of a GMR system assure maximum I/O data integrity.

Genius Modular Redundancy is an extremely flexible system that is able to provide variable redundancy from the input modules through one to three PLC CPU processors to the output modules.

Input data is gathered from field input devices wired to groups of one to three Genius discrete or analog blocks, or Field Control analog input modules. Each input may be simplex (single), duplex (double) or triplex (triple) depending on the needs of the application.

Each Genius or Field Control device transmits input data once each scan on a Genius bus. Because these devices broadcast their input data, the same inputs are available to all PLCs on the bus.
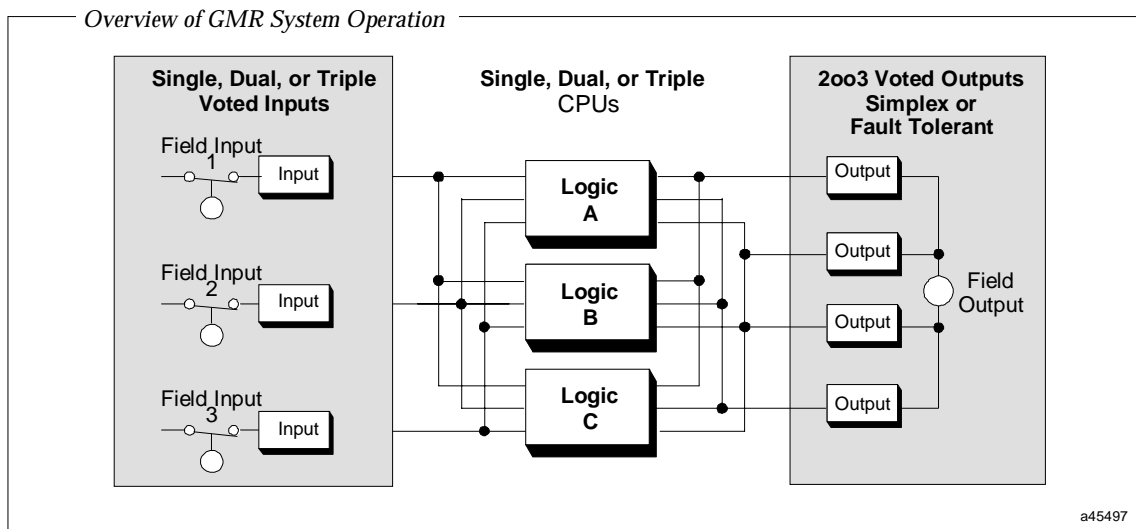
Depending on the redundancy needs of the application, there may be one, two, or three PLCs in the GMR system. Each PLC CPU votes on the input data it has received before each execution of the application program.

CPUs run asynchronously from each other and do not share their I/O data, which eliminates the possibility of one CPU corrupting input data memory in another CPU. This feature reduces overall system components, and prevents a common mode single point failure. Any input voting discrepancies are reported to the built-in PLC Fault Table in each PLC.

Each CPU executes the same application program, processing the input data and creating new output data. Each bus scan, each PLC sends output data to groups of Genius I/O blocks that control field output devices.

The intelligent Genius output block groups perform output voting. The manner of voting is configurable for the application. Because output voting is performed by the block groups at the point of control, output data discrepancies are caught by the voting process.

Overview of GMR System Operation

Single, Dual, or Triple Voted Inputs

Field Input 1 — Input

Field Input 2 — Input

Field Input 3 — Input

Single, Dual, or Triple CPUs

Logic A

Logic B

Logic C

2oo3 Voted Outputs Simplex or Fault Tolerant

Output

Output

Output

Output

Field Output

a45497

Input Subsystem

A GMR Input sub-system is

- A group of 2 or 3 discrete GENIUS blocks (16 or 32 points each with 1 circuit reserved for autotest) connected to redundant GENIUS lans. Either common or redundant sensors may be used as represented in the next two illustrations.

- A group of 2 or 3 analog GENIUS blocks (2 or 6 channels) or Field Control modules (4, 8, or 16 channels) connected to redundant GENIUS lans. Voltage inputs may use a common sensor; current inputs requires separate sensors.

- A single GENIUS or Field Control device (not safety-related).

Two-block Groups

Bus A & B
or B & C
or C & D

Duplex Sensors   **Single Sensor**

Three-block Groups

Bus A | Bus B | Bus C   Bus A | Bus B | Bus C

Triple Sensors   **Single Sensor**
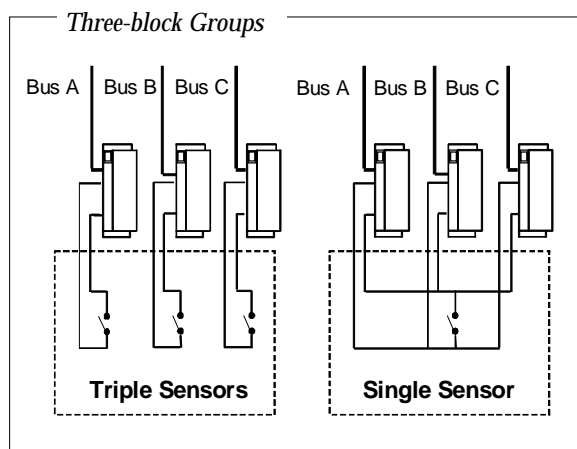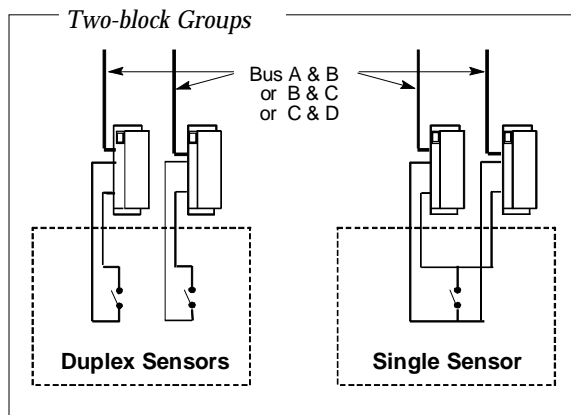
Discrete Inputs

Each Genius block is attached to a separate Genius bus. Each block independently broadcasts its inputs to all PLCs, so each PLC CPU receives an independent copy of all inputs.

Each input can be configured for Input Autotesting, default state, and Voting Adaptation mode. The Voting Adaptation method determines how the PLC will perform voting when fewer than three input signals are present in a group.

All voting for discrete and analog inputs is performed independently at each PLC. For a two- or three-block input group, the CPU performs a 2-out of 3 vote on corresponding inputs. Depending on the configuration of the input group, input voting may adapt from three inputs to two inputs to one input or from three inputs to two inputs to the configured Default State. When three inputs are present the vote is a simple majority vote. If only two inputs are present the PLC uses the point's configured "duplex" state as the third input and performs a majority vote. If only one input is present and the circuit is configured for 3, 2, 1, 0 voting adaptation, the single input is used as the voted input value. However, if the circuit is configured for 3, 2, 0 voting adaptation the circuit's configured default value is used instead. The result of voting is provided to the application program.

Single Genius input blocks of any type can be connected to any Genius bus. The actual input value is used by the application program.

Analog Inputs

Genius analog blocks and Field Control analog input modules can be used in GMR input groups in the input subsystem. Analog input blocks can support 0 to 10V, +/-10V, +/-5V, 0 to 5V and 4ma to 20ma. RTD and thermocouple modules are also available.

Analog inputs are handled very much like discrete inputs. Groups of one to three analog input blocks are connected to separate Genius busses. They broadcast their inputs to all PLCs. The PLCs select the mid-value from among the three corresponding inputs. Depending on the configuration of the input group, input voting may adapt from three inputs to two inputs to one input, or from three inputs to two inputs to the configured Default Value. The result of the voting is provided for use by the application program.

The ability of Genius Analog blocks and Field Control Analog Input modules to convert raw data to engineering units and directly drive discrete preset alarm limit points reduces the complexity of software at the CPU and increases system reliability.

Input Diagnostics

The GMR input subsystem provides extensive diagnostic capabilities through:

- Genius diagnostics.

- Input Discrepancy Reporting flags any input which is not in agreement with the majority vote.

- Input Autotest determines the ability of each input to attain the safe state (opposite of its normal state) and checks for channel-to-channel shorts.

Genius Diagnostics. Genius devices provide extensive diagnostics protection.

16-circuit DC Sink/Source blocks detect line faults on tristate inputs ("supervised inputs"). For blocks that are configured to be in GMR mode, this diagnostic detects short circuit faults on the field wiring.

Some analog Input devices allow embedded detection of open wire and other faults.

Genius blocks identify fault type and exact location to the point level, and automatically provide that information to the PLC fault tables. The information is also available to the application program. This level of precision in the diagnostics makes it possible to perform specific repairs without disrupting other elements of the system unnecessarily.

Input Autotest. The GMR Input Autotest feature accommodates normally-closed and normally-open devices with the devices in either state. Input Autotest detects any failure associated with an input that would result in a failure to respond. It does not cause spurious inputs.

Input Autotesting is configurable on a circuit-by-circuit basis for discrete GMR input circuits.

On blocks set up for autotesting, power to the input device is provided by Power Feed Outputs from the blocks in the Input Group, as illustrated below. (This output occupies one of the block's I/O circuits, leaving either 15 or 31 circuits available for use with input devices, depending on the block type.) On a configurable time interval, Input Autotest pulses the Power Feed Output to Off (this does not change the input reported to the application). If an input does not turn Off during the Autotest period, the CPU places a message in the I/O Fault Table. Off inputs are also tested to ensure that the blocks' input circuits can detect the On state. Input-to-input shorts are also detected.

Input Autotest

TRIPLICATED BUS

* POWER FEED OUTPUT CHANNELS

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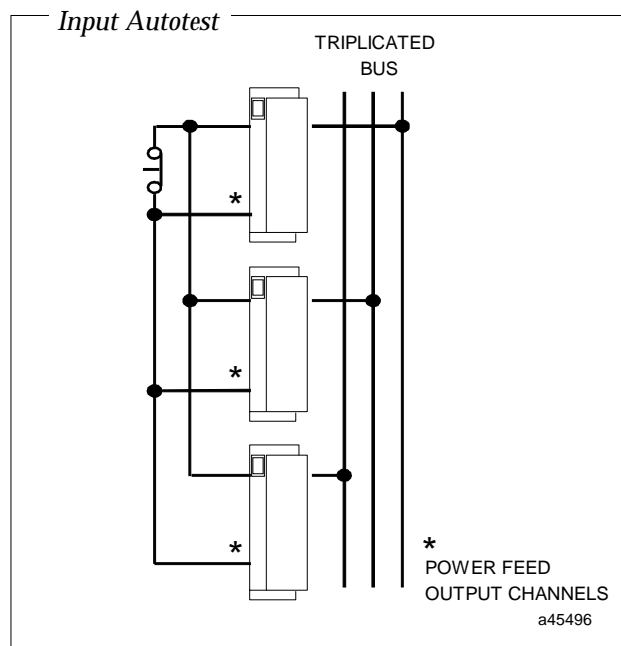
Processors

In a GMR system, processing is performed by one to three Programmable Logic Controllers (PLCs). Each PLC is modular in design, consisting of a rack with a power supply module, a CPU module, and other modules that perform specific operations needed for the application.

Unlike other triplicated systems, GMR does not require ongoing processor synchronization, greatly reducing the probability of software and hardware common-mode failures.

The illustration below represents the basic parts of a sample GMR system--three PLCs, three Genius busses, three Genius Bus Controllers in each PLC, one input group of Genius blocks, and one output group of Genius blocks. In an actual system, there can be many input groups, output groups, and triplex busses. Although the illustration shows each block connected to just one field device, there can be up to 32 field devices connected to each block or block group (31 if autotesting is used).

Genius Bus Controllers and Busses

One to three Genius busses transmit I/O and communications data for the GMR system. Redundant

Bus Controllers and bus cables prevents a single point of failure in the communications subsystem.

A Bus Controller manages data transfer between its bus and the CPU by maintaining two separate on-board RAM memories. One interfaces with the bus and the other interfaces with the CPU. The Bus Controller automatically transfers data between these two memories, making data available to the bus or to the CPU when it is needed.

In addition to being used for I/O data, the Genius busses provide communications between the PLCs, which regularly exchange status data. A limited amount of application data can also be exchanged. Separate busses can be used for additional data exchanges between the PLCs and with host devices that communicate using Genius protocol.

The Genius Bus Protocol provides inherent protection against transmission errors. Each transmitting device sends each bit three times. Each receiving device performs a 2-out of 3 vote on each bit received, and a CRC checksum on each packet This process automatically corrects any bits received in error and eliminates the need for retransmission.

PLCs, Bus Controllers and Busses
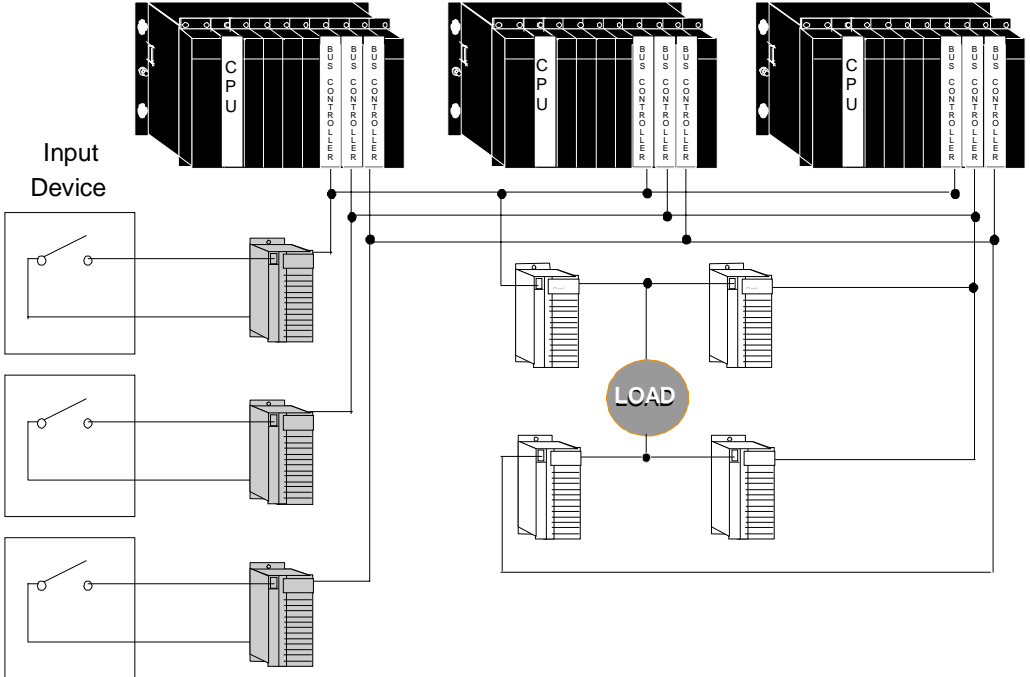
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Synchronization

Unlike other triplicated systems, GMR does not require ongoing processor synchronization, greatly reducing the probability of software and hardware common mode failures. In a GMR system, each PLC typically runs the same application program. Application program data is optionally synchronized among the PLCs during system startup. It is also optionally synchronized whenever one or more PLCs is taken offline and then restarted.

Initial System Program Synchronization

Upon initialization of the application program, each PLC runs a startup diagnostic, checks the status of all system components and provides an orderly, controlled startup. If any errors occur, they are logged into a fault table in the PLC and made available to the application program through diagnostic status bits. Initialization errors may or may not stop the PLC; this is determined by the GMR configuration set up for the application.

Partial Restart System Program Initialization

If one or more CPUs are taken offline while the system continues to operate, a "warm start" is automatically initiated when the offline CPU(s) are re-introduced. This optionally allows data to synchronize with the other CPU(s), verifies that system operation is correct, and determines the application logic is equal in the PLCs. Optional data synchronization eliminates potential discrepant control commands being issued between individual processors that are joining the online operational system.

Inputs and Outputs

Genius and Field Control devices broadcast the status of all inputs simultaneously to all online CPUs. Each CPU independently solves the application logic and transmits the resulting commanded output states independently to the output modules.

Global Data

During GMR system operation, the PLCs use Global Data to automatically exchange eight registers of system status and diagnostic data. This data is directly available for the application program in each PLC. Global Data transfer occurs on two of the fault-tolerant GMR busses, so each PLC actually receives two sets of Global Data from each of the other PLCs. The use of two busses provides redundant operation in case a bus or bus controller is not available.

In some applications, it may also be desirable to regularly exchange additional application data between the PLCs. Up to 56 registers of application data can be exchanged on the redundant GMR busses using Global Data.

PLC Diagnostics

Each PLC executes continuous diagnostics to detect internal overt and covert failures. Memory errors are detected via parity or checksum.

Each CPU receives the other CPUs' status as part of the Global Data exchange. This status information is available for the diagnostic fault table, system default operation, and application program. Each PLC can monitor the actions of the two other PLCs to detect voting discrepancies. Each PLC also compares its application program checksum with those of the other PLCs and can be shut down if it is in discrepancy with the other two. A PLC that goes off-line is reported by the other two.

The application program can make use of additional diagnostics mechanisms provided by the Series 90-70 PLC and special diagnostics features of the GMR system software.

- System Status References.
- Fault and Alarm contacts.
- GMR Status and Control references.

System Status References are pre-defined references that can be included in the application program to check for specific fault-related conditions. Additional system status references indicate when the fault table has a new entry, has any entry, or is full.

Fault and Alarm Contacts: The GMR system software can optionally utilize the Fault and Alarm contacts capability of the Series 90-70 PLC to make fault and alarm information available to the application program. Fault and No Fault contacts can be used to detect fault or lack of fault conditions on a discrete or analog point. Fault and No Fault contacts can also be programmed with the Series 90-70's built-in fault-locating references. Fault-locating references identify faults associated with the system hardware to the point level. Alarm contacts can be used to indicate when an analog value has reached an assigned alarm limit.

GMR Status and Control References. The GMR system includes many status and control bits that can be used in an application program. **Status bits** provide information about GMR operations such as: system fault at startup, output discrepancy, autotest in progress, I/O reset in progress, PLC is online, I/O shutdown is activated, PLC is OK. These references can be read as needed by the application program. **Control bits** can be used to command system operations such as: clearing fault tables, initiating or inhibiting autotesting, and canceling I/O shutdown.

Input Processing

Each block in an Input Group is attached to a separate Genius bus. When the Genius blocks in the Input Group broadcast their inputs, each PLC CPU receives a copy of the corresponding inputs from each block in the group.

Input Group Broadcasting Inputs
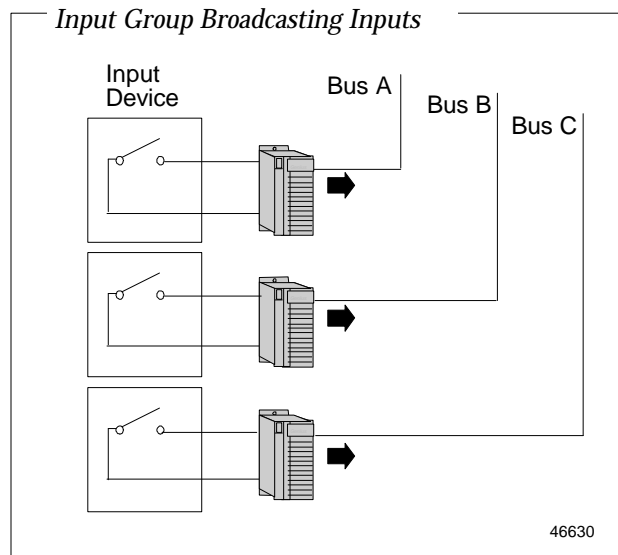
In each PLC, the Bus Controller on each bus receives the input data and provides it to the CPU.

Inputs from Bus Controllers to a CPU
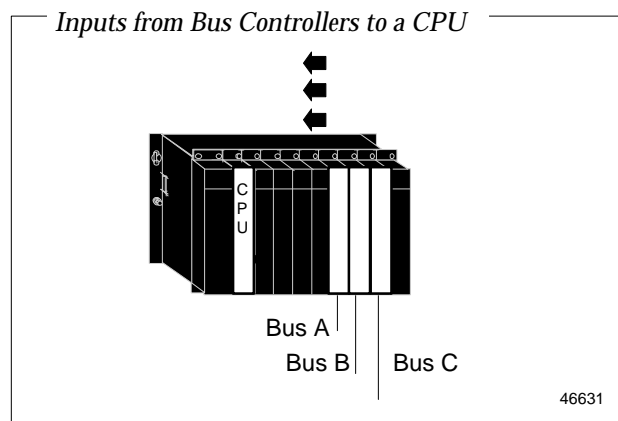
Each CPU places the input data it receives from the Bus Controllers in separate input tables, shown as A, B, and C in the next illustration. The parallel update of these input tables eliminates the need for additional I/O data communication networks between processors – along with the possibility of one CPU corrupting input data memory in another CPU. This reduces overall system components and prevents a common-mode single point failure.

Before each execution of the application program each CPU votes on the input data in input tables A, B, and C and places the results into its Voted Inputs table. The

Voted Inputs data is used in the application program. The original, unvoted input data is also available, if needed.

Input Table Mapping in Each CPU

Input Discrepancy Reporting

Each PLC performs Input Discrepancy Reporting on all discrete and analog blocks for which the feature is enabled. For dis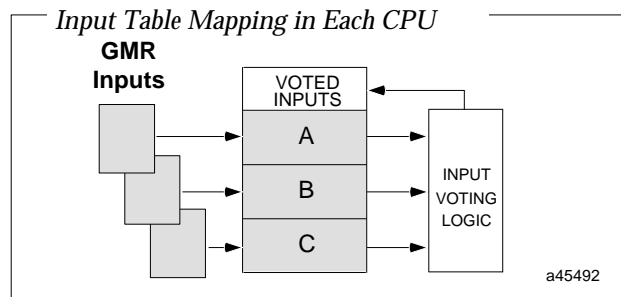crete inputs, a discrepancy exists if one input remains at variance with the other two. For analog inputs, a discrepancy exists if one analog channel deviates by more than a configurable percentage from the selected mid-value. If a discrepancy is detected, the PLC places a message in the I/O fault table indicating which input does not agree. The fault message can be seen by an operator and by the application program.

Discrete Input Voting Adaptation

For a two or three block input group, the CPU performs a 2-out of 3 vote on corresponding bits in each section (A, B, C) and places the result in the Voted input section of the input table. For single Genius input block, the actual input value is used by the application program. If a discrepancy fault, Input Autotest fault or Genius fault occurs on any point, the CPU rejects that input. Depending on the configuration of the input group, input voting may adapt from three inputs to two inputs to one input (a 3, 2, 1, 0 degradation path) or from three inputs to two inputs to the configured Default State (a 3, 2, 0 degradation path).

Analog Input Voting Adaptation

For a three-block analog input group or Field Control analog input group, the Input Voting Logic in each PLC selects the mid-value from three corresponding inputs and places the result in the Voted Input section of the Analog Input Table for use by the application program. For a group with two analog inputs, the CPU uses the high, low, or average value of the two inputs, depending on how that input group has been configured. If there is only one input value, that is used for the application program value. If a failure (discrepancy fault, or Genius fault) occurs, the GMR software rejects the faulty data. Depending on the configuration of the input group, input voting may go from three inputs to two inputs to one input, or from three inputs to two inputs to the configured default value.

Output Processing

Each CPU executes the same application program, processing the input data and creating new output data. The PLC uses separate areas of the Output Table for non-voted discrete outputs, fault-tolerant outputs, and copies of the fault-tolerant outputs.

■   Data for blocks that are included in the GMR configuration is placed at the start of the Output Table. In the illustration below, the application program outputs for redundant blocks are labeled "logic outputs". This data is followed by outputs for non-voted blocks.

■   The CPU copies these logic outputs into the bottom portion of the Output Table. This data, shown as Fault-tolerant Outputs in the illustration, is used for physical outputs for the blocks. This separation of physical outputs from logical outputs prevents disruption of outputs such as latches and seal circuits during autotesting.

■   Each bus scan, the Bus Controllers automatically send the non-voted outputs plus the copied fault-tolerant outputs to the Genius blocks.

Discrete Output Processing in Each CPU

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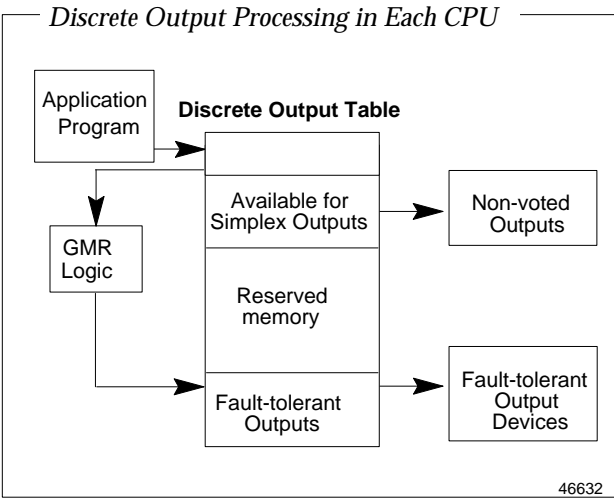
The Genius blocks in GMR output groups perform output voting, as described on the following pages.

I/O Shutdown

When the GMR system diagnoses a discrete I/O fault, it logs the appropriate faults in its fault tables and sets appropriate fault contacts. For certain types of discrete I/O faults, the system optionally allows a predefined amount of time for the problem that caused the fault to be repaired. If the problem is not rectified within this period of time, an I/O Shutdown of the I/O corresponding to the affected block(s) occurs.

I/O Shutdown is defined as setting the affected I/O to its safe state. For outputs, this is the Off state. For discrete inputs, the shutdown state is the "default" state for an input group in the GMR configuration. This is selectable for each input group.

The application program can monitor status bits to be made aware of a pending I/O Shutdown, or to completely prevent an I/O Shutdown from occurring.

The period of time before an I/O Shutdown occurs depends on the autotest interval which is set for the system. The initial autotest interval is set by the autotest interval value selected in the GMR configuration. The configured autotest interval can be adjusted in each CPU through the application program by varying the value in the autotest interval register. For example, the system allows a total maximum time of 24 hours between a fault occurring and the resultant I/O shut down when the autotest interval is set to 8 hours.

Output Subsystem

The output subsystem portion of a GMR system can include:

- Output Groups of two or four Sink and Source DC discrete Genius blocks wired to up to 32 actuators and other field output devices

- Individual Sink and Source DC discrete Genius blocks wired to up to 32 field output devices, for processor redundancy and pulse testing.

- Other types of discrete and analog blocks, which can provide Hot Standby or Duplex PLC Redundancy.

The intelligent Genius Sink and Source DC blocks store multiple sets of outputs in internal output tables. These block groups perform the voting. The manner of voting is configurable for the application. Because output voting is performed by the blocks at the point of control, bus errors are compensated for by the voting process.

Discrete Outputs

A standard "H" pattern output Genius block group provides fault-tolerant control for discrete outputs. An output group consists of two parallel Source-type blocks connected to one side of the actuator or other device and two parallel Sink-type blocks connected to other side. The diagram below represents connections between a triplicated bus, a group of 16-circuit Genius blocks and one load device. Up to 16 field devices can be connected to a group of four 16-circuit blocks. Up to 32 field devices can be connected to a group of four 32-circuit blocks.
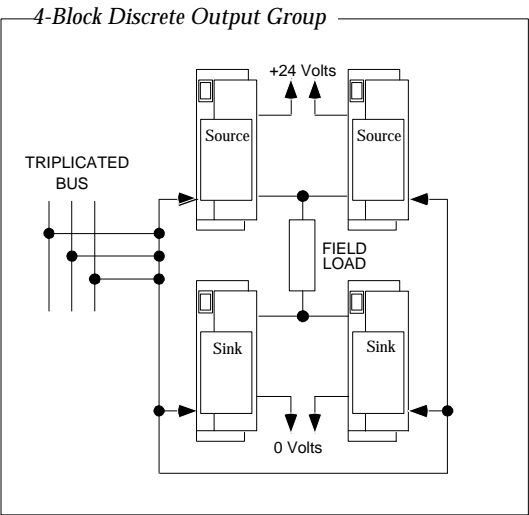
For each output device, each PLC sends a commanded state output to each of the four blocks. Under ordinary circumstances, the outputs received from all the PLCs match. For each output, the block group performs voting on the data received from the PLCs to determine the output state.

If the blocks receive outputs from three PLCs, they perform 2 out of 3 voting. If only two outputs are received, the blocks do either 1 out of 2 or 2 out of 2 voting. The method of voting is easily configured for each output group. If only a single output is received, the outputs follow the commanded state. The system can be configured to default the outputs if only a single output is received.

In a four-block output group, the combination of the voted output states of all four blocks controls the load, due to the electrical characteristics of the four blocks.

"T" Output Groups consist of of two source-type (shown here) or sink type Genius blocks, connected in parallel on one side of the load. The other side of the load is tied to ground. when two source blocks have been configured. In the T configuration where two sink blocks have been used, the other side of the load is tied to 24V. A 2-Block T Output group is "fault tolerant". This type of group might be used in high-availability or fire-and-gas applications where it is necessary to be able to turn ON a critical load.

4-Block Discrete Output Group

2-Block "T" Discrete Output Group
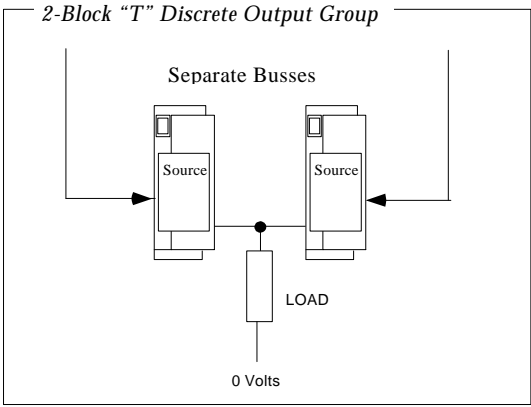
"I" Output Groups consist of a source-type Genius block connected to one side of the load and a sink-type Genius block connected to the other side of the load. This type of group is most suitable for redundant shutdown applications

This type of group might be used in fail-safe applications where it is necessary to be able to turn OFF a critical load. If either block faults. The other can still turn the load OFF.

2-Block "I" Discrete Output Block Group

Non-critical discrete outputs may be wired to Genius blocks of any type. GMR capable blocks can be configured to perform GMR voting as described above. Any single block can be configured for Hot Standby or Duplex redundancy, or for no CPU redundancy at all.

Analog Outputs

Analog blocks can be used as single blocks in a GMR output subsystem. They can be configured for either No CPU Redundancy or Hot Standby Redundancy. In Hot Standby mode, a block prefers outputs from one of the PLCs, but it will accept outputs from a second PLC if the first becomes unavailable. Current and voltage type outputs are available.

Output Diagnostics

In a GMR system, the output subsystem provides extensive diagnostic capabilities through:

- Genius Output Diagnostics, which include Short Circuit detection, Overtemperature detection, and Failed Switch detection (which compares the actual output state with the commanded state). The 16-circuit DC Sink/Source blocks also perform No Load reporting, which monitors individual outputs for the presence of a minimum load.
- Output Autotest, which determines whether each output can attain the opposite of its normal state.
- Output Discrepancy Reporting, which informs each PLC of any output which is not the same among all PLCs. Discrepancy reporting also reports on each PLC's online/offline status.

Genius Output Diagnostics. Each I/O point on a 16-point discrete DC Sink/Source block incorporates a current sensor and a voltage sensor in the smart switch design. This provides data about output circuitry and load state.

On 16-point blocks, discrete output circuits are protected by a short circuit sensor at the switching device. If the instantaneous current on an output exceeds 20 Amps, the output turns off within several microseconds. The Genius block automatically tries to restart the load. If repeated tries fail, the block turns the output Off and sends a Short

Circuit diagnostic message which is received by each PLC CPU. In the event of a transient short, normal operation can be restored by clearing the fault in any of the PLCs.

Output Autotest. Each output can be configured for Output Autotesting. The GMR Output Autotest checks the ability of each discrete output block to respond to the commanded output state. Discrete Output Autotest works on outputs that are either On or Off, with or without load monitoring. Output Autotest does not cause spurious faults to be logged and does not affect field output devices-the Genius blocks still control the physical outputs. Output Autotest can be inhibited for repair. The test uses the blocks' built-in Pulse Test capability.

Single blocks configured for Duplex or No CPU Redundancy cannot be autotested, but can be pulse-tested.

Output Discrepancy Reporting. If the blocks receive different outputs for the same load from the PLCs, they report the discrepancy back to each PLC, where a discrepancy message is placed in the Fault Tables. At the same time, a status bit is set. By checking this bit, the application program can automatically be alerted to output discrepancies at the blocks.

Output Discrepancy reporting also supplies the online/offline status of each PLC to the other PLCs.
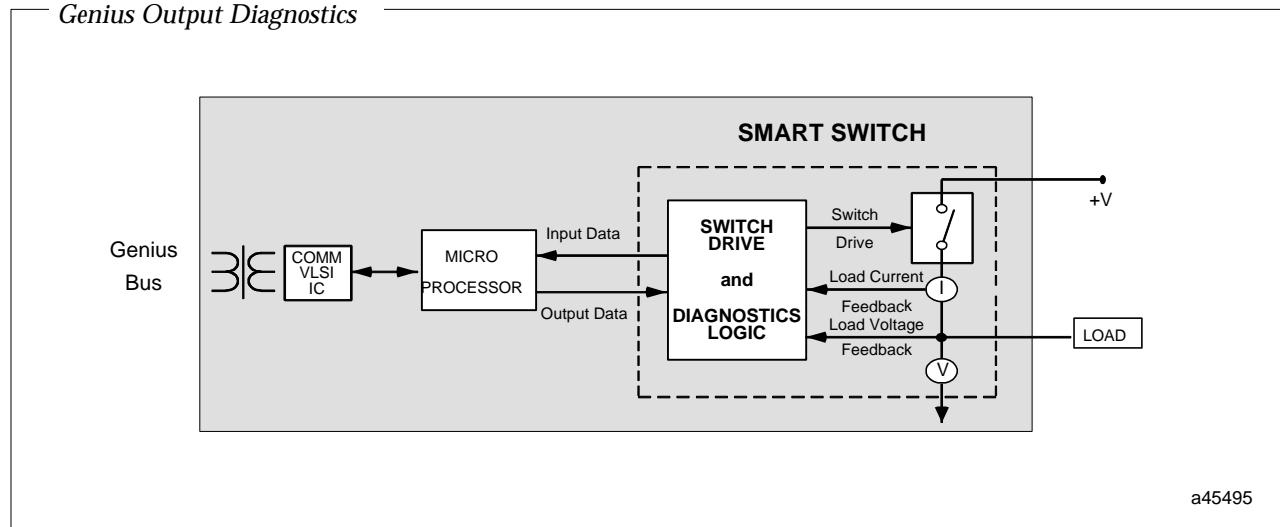
Genius Output Diagnostics
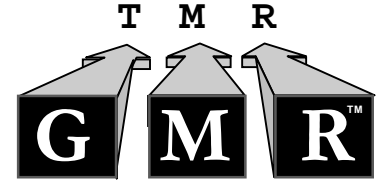
The purpose of this section is to give an overview of the elements that make up a GMR system, and to describe different types of GMR systems that can be designed.

PLC System Architecture

The GMR CPU resides in the Main Rack of a Series 90-70 PLC, immediately to the right of the power supply. The rest of the slots in the Main Rack can be used for communication modules, coprocessors, Genius Bus Controllers, and rack–based I/O modules. Special-purpose modules and custom modules (as illustrated below in slot 9) can also be included.

A Main Rack with six Bus Controllers can handle hundreds of single, dual, and triple discrete and analog I/O points using Genius I/O blocks and Field Control modules.

Larger applications can include up to seven Expansion Racks daisy-chained from the Main Rack of each GMR PLC. In a system with Expansion Racks, there must be a Bus Transmitter Module in the Main Rack and a Bus Receiver Module (BRM) in each Expansion Rack. The last Expansion Rack can be up to 50 feet (15 meters) from the Main Rack.

Each Expansion Rack supports up to nine modules, with one slot used for a BRM. A GMR system with three PLCs can include up to 24 racks with to 93 Genius Bus Controllers (31 triplicated sets). Some intelligent modules must be located in the Main Rack. GMR Bus Controllers can be located in the Main Rack or in any Expansion Rack.

No spare slots are required in any rack for "spares" or "hot replacements". Mechanical keying prevents modules from being inserted into the wrong location. The architecture of a GMR system makes it possible to replace any module while the system continues operating.

Series 90-70 PLC 19-inch Main Rack with Typical Modules

| POWER SUPPLY | CENTRAL PROCESSOR UNIT | BUS TRANSMITTER | GENIUS BUS CONTROLLER | *GENIUS BUS CONTROLLER* | GENIUS BUS CONTROLLER | PROGRAMMABLE COPROCESSOR | COMMUNICATIONS COPROCESSOR | ETHERNET CONTROLLER |

GE Fanuc

SERIES 90-70

PROGRAMMABLE CONTROLLER
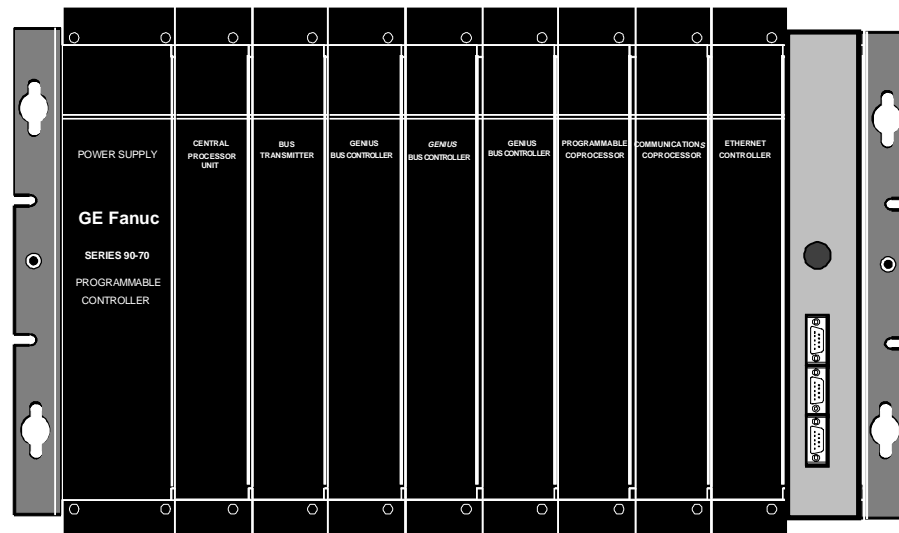
Power Supply   1   2   3   4   5   6   7   8   9

Modules can be selected to suit the application

a46600

PLC Redundancy Options

Redundancy options for the PLC portion of a GMR system include:

- Simplex: one PLC
- Duplex: two PLCs
- Triplex: three PLCs

Each PLC CPU resides in an independent rack, eliminating mechanical and electrical common mode failure. Individual PLC CPU racks may be located up to 7500' apart (the maximum distance between PLCs depends on the baud rate selected for the Genius bus that connects them).

A minimum of two bus controllers per PLC are required for fault-tolerant inter-processor communications. This allows the GMR PLCs to exchange initialization data at startup and exchange up to 64 words of global data during operation.

For maximum system integrity, two or three PLCs protect against failure of the PLC CPU or power source, or even loss of an entire PLC system. The ability to have processing performed by two or three independent PLCs is an additional important advantage of GMR.

Even when only one PLC is used, triplicated Genius Bus Controllers and bus cables, along with the ability to have triplicated inputs and fault tolerant, failsafe voted outputs, provides significant levels of redundancy.

The GMR redundancy options for both inputs and outputs can be used with one, two, or three GMR PLCs, as shown by the following illustrations. For clarity, the illustrations show PLCs without expansion racks and only a few Genius blocks per bus. In an actual system, there can be up to eight racks *per PLC* and 32 devices (Genius blocks, Bus Controllers, etc) *per Genius bus*.

GMR System with One PLC

Independent Field Input Device(s)

Single Nonvoted or Simplex, Duplex or Triplex Voted

LOAD

Fault Tolerant Fail Safe Voted Outputs

a46601

GMR System with Two PLCs

Independent
Field
Input
Device(s)

Single Nonvoted
or Simplex,
Duplex or
Triplex
Voted

LOAD

Fault Tolerant
Fail Safe
Voted Outputs

LOAD

Single
Hot Standby
or Voted
Outputs

a46602

GMR System with Three PLCs

Independent
Field
Input
Device(s)

Single Nonvoted
or Simplex,
Duplex or
Triplex
Voted

LOAD

Fault Tolerant
Fail Safe
Voted Outputs

LOAD

Single
Hot Standby
or Voted
Outputs

a46603

Input Redundancy Options

The flexibility of the GMR system makes it possible to apply the exact mix of input redundancy options needed for the application. The use of duplex or triplex sensors that provide signals to either two or three Genius blocks or Field Control analog input modules from the *same portion* of the monitored process provides maximum input redundancy.

Redundancy options for input devices in a GMR system are shown in the following illustrations.

The types of redundant input options shown in these illustrations are available for both discrete inputs and analog inputs. Note that analog inputs can use either Genius or Field Control devices, including inputs from thermocouples and RTDs.

Three Input Devices Connected to Three Blocks or One Input Device Connected to Three Blocks

Field Device

Field Device

Triplex sensors
Discrete, analog, thermocouple, RTD
Separate Genius bus for each block
All PLCs receive all inputs

Single sensor
Discrete, analog, thermocouple, RTD
Separate Genius bus for each block
All PLCs receive all inputs

a46604
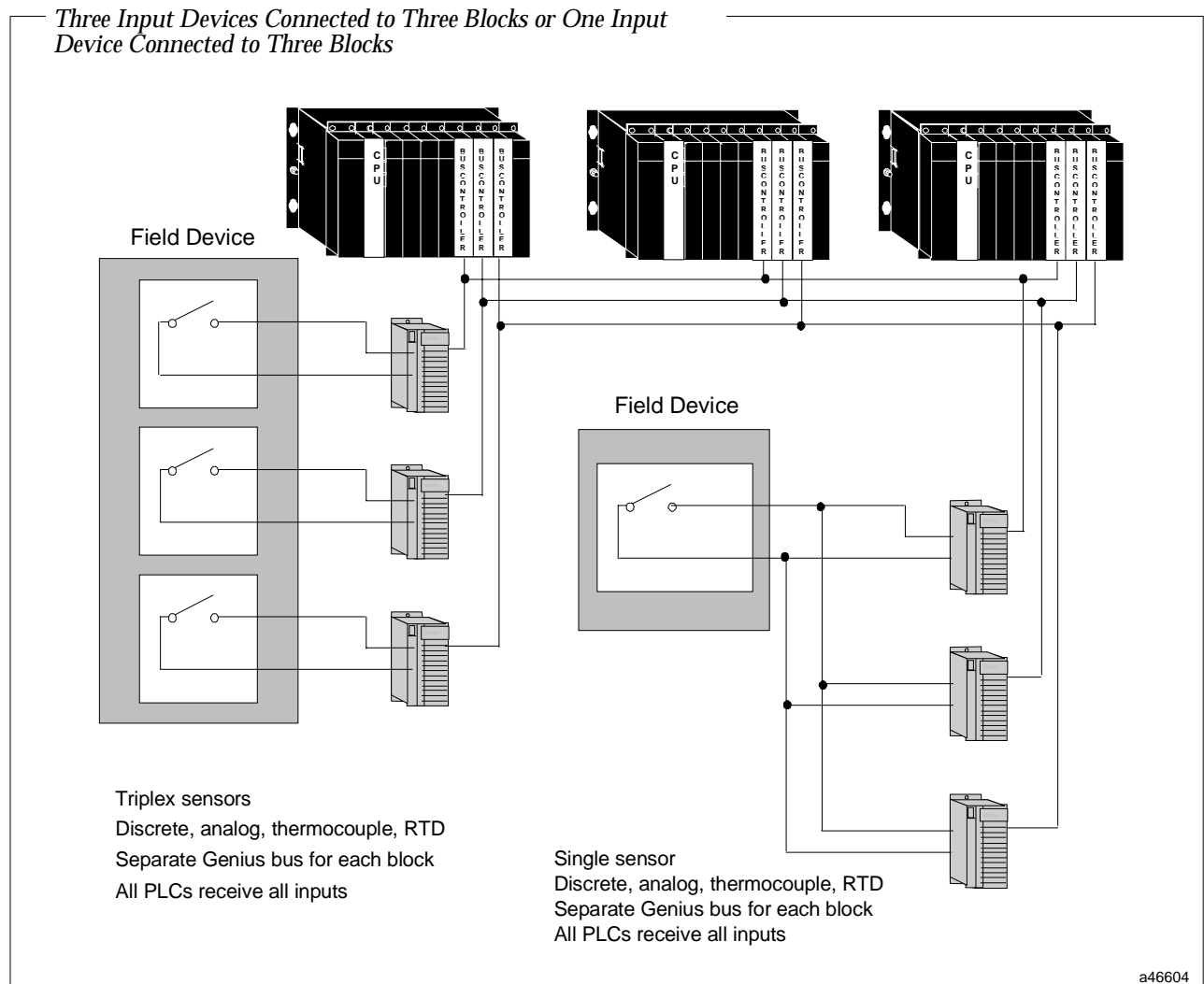
Two Input Devices Connected to Two Genius Blocks or One Input Device Connected to Two Blocks

Field Device

Field Device
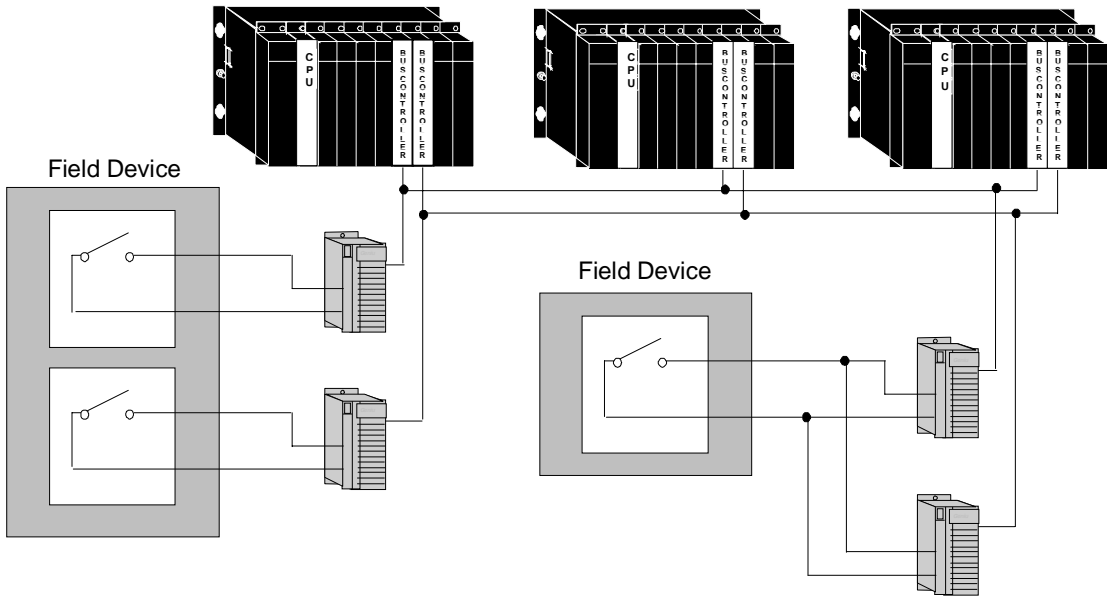
Duplex sensors

Discrete, analog, thermocouple, RTD

Separate Genius bus for each block

All PLCs receive all inputs

Single sensor

Discrete, analog, thermocouple, RTD

Separate Genius bus for each block

All PLCs receive all inputs

a46605

One Input Device Connected to Simplex or Non-voted Block

Field Device
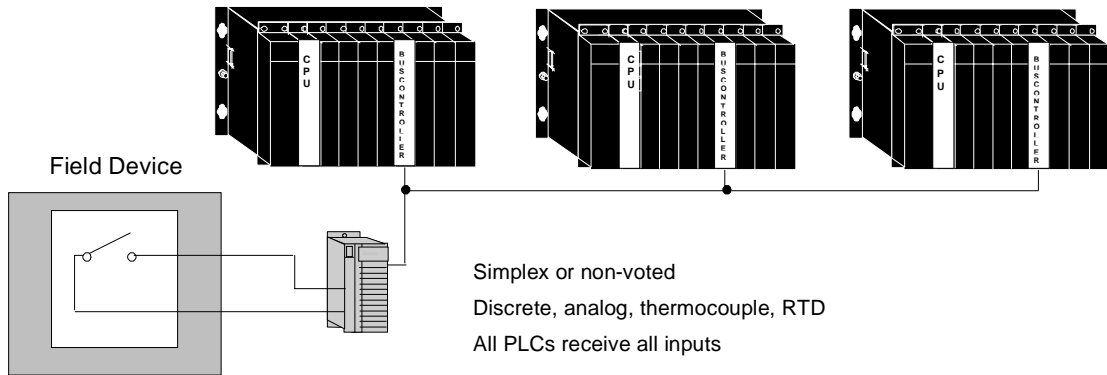
Simplex or non-voted

Discrete, analog, thermocouple, RTD

All PLCs receive all inputs

a46606

Output Redundancy Options

Output redundancy options can be mixed as appropriate within the system. Options for output devices in a GMR system include:

- ■ Single, hot standby outputs.
- ■ Single voted outputs.
- ■ H–pattern group for fault–tolerant, failsafe outputs.
- ■ T–pattern group for fault tolerant outputs.
- ■ I–pattern group failsafe for shutdown outputs.

A single block in GMR mode receives outputs from all CPUs and performs voting (2 out of 3, 2 out of 2, or 1 out of 2).

For Hot Standby redundancy, a load must be connected to one sink-type or source-type discrete Genius block. Blocks in Hot Standby mode receive outputs from all GMR CPUs and use the output data from the CPU with the Bus Controllers at the highest serial bus address (31, 30, 29) that are currently online.

Output loads that must be both failsafe and fault-tolerant are connected to a standard "H" pattern group of two

parallel source-type blocks and two parallel sink-type blocks.

A T-pattern output group can provide fault–tolerant operation with two parallel sink-type or source-type blocks. This type of group might be used in high-availability or fire–and–gas applications where it is necessary to be able to turn ON a critical load.

An I-pattern output group can provide failsafe operation with one sink–type and one source-type block wired in series with a load. This type of group might be used in failsafe applications where it is necessary to be able to turn OFF a critical load.

Non-critical outputs can be wired to individual discrete or analog blocks. Such blocks can be configured for no redundancy, or for one of the three CPU redundancy modes: Hot Standby, Duplex or GMR (2 out of 3).

For clarity, the illustrations show only one output load connected to a single block or to a group of blocks. However, each block or group of blocks can control outputs to 16 or 32 loads, depending on the block type.

Single Hot Standby Output

Single Genius block

Block receives command from all PLCs

For Hot Standby redundancy, a load must be connected to one sink-type or source-type discrete Genius block. Blocks in Hot Standby mode receive outputs from all GMR CPUs and use the output data from the CPU with the Bus Controllers at the highest serial bus address that are currently online.

LOAD

a46607

Single Voted Output

Single Genius block

Block receives command from all PLCs

2 out of 3 voting done by output block
Duplex default selection determines 1 out of 2 or 2 out of 2 voting

LOAD

a46608

Fail Safe and Fault Tolerant Output

Standard "H" pattern

Sink and source blocks

Each block receives command from all PLCs
2 out of 3 voting done by output block group
Duplex default selection determines 1 out of 2 or 2 out of 2 voting

LOAD

a46609

2 Block T-Pattern Group for High Availability

"T" pattern
Two Source or Two Sink blocks. Blocks must be on
two different busses
Each block receives command from all PLCs
Either block can control the load

a46634
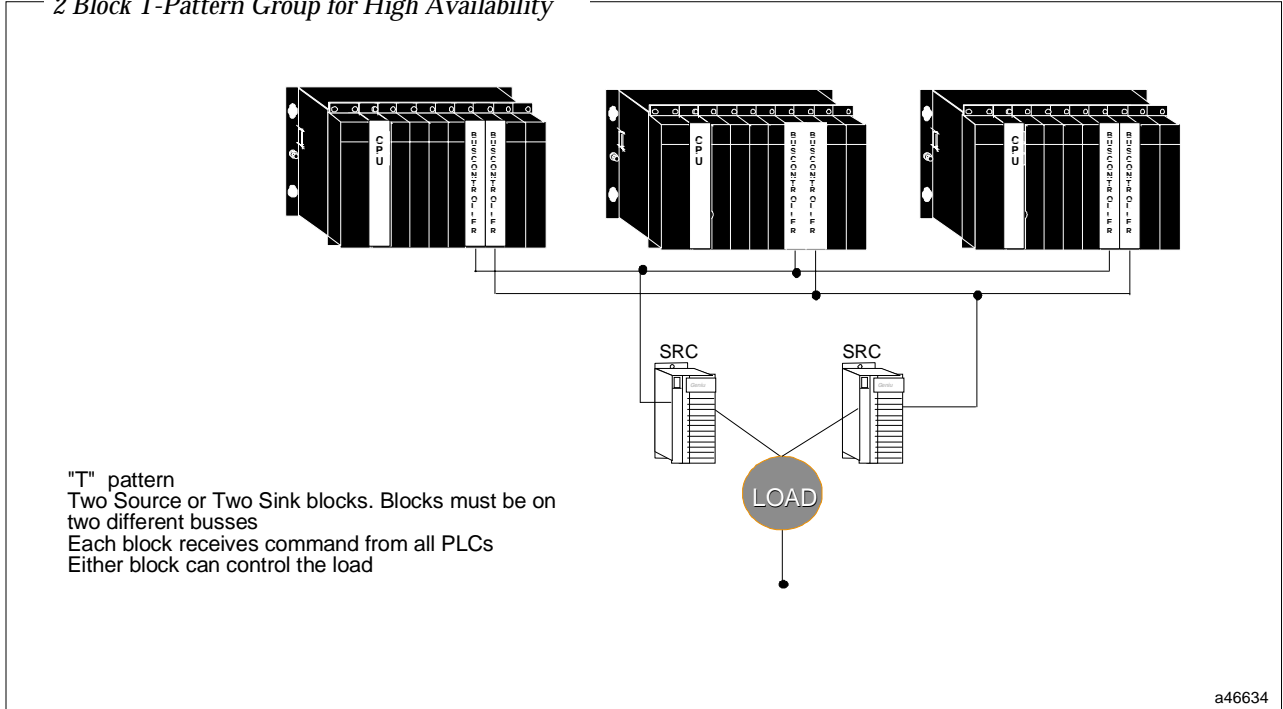
2 Block, I-Pattern Group for Redundant Shutdown

"I" pattern
One Source and One Sink block connected to different busses
Each block receives command from all PLCs
Both blocks must be active to control the load. If either
fails On, turning the other Off turns the load Off

a46633

Section	*Product*	**T M R**
4	*Specifications*	**G M R**™
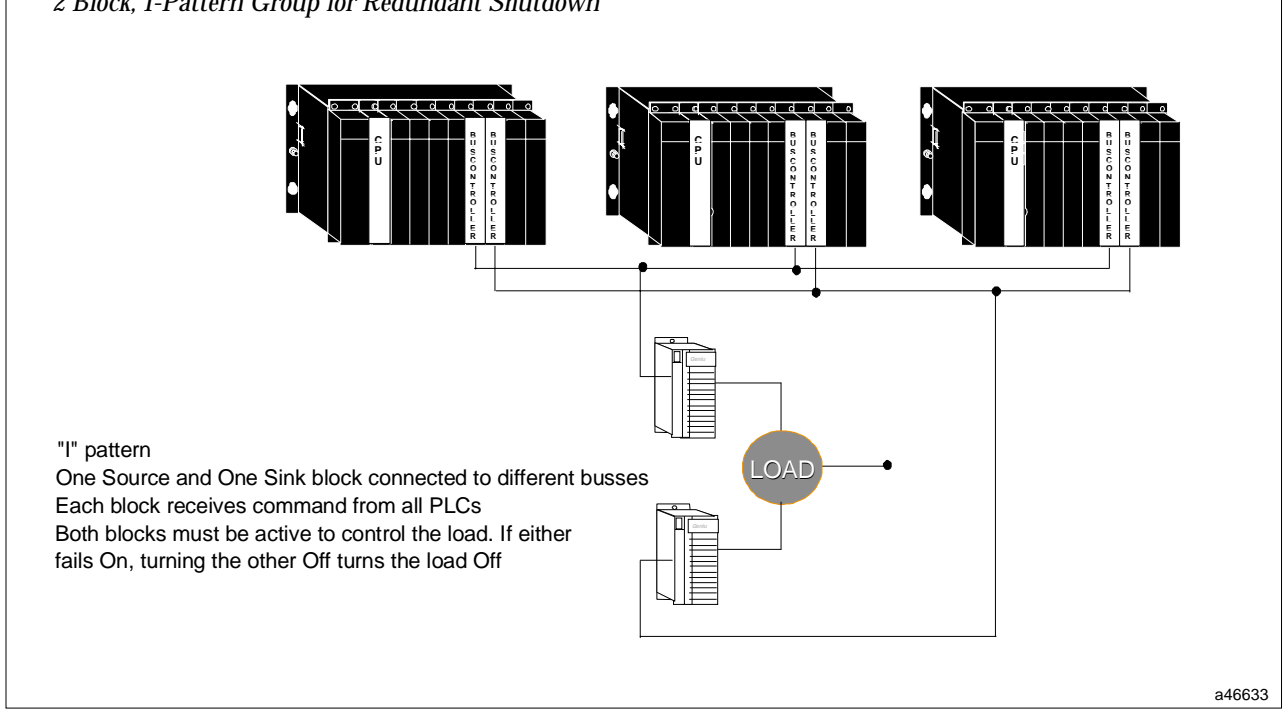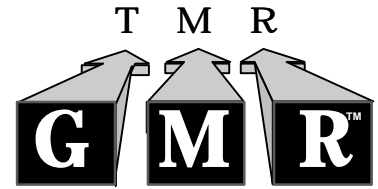
The purpose of this section is to describe in detail the Series 90-70 PLC, Genius I/O, and Field Control I/O products that might be included in a GMR system.

The section begins with a group of lists of components. Each list includes product catalog numbers and the individual TÜV approval status of each component.

Following the component listings, you will find information on agency approvals and standards.

Detailed product information begins on page 4-8, immediately after the listings. The product descriptions are included under the following headings:

- Racks
- Power Supply Modules
- CPU Modules
- Communications Modules
  - □ Communications Coprocessor Module (CMM)
  - □ Programmable Coprocessor Module (PCM)
  - □ Factory LAN Ethernet Controller Module
- Bus Transmitter & Bus Receiver Modules
- Genius Bus Controller Module
  - □ Genius I/O Network
- Genius I/O Blocks
- Genius Hand-Held Monitor
  - □ Genius Block GMR Termination Boards and Interface Modules
- Field Control Bus Interface Units and I/O Modules
  - □ Field Control Analog Input Modules
  - □ I/O Terminal Blocks

If you need more information about any of these products, please refer to other GMR, Series 90-70 and Genius manuals for further details.

GMR Components List

Software

Description	Catalog Number	TÜV Approved	Refer To:
GMR System Software for CPU 788, 789, and 790	IC641SWP715	Yes	n/a
Logicmaster 90-70 Programming Software w/CD–ROM Documentation	IC640HWC706	Yes	n/a
Logicmaster 90-70 Programming Software w/Paper Documentation	IC640HWP706	Yes	n/a
TCP/IP Ethernet Logicmaster 90–70 Programming Software w/CD–ROM Documentation	IC641SWC713		n/a
TCP/IP Ethernet Logicmaster 90-70 Programming Software w/Paper Documentation	IC641SWM713		n/a

Racks

Description	Catalog Number	TÜV Approved	Refer To:
9–slot rear mount (panel mount)	IC697CHS790D	Yes	Page 4-8
9–slot front mount (19–inch rack mount)	IC697CHS791	*	Page 4-8
5–slot rear mount (panel mount)	IC697CHS750	*	Page 4-8
17–VME-slot rear mount (panel mount)	IC697CHS782	*	Page 4-8
17–VME-slot front mount (19–inch rack mount)	IC697CHS783	*	Page 4-8
Rack Fan Assembly	IC697ACC721/724	*	-

Power Supply Modules

Description	Catalog Number	TÜV Approved	Refer To:
120/240Vac, 125Vdc, 50 Watt	IC697PWR710	*	Page 4-9
120/240Vac, 125Vdc, 50 Watt	IC697PWR712	*	Page 4-9
115/240Vac, 125Vdc, 100 watt	IC697PWR711	Yes	Page 4-9
115/240Vac, 125Vdc, 100 watt	IC697PWR713	*	Page 4-9
24Vdc, 90 watt	IC697PWR724	*	Page 4-9
48Vdc, 90 Watt	IC697PWR748	*	Page 4-9
Power Supply Expansion Cable (For 2–rack P/S function)	IC697CBL700	*	Page 4-9

CPU Modules

Description	Catalog Number	TÜV Approved	Refer To:
790 GMR CPU (2048 TMR I/O). Includes 1 meg. of memory	IC697CPM790	Yes	Page 4-11
788 GMR CPU (100 TMR I/O)	IC697CPU788	Yes	Page 4-11
789 GMR CPU (2048 TMR I/O)	IC697CPU789	Yes	Page 4-11
512K byte Memory Daughterboard (One required for each CPU 788 or CPU 789)	IC697MEM735	Yes	--

*   All Series 90–70 PLC and Genius I/O products can be used in a GMR system, however, not all of the available components are TÜV approved for use in the safety relevant portion of a system.

GMR Components List

Communications Interface Modules

Description	Catalog Number	TÜV Approved	Refer To:
Ethernet Communication Module	IC697CMM741	**	Page 4-15
Comm. Coprocessor Module (CMM)	IC697CMM711	**	Page 4-13
Programmable Coprocessor Module (PCM)	IC697PCM711	**	Page 4-14
Genius Bus Controller (GBC) Module	IC697BEM731	Yes	Page 4-17

**These communications interface modules may be used in a TÜV approved system when the appropriate variable write access protection is configured in the CPU.

Expansion Interfaces

Description	Catalog Number	TÜV Approved	Refer To:
Bus Transmitter Module	IC697BEM713F	Yes	Page 4-16
Bus Receiver Module	IC697BEM711J	Yes	Page 4-16
Field Control Genius Bus Interface Unit	IC670GBI002/102	*	Page 4-31
Field Control I/O Terminal Block with Barrier Terminals	IC670CHS001/101	*	Page 4-32
Field Control I/O Terminal Block with Box Terminals	IC670CHS002/102	*	Page 4-32
Field Control I/O Terminal Block with Wire to Board Connectors	IC670CHS003/103	*	Page 4-32

Cables, Etc...

Description	Catalog Number	TÜV Approved	Refer To:
Multi-Drop SNP Cable	IC690CBL714	*	n/a
RS232/RS485 Converter	IC690ACC901	*	n/a
Parallel I/O Expansion Cables	IC600WDXXX	*	n/a
Parallel Bus Terminator Plug	IC697ACC702	*	n/a

Termination Boards & Interface Modules

Description	Catalog Number	TÜV Approved	Refer To:
TB, 16 Disc. Src Inputs	GBC1-SC-DI16	Yes	Page 4-27
TB, 16 Disc. Sink Inputs	GBC1-SK-DI16		Page 4-27
IM, 16 Disc. Src Inputs	IMC3-SC-DI16	Yes	Page 4-27
IM, 16 Disc. Sink Inputs	IMC1-SK-DI16		Page 4-27
TB, 32 Disc. Src Inputs	GBC1-SC-DI32	Yes	Page 4-27
TB, 32 Disc. Sink Inputs	GBC1-SK-DI32		Page 4-27
IM, 32 Disc. Src Inputs	IMC3-SC-DI32	Yes	Page 4-27
IM, 32 Disc. Sink Inputs	IMC1-SK-DI32		Page 4-27
TB, 6 Analog Inputs	GBC1-CK-AI6	Yes	Page 4-27
IM, 6 Analog Inputs	IMC3-CK-AI6	Yes	Page 4-27
TB, 16 Discrete Outputs	GBC1-CK-DO16	Yes	Page 4-27
IM, 16 Discrete Outputs	IMC4-CK-DO16	Yes	Page 4-27
TB, 32 Disc. Src Outputs	GBC1-SC-DO32	Yes	Page 4-27
TB, 32 Disc. Sink Outputs	GBC1-SK-DO32	Yes	Page 4-27
IM, 32 Discrete Outputs	IMC4-CK-DO32	Yes	Page 4-27
TB to IM Cable	CBL1-CK-RRnn		Page 4-27
Cable w/2 ELCO 8016 connectors	CBL1-CK-EEnn		Page 4-27
Cable w/1 ELCO 8016 connector, stripped, tinned connectors at other end	CBL1-CK-EBnn		Page 4-27

* All Series 90-70 PLC and Genius I/O products can be used in a GMR system, however, not all of the available components are TÜV approved for use in the safety relevant portion of a system.

GMR I/O Components List

Genius Discrete Inputs

Description	Type	Catalog Number	TÜV Approved	Refer To:
24/48Vdc Source 15/16 Circuit	TMR/Simplex	IC660BBD020M	Yes	Page 4-20
24/48Vdc Sink 15/16 Circuit	TMR/Simplex	IC660BBD021M	Yes	Page 4-20
12/24Vdc Source 31/32 Circuit	TMR/Simplex	IC660BBD024N	Yes	Page 4-20
5/12/24Vdc Sink 31/32 Circuit	TMR/Simplex	IC660BBD025N	Yes	Page 4-20
115Vac 8 Circuit	Simplex	IC660BBD101	*	Page 4-21
115Vac/125Vdc 8 Circuit Isolated	Simplex	IC660BBS102	*	Page 4-21
115Vac/125Vdc 8 Circuit Isolated	Simplex	IC660BBS103	*	Page 4-21
115Vac 16 Circuit Isolated	Simplex	IC660BBD110	*	Page 4-21

Genius Discrete Outputs

Description	Type	Catalog Number	TÜV Approved	Refer To:
24/48Vdc Source 15/16 Circuit	TMR/Simplex/HSB	IC660BBD020M	Yes	Page 4-22
24/48Vdc Sink 15/16 Circuit	TMR/Simplex/HSB	IC660BBD021M	Yes	Page 4-22
24/48Vdc Source 31/32 Circuit	TMR/Simplex/HSB	IC660BBD024N	Yes	Page 4-22
5/24/48Vdc Sink 31/32 Circuit	TMR/Simplex/HSB	IC660BBD025N	Yes	Page 4-22
115Vac 8 Circuit	Simplex/HSB	IC660BBD101	*	Page 4-23
115Vac/125Vdc 8 Circuit Isolated	Simplex/HSB	IC660BBS102	*	Page 4-23
115Vac/125Vdc 8 Circuit Isolated	Simplex/HSB	IC660BBS103	*	Page 4-23
Relay N.C. 16 Circuit	Simplex/HSB	IC660BBR100	*	Page 4-23
Relay N.O. 16 Circuit	Simplex/HSB	IC660BBR101	*	Page 4-23

Genius Analog Inputs

Description	Type	Catalog Number	TÜV Approved	Refer To:
115Vac Volt/Current 4In/2Out	TMR/Simplex/HSB	IC660BBA100	*	Page 4-245
24/48Vdc Volt/Current 4In/2Out	TMR/Simplex/HSB	IC660BBA020	*	Page 4-24
115Vac/125Vdc Current Src. 4In/2Out	TMR/Simplex/HSB	IC660BBA104	*	Page 4-24
24/48Vdc Current Src. 4In/2Out	TMR/Simplex/HSB	IC660BBA024	Yes	Page 4-24
115Vac/125Vdc Current Src. 6 Input	TMR/Simplex	IC660BBA106	Yes	Page 4-24
24/48Vdc Current Src. 6 Input	TMR/Simplex	IC660BBA026	Yes	Page 4-24
115Vac/125Vdc R.T.D. 6 Input	TMR/Simplex	IC660BBA101	*	Page 4-24
24/48Vdc R.T.D. 6 Input	TMR/Simplex	IC660BBA021	Yes	Page 4-24
115Vac/125Vdc Thermocouple 6 Input	TMR/Simplex	IC660BBA103	*	Page 4-24
24/48Vdc Thermocouple 6 Input	TMR/Simplex	IC660BBA023	Yes	Page 4-24

Field Control Analog Inputs

Description	Type	Catalog Number	TÜV Approved	Refer To:
0–20 or 4–20mA, 8–Input Module	TMR/Simplex	IC670ALG230	*	Page 4-33
0–20, 4–20, or 4–24mA, 16–Input Module	TMR/Simplex	IC670ALG240	*	Page 4-33
RTD Input Module	TMR/Simplex	IC670ALG620	*	Page 4-33
Thermocouple Input Module	TMR/Simplex	IC670ALG630	*	Page 4-33

Genius Analog Outputs

Description	Type	Catalog Number	TÜV Approved	Refer To:
115Vac Volt/Current 4In/2Out	Simplex/HSB	IC660BBA100	*	Page 4-25
24/48Vdc Volt/Current 4In/2Out	Simplex/HSB	IC660BBA020	*	Page 4-25
115Vac/125Vdc Current Src. 4In/2Out	Simplex/HSB	IC660BBA104	*	Page 4-25
24/48Vdc Current Src. 4In/2Out	Simplex/HSB	IC660BBA024	Yes	Page 4-25
115Vac/125Vdc Current Src. 6 Out	Simplex/HSB	IC660BBA105	*	Page 4-25
24/48Vdc Current Src. 6 Out	Simplex/HSB	IC660BBA025	*	Page 4-25

GMR I/O Components List

Additional Genius Components

Description	Type	Catalog Number	TÜV Approved	Refer To:
High Speed Counter (HSC) Block	Simplex/HSB	IC660BBD120	*	See GFK–0367
PowerTRAC Block	Simplex/HSB	IC660BPM100	*	See GFK–0366
Red "Safety" Labels (Qty. 20)				n/a
for IC660BBA020	n/a	IC660SLA020	*	n/a
for IC660BBA021	n/a	IC660SLA021	*	n/a
for IC660BBA023	n/a	IC660SLA023	*	n/a
for IC660BBA024	n/a	IC660SLA024	*	n/a
for IC660BBA026	n/a	IC660SLA026	*	n/a
for IC660BBA100	n/a	IC660SLA100	*	n/a
for IC660BBA101	n/a	IC660SLA101	*	n/a
for IC660BBA103	n/a	IC660SLA103	*	n/a
for IC660BBA104	n/a	IC660SLA104	*	n/a
for IC660BBA106	n/a	IC660SLA106	*	n/a
for IC660BBD020	n/a	IC660SLD020	*	n/a
for IC660BBD021	n/a	IC660SLD021	*	n/a
for IC660BBD024	n/a	IC660SLD024	*	n/a
for IC660BBD025	n/a	IC660SLD025	*	n/a
Genius Hand Held Monitor	n/a	IC660HHM501	*	Page 4-27
Prefab Cable 15 Inch (qty. 3)	n/a	IC660BLC001	*	n/a
Prefab Cable 3 Foot (qty. 1)	n/a	IC660BLC003	*	n/a

* All Series 90-70 PLC, Field Control I/O, and Genius I/O products can be used in a GMR system, however, not all of the available components are TÜV approved for use in the safety relevant portion of a system.

NOTE: Not listed here are more than 30 other Field Control I/O, rack-based I/O and special-purpose intelligent modules which can be used in a simplex manner with GMR systems. Please contact your GE Fanuc Sales office for more details.

General Environmental Specifications

90-70 Components

Operating Temperature	0 to 60° C (32 to 140°F)
	0 to 40° C (32 to 104°F) for CPU model CPM790 without forced air. See I/O racks for catalog number of fan assembly.
Storage Temperature	–40° to 85° C (–40 to 185°F)
Humidity	5 to 95% non-condensing
Vibration	5–9 Hz 3.5mm displacement: 9–150 Hz at 1.0 G
Shock	15 Gs for 11 msec

Genius I/O Components

Operating Temperature	0 to 60° C (32 to 140°F)
Storage Temperature	–40 to +100° C (–40 to +212° F)
Humidity	5 to 95% non-condensing
Vibration	5–10 Hz 5.08mm displacement, 10–200 Hz at 1.0 G

Field Control Components

Operating Temperature	0 to 55° C (32 to 131°F)
Storage Temperature	–40 to +85° C (–40 to +185° F)
Humidity	5 to 95% non-condensing
Vibration	10 to 57 Hz 0.012 in displacement (p–p) 57 to 500 Hz at 2 g (or as specified)
Shock	15G, 11 ms, half sine wave

Agency Approvals, Compliances, Standards _____

TÜV

TÜV Rheinland – The Genius Modular Redundancy system has been certified by TÜV Rheinland for the following system configurations and classes:

- Triple Modular Redundant (TMR 2v3) Fault Tolerant and Fail Safe up to Class 6.
- Duplex (2v2) Fail Safe up to Class 5.
- Duplex (1v2) Fault Tolerant and Fail Safe up to Class 4.

For details and restrictions, refer to TÜV report 945/EL 340/96 or contact GE Fanuc for more information.

ISO

GE Fanuc Automation is ISO 9000 certified and ISO 9001 registered. GE Fanuc is also registered with Underwriters Laboratories (USA), the British Standards Institute (UK) and the Quality Management Institute of the Canadian Standards Association.

Standards

Most GMR components (90-70, Field Control and Genius I/O) comply with the following standards. However not every component complies with every standard listed. For specific information, please refer to the appropriate technical manual or contact your GE Fanuc Sales office.

IEC No. 142, C22.2	435,380	CSA	C22.2
JIS A–1978	C 0912, JIS C 0911	ANSI/IEEE	C–37.90
DIN 871–877	435, 380	VDE	805, 806,
UL A	508, 1012	FCC	15J Part
Hazardous Location Class I, Div II .			
NEMA/ICS	2–230.40	VME	C.1

Those components identified earlier in the components list of this document which were marked as being TÜV approved (YES) also have passed the following tests per the identified standards, which are required for TÜV approval.

Cold test	IEC 68–2–1
Dry Heat test	IEC 68–2–2
Shock test	IEC 68–2–27
Change of Temp test	IEC 68–2–14
Damp Heat Cyclic test	IEC 68–2–30
Vibration test	IEC 68–2–6
Electrostatic Discharge	IEC 801–2
RF & Electromag. Immunity	IEC 801–3
Burst test	IEC 801–4
Surge test	ANSI/IEEE 37.90.1
Overvoltage test	DIN VDE 0160 – 7.3
P.S. Interrupt test	DIN VDE 0116
P.S. Variation test	DIN VDE 0116

Racks

Standard racks are available in five-slot panel-mount, nine-slot panel mount, and 19-inch rack-mount styles. Also available is a rack with 17 standard VME slots which can be used to facilitate integration of 3rd-party modules. It is also available in panel-mount or rack-mount styles. Each of the racks can function either as the main CPU rack or as an expansion rack.

Rack fan assemblies are available for use in installations where heat buildup is a problem. The fans have a low noise level and use ball bearings for extended life.

Module Retention

All Series 90-70 modules have molded latches that automatically snap onto the upper and lower rails of the rack when the module is fully inserted. Optionally M2.5X8 screws may be used to secure the modules to the rack for high vibration applications.

Slot Covers

Unused rack slots should be covered with blank slot covers to minimize connector exposure to foreign material.

Rack and Mounting Specifications

Dimensions	Height	Width	Depth
Nine Slot Rack	266mm 10.47"	483mm 19.00"	190mm 7.5"
Five Slot Rack	266mm 10.47"	320mm 12.6"	190mm 7.5"
	Note: All modules extend 43mm (1.7") beyond the front of the rack.		
Number of Slots:	5 or 9, plus power supply slot		
Maximum 5 Volt Current:	18 amps (with 100 watt power supply) 11 amps (with 55 watt power supply)		
Current Required from I/O bus:	0.5 amps		
Ground Connection	Ground terminals are provided on each side of the rack.		
	Ring terminal, star washer and AWG#12 wire is recommended		
I/O Reference Assignment	User configurable via software (no switches)		
Rack Identification	Rack select jumpers at back of power supply slot		

Dimensions of a Standard Series 90-70 PLC Rack
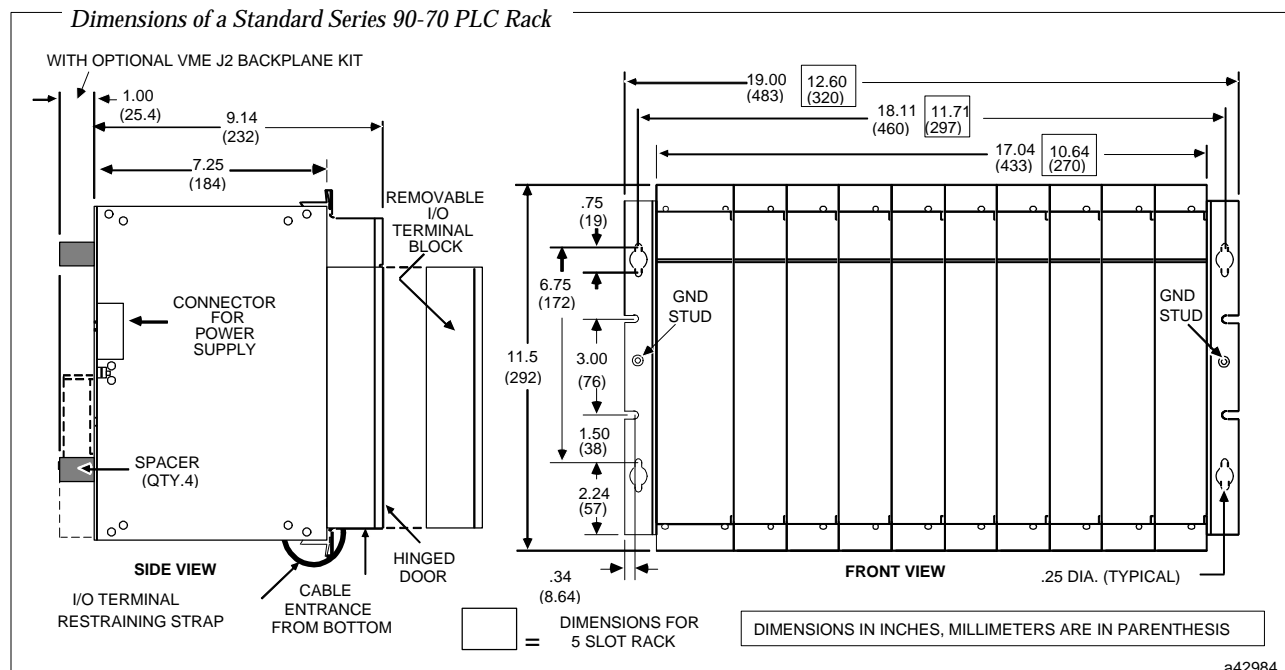
Power Supply Modules

CPU and expansion rack power supplies are inherently redundant in the GMR system, because an individual power supply is normally used in each rack. In some configurations a single power supply may be used to power both a CPU rack and an expansion rack by using a power supply expansion cable.
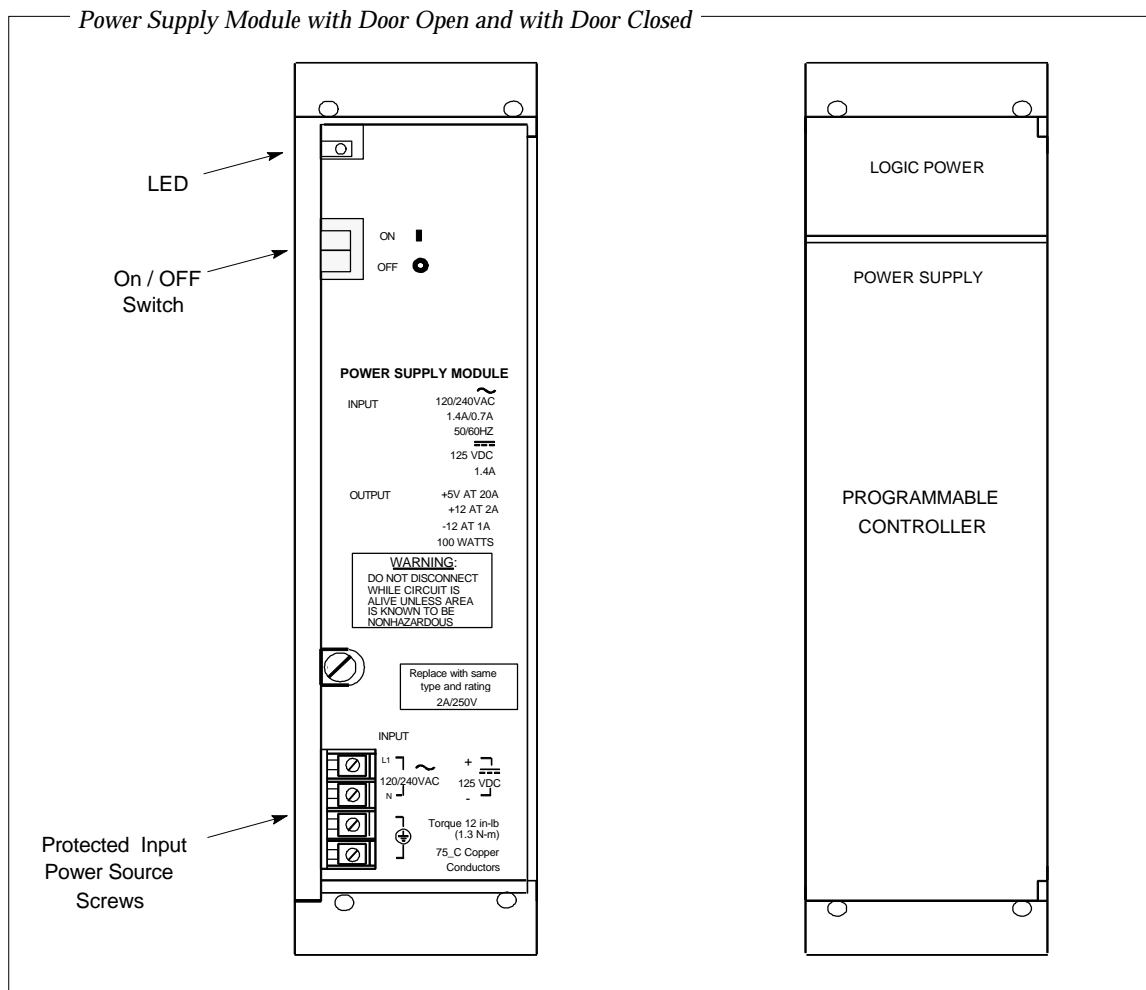
Power supplies are available that handle input power sources of 24 Vdc, 48Vdc, 125 Vdc, 120 Vac and 240 Vac. Power supplies are also available with different output wattage capabilities up to 100 watts (at 60 degrees C). Selection of a power supply can be tailored to the needs of your system.

The input power source connects to the power supply through a group of protected screw connections on the front of the power supply module.

The module LED is visible through the transparent upper portion of the door. The LED indicates the status of the power supply. If the LED is off it indicates an overload condition or output voltage levels that are out of tolerance.

Each supply provides automatic overvoltage and overcurrent protection for its DC outputs. Some supply types include a replaceable input power fuse.

Most supply types have an on/off toggle switch located inside the hinged door.

Power Supply Module with Door Open and with Door Closed

LED

On / OFF Switch

ON

OFF

POWER SUPPLY MODULE

INPUT   120/240VAC
             1.4A/0.7A
             50/60HZ
             125 VDC
             1.4A

OUTPUT   +5V AT 20A
             +12 AT 2A
             -12 AT 1A
             100 WATTS

WARNING:
DO NOT DISCONNECT
WHILE CIRCUIT IS
ALIVE UNLESS AREA
IS KNOWN TO BE
NONHAZARDOUS

Replace with same
type and rating
2A/250V

INPUT

L1   120/240VAC   + 125 VDC
N   -

Torque 12 in-lb
(1.3 N-m)
75_C Copper
Conductors

Protected Input Power Source Screws

LOGIC POWER

POWER SUPPLY

PROGRAMMABLE CONTROLLER

Dual Rack Configuration

The use of the power supply expansion cable (IC697CBL700) provides the capability to power a second rack (with +5 volts only) from the same power supply if the power supply's maximum current rating is not exceeded.

a46611
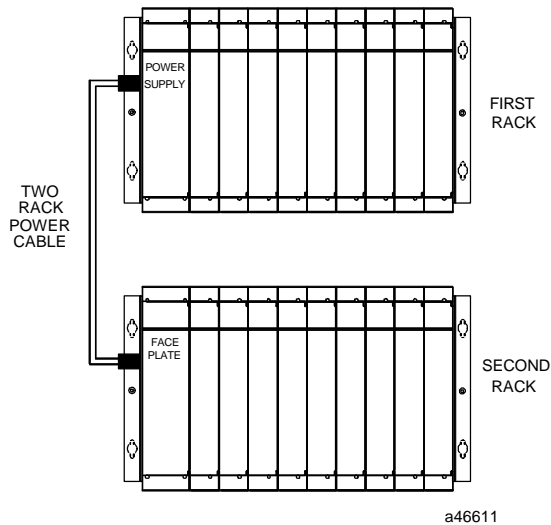
Input Power Source Connections

The illustration below shows input power source connections to the power supply through the protected screw connections on the front of the module. The AC input supplies have a jumper that must be attached to the bottom terminals for 120Vac operation. This jumper must be removed for 240Vac operation.

Example Power Connections to the Power Supply

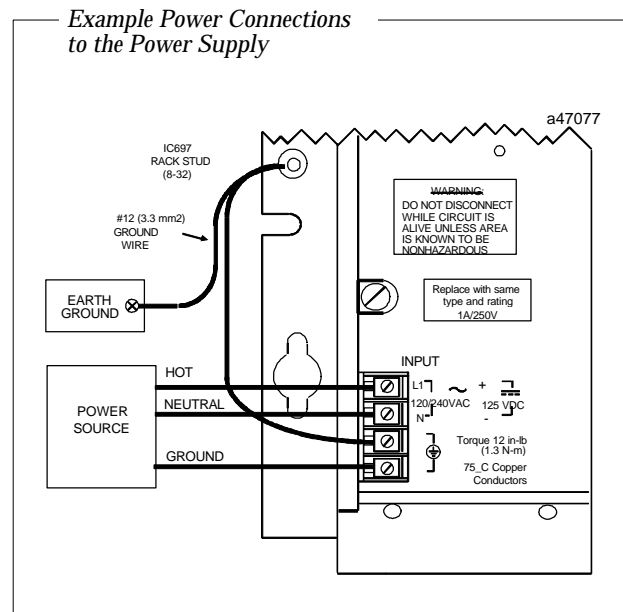| MODEL # (IC697)	PWR710 PWR712	PWR711/713 Version H or later	PWR724	PWR731 PWR732	PWR748
Nominal Voltage	120/240Vac	120/240Vac or 125 VDC	24Vdc	125Vdc	48Vdc
Input Voltage @ 47–63Hz (AC)	90–132 180–264	90-264	N/A	N/A	N/A
Input Vdc	N/A	100-150VAC	18–32	100–150	35–60
Input Power	90 Watts	160 Watts	160 Watts	100 Watts	90 Watts
Output Voltage	+5Vdc	+5,+12,–12Vdc	+5,+12,–12Vdc	+5,+12,–12Vdc	+5,+12,–12Vdc
Output Power	55.8 Watts	100 Watts	90 Watts	60 watts	90 Watts
Overvoltage Limit	5.7 – 6.7 Volts	5.7 – 6.7 Volts	5.7 – 6.7 Volts	5.7 – 6.7 Volts	5.7 – 6.7 Volts
Overcurrent Limit	12 – 14.5 amps	21 amp (5V) 3.5 amp (+12V) 1.6 amp (–12V)	26 amp (5V) 4 amp (+12V) 2 amp (–12V)	32 amp (5V) 10 amp (+12V) 10 amp (–12V)	26 amp (5V) 4 amp (+12V) 2 amp (–12V)
Holdup Time	21 ms min.	21 ms min.	10 ms min.	10 ms min.	10 ms min.

CPU Modules

Three Series 90-70 CPUs are available for TMR applications. The high-performance CPM790 CPU, which supports 2048 TMR I/O points, is based on a 64 MHz 80486DX2 microprocessor and includes a 1-megabyte memory daughterboard.. The model 788 CPU supports approximately 100 TMR I/O points and the model 789 CPU supports approximately 2048 TMR I/O points. Both the 788 and 789 have a 16 Mhz 80386DX microprocessor and occupy one slot in the CPU rack (with memory daughterboard attached). Software configuration of the CPUs is done using the LM90-70 programming and configuration software--no switches or jumpers are used.

These CPUs execute both the GMR system software and the application program logic. Application program logic is typically written in ladder logic form, but Sequential Function Chart (SFC) programming and "C" programming capabilities also exist. These CPUs along with the GMR system software perform the following functions:

- User application program execution
- Inter-CPU communications
- Majority voting of all inputs
- Input and output autotesting
- Input and output discrepancy checking
- General system diagnostics
- Fault reporting

The CPM790 CPU module includes 1 megabyte of memory. Approximately 512K bytes of this memory is available for the application program. The CPU 788 and 789 modules require a 512K-byte memory daughterboard. Approximately 200K bytes of this memory is available for the application program. This CMOS RAM is battery-backed by a lithium battery on each CPU module. The battery can retain memory contents for up to six months. The battery has a life of at least ten years. The module has two battery connectors so a replacement battery can be added before a "low" battery is disconnected. A low battery, dead battery and missing battery are all diagnosed and alarmed by the CPU.

Each of up to three CPUs in a system operates entirely independent from each other CPU. The CPUs exchange general status information, autotesting and fault information, program checksum and configuration data checksum information and optionally user application data via a built–in global data facility. This information and data is exchanged between the physically-isolated CPUs over the same Genius I/O buses that are already present to interface to I/O modules.
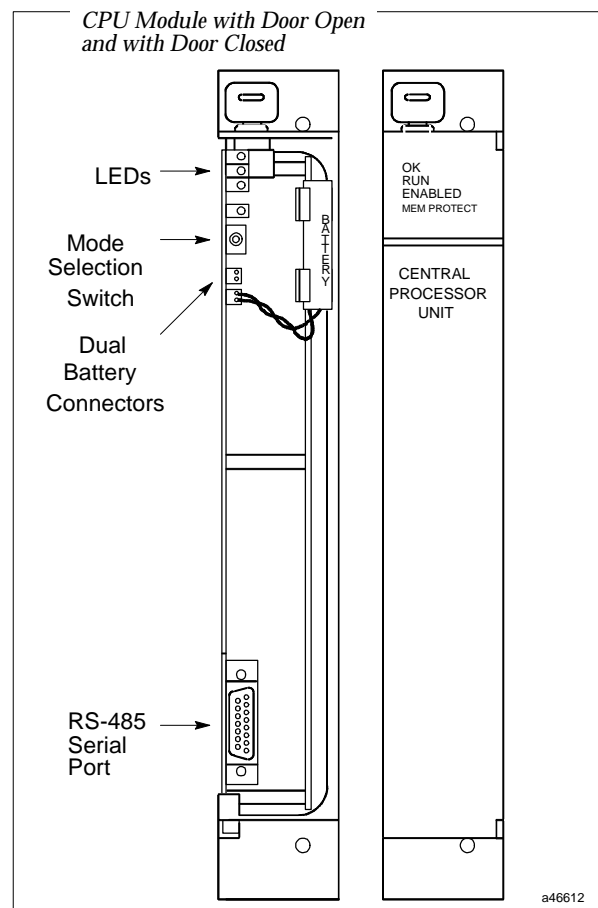
Extensive CPU module and memory diagnostics are performed both at powerup and continuously by each CPU. Faults are logged in a PLC fault table which can be viewed with the Logicmaster programming and configuration software. The

other CPUs are made aware of any individual CPU faults by reading status information.

Each CPU has a built-in RS-422/RS-485 serial port which is typically used for a multi-drop connection to the programming and configuration system. It can also be used for connection to a host system or operator interface.

A three–position toggle switch can be used select Run Mode or Stop mode. A Memory Protect prevents accidental program changes (passwords can also be used). Four status LEDs (all normally on) show the CPU's status:

- "OK" LED – CPU diagnostic tests executed successfully (no faults).

- "RUN" LED – CPU is in Run mode and executing application program.

- "ENABLED" LED –CPU has enabled outputs to turn on/off as set in the application program

- "MEM PROTECT" LED – Memory Protect keyswitch is on.

CPU Module with Door Open and with Door Closed

LEDs

Mode Selection Switch

Dual Battery Connectors

RS-485 Serial Port

OK
RUN
ENABLED
MEM PROTECT

CENTRAL PROCESSOR UNIT

a46612

CPU Module Specifications

MODEL # (IC697)	CPU788	CPU789	CPM790
Max. fully triplicated TMR Digital Inputs	112	2048	2048
Max. fully triplicated TMR Digital Outputs	80	2048	2048
Max. fully triplicated TMR Digital I/O (Combined I&O)	112	4096	4096
Max. Total Digital I/O (Simplex, Duplex & TMR) Depends on amount of TMR I/O)	352	12288	12288
Max. Total voted analog inputs	1024	1024	1024
Max. Total simplex inputs/outputs	8192	8192	8192
Maximum Application Program Size (Approximate)	200K bytes	200K bytes	512K bytes
Cooling Fans	Not required	Not required	Not required for ambient $\leq$40° C Fan kit is required for ambient >40° C

All Remaining CPU Module Specifications are common to the CPU788, CPU789, and CPM790.

Max. Register Table Size	16 Kwords
Max. Analog Inputs	8192 (Depends on amount of TMR Analog Inputs)
Max. TMR Analog Inputs	1024
Max. Analog Outputs	8192
Autotest Time Interval	0 to 65535 Minutes
Ladder Logic Execution Rate	Boolean = 0.4ms per 1024 elements
Lithium Battery for Memory Backup	3 Volt; 1000mA hours (6 months minimum retention)
Clock	Battery Backed Calendar Clock
Ladder Instruction Set	Contacts, Coils, Links, Timers, Counters, Bit Operation, Conversion, Relational, Control, Math, Data Table and Data Move
WatchDog Timer	Configurable from 10 to 2250 milliseconds
Digital Vote Type	2 out of 3 (also configurable for 2oo2, 1oo2, or 1oo1)
Analog Vote Type	Mid–value select (also for duplex–average, high or low select)
Degradation Options	3–2–1–0 or 3–2–0 (available for inputs, outputs, and CPUs)
On–Line Programming	Configurable as Enabled or Disabled
Write Protection for Application Program Variables	Configurable limits for (%R, %I, %Q, %AI, %AQ, %T, %M and %G)
Processor Synchronization	None – Asynchronous
Effect of CPU Failure	None – Remaining CPU(s) will report loss of CPU only and continue to operate

Communications Modules

Communications Coprocessor Module (CMM)

The Communications Coprocessor Module (CMM) provides Communications Control (CCM), Remote Terminal (RTU) and Series Ninety (SNP) communications. CCM, RTU (slave)* and SNP are available on the serial ports in nine selectable combinations: CCM/CCM, CCM/RTU, RTU/CCM, RTU/RTU, SNP/SNP, SNP/CCM, CCM/SNP, SNP/RTU, and RTU/SNP.

CCM

Functions in CCM mode are: read/write of register, input and output tables; bit set/clear of inputs and outputs; read scratch pad; Q sequence commands for fast reads; and modify diagnostic status word. In the master and peer CCM configurations the CMM module initiates communications with other devices through the application program.

RTU

In the RTU Slave protocol, the following functions are provided: read input and output tables; read analog input; read register table; read scratch pad; read exception status; force a single or multiple outputs; preset a single or multiple registers; report device type and perform loopback maintenance. RTU master protocol is available in the PCM module with application code.

SNP

Each serial port on the CMM can be configured to provide SNP master or slave capability. The SNP protocol on the CMM module provides read and write access to registers, inputs, outputs, analog inputs, analog outputs, %T, %M, %P, %L and %G variable types. Full Series Ninety datagram capability and many status and control functions are also supported. An "autodial" feature is provided to control a Modem. SNP-X extensions to the SNP protocol provide high performance read and write access to the same variable types listed above. SNP-X is especially useful for high-speed data acquisition and control in multidrop configurations. In the master SNP configurations the CMM module initiates communications with other devices through application program communications requests.

The CMM provides both the RS-232 and RS-485 Interfaces and communicates with the CPU over the backplane. It is typical in a GMR system to use one CMM in each of up to three CPUs, however each CPU can support multiple CMMs mounted in either the CPU rack or an expansion rack.

Three status LEDs at the top of the module indicate "module OK" and "Port 1" and "Port 2" transmit/receive activity. A single pushbutton in located beneath the LEDs and can be pushed to reinitialize communications at both serial ports. No other switches or jumpers exist on the board – configuration is accomplished by using the LM90-70 programming and Configuration software. The CMM module utilizes a 12 Mhz 80C186 microprocessor.

CMM Module with Door Open
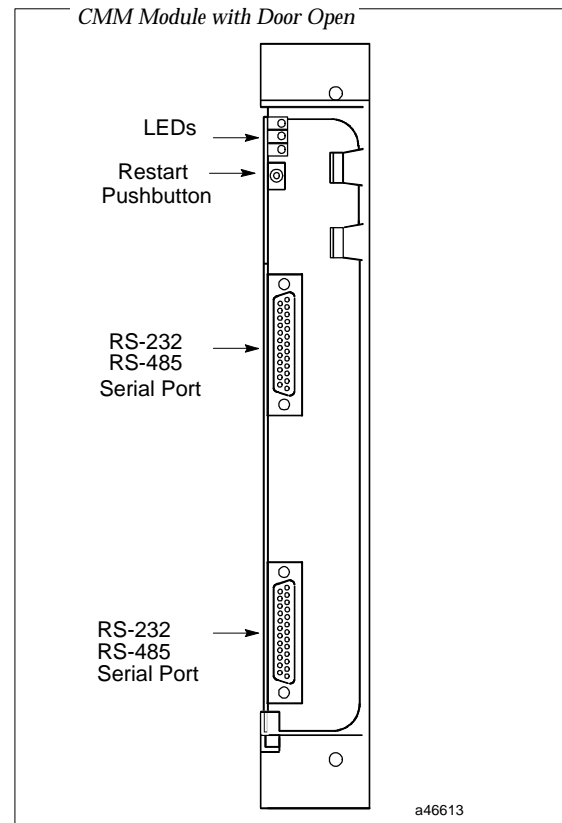
MODEL # (IC697)	CMM711
Protocols	CCM, RTU, SNP/SNP–X
Port # 1 Interface type	RS–232 or RS–422/RS–485
Port # 2 Interface type	RS–232 or RS–422/RS–485
Port #1 Max Data Rate	19.2 Kbps (full duplex)
Port #2 Max Data Rate	19.2 Kbps (full duplex)
Dual Port Max Data Rate	19.2 Kbps (full duplex) on both port simultaneously
Battery	None Required
Microprocessor	12 Mhz 80C186
Configuration	Via LM90-70 Software (No Switches or Jumpers)

Communications Modules *(continued)*

Programmable Coprocessor Module (PCM)

The Programmable Coprocessor Module (PCM) functions as a coprocessor to the CPU. It can be programmed to perform operator interface, real-time computations, data storage and custom protocols for data acquisition or data communications functions. CCM2 functions provided by the PCM module are: read/write of register, input and output tables; bit set/clear of inputs and outputs; read scratch pad; Q sequence commands for fast reads; and modify diagnostic status word. In the master and peer CCM configurations, the PCM module initiates communications with other devices through application program requests.

The PCM communicates with the CPU over the backplane. It can access user and system data using extensions to the powerful Megabasic language. No application program support is required in the PLC CPU. Multiple PCMs can be supported by each CPU. The PCM board has up to 95 Kbytes of user memory. In addition, a PCM can accommodate an optional expansion memory daughterboard up to 512 Kbytes in size. Both types of memory are backed by a replaceable lithium battery.
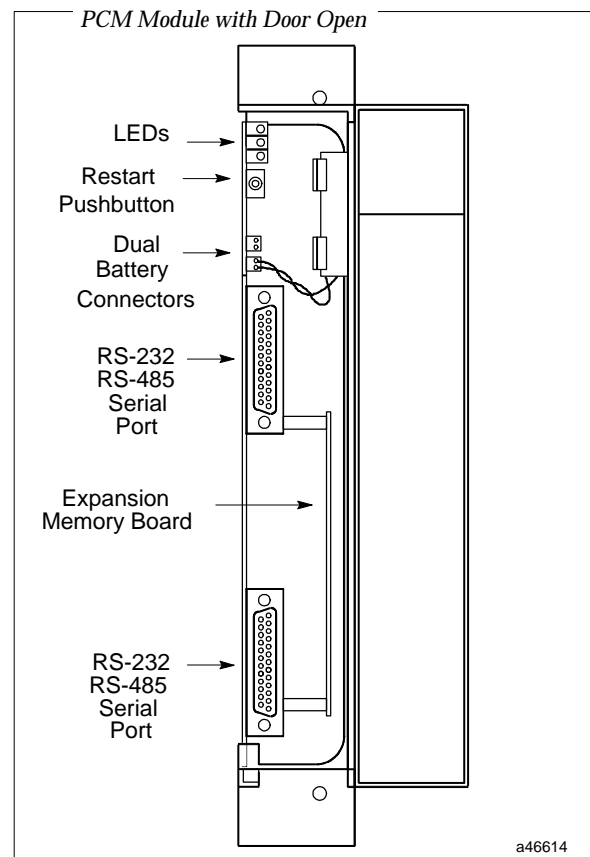
MODEL # (IC697)	PCM711
Dual Tasking	CCM/Megabasic
Protocols	CCM2 or Custom via Megabasic application program.
Port # 1 Interface type	RS–232 or RS–422/RS–485
Port # 2 Interface type	RS–232 or RS–422/RS–485
Port #1 Max Data Rate	19.2 Kbps (full duplex)
Port #2 Max Data Rate	19.2 Kbps (full duplex)
Dual Port Max Data Rate	19.2 Kbps (full duplex) on both port simultaneously
Microprocessor	12 Mhz 80C186
Memory	Up to 96 Kbytes of battery backed CMOS RAM on board
Expansion Memory	64, 128, 256 or 512 Kbytes battery backed CMOS RAM
Lithium Battery for Memory Backup	3 Volt; 1000mA hours (6 months minimum retention)
Clock	Real time calendar clock synchronized to GMR CPU
Configuration	Via LM90–70 Programming and Configuration Software or PCM Development Software (No Switches or Jumpers)
Controls/Indicators	Reset Pushbutton / Three Status LEDs

The PCM has three Status LEDs. One indicates the condition of the module (Module OK). The others may be assigned a function. The module pushbutton is used to restart a PCM application or to set the PCM to its factory default configuration but retain any application program. Both serial ports are RS-232 and RS-422/485 compatible. Both ports operating simultaneously can support up to 19.2 Kbaud full duplex communications.

The PCM is a dual-tasking processor; a custom Megabasic program can run while the PCM is being used as a communications interface.

Software is used to configure the port parameters, to define the interface to the CPU, to select task functions and to program Megabasic applications. Configurations include:

- CCM only – CCM2 master, slave or peer on both ports.

- BASIC – Megabasic only where the Megabasic application has access to both serial ports.

- BAS/CCM – Megabasic and CCM2 together. The Magabasic application has access to port 1 and port 2 is used as a CCM communication interface.


PCM Module with Door Open

LEDs

Restart Pushbutton

Dual Battery Connectors

RS-232 RS-485 Serial Port

Expansion Memory Board

RS-232 RS-485 Serial Port

a46614

Communications Modules *(continued)*

Ethernet Modules

The Ethernet Controller module (IC697CMM741) provides direct connection to IEEE 803.2 CSMA/CD LANs. The module has an 802.3 standard D-connector for attachment of a user-supplied AUI (Attachment Unit Interface) or transceiver cable. The AUI cable connects directly to a user-supplied transceiver that is directly connected to the 10Mbps Ethernet network. The transceiver must be 802.3 compatible and must have the SQE option.

The Ethernet Interface (Type 2) Module (IC697CMM742) provides high-performance TCP/IP communications. The module's 10BaseT and 10Base2 ports permit direct connection to a network without an external transceiver. The AUI port permits attachment to a user-supplied AUI cable and user-supplied transceiver.
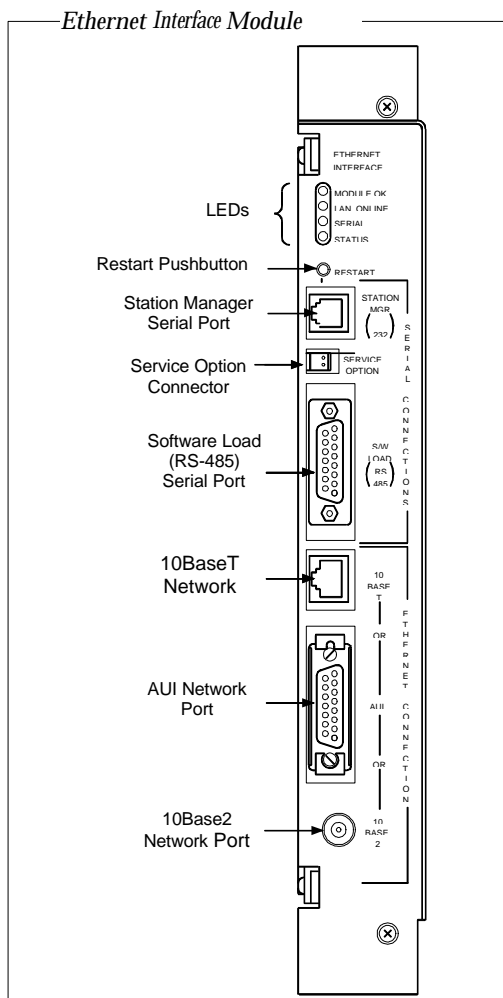
These Ethernet modules plug into a single slot of a PLC rack. Module LEDs indicate status. The module's Restart pushbutton is used to restart the module and to reload the software. A local serial port is provided to connect to the Factory LAN System Manager (GSM) terminal. The communications software may be loaded through this port.

Note: Fault-tolerant redundant serial communications can be provided by using communications modules in rack 1 and rack 2.

Model # (IC697)	CMM741	CMM742
Protocols Supported	TCP/IP, MMS/OSI, SRTP	TCP/IP, SRTP
Interface	IEEE 802.3 CSMA/CD Medium Access Control 10 Mbps	
Media	10Base5, 10Base2, 10BaseT, 10BaseF, 10Broad36	
Software	Stored in RAM Memory – easily updated	
System Management Tools	GSM System Manager provides Network Performance Measurement, Fault Diagnosis, Configuration Management and Software Downloading	
Configuration	Via LM90–70 Programming and Configuration Software "Soft Switches	
Controls, Indicators	Restart Pushbutton / Three Status LEDs	Restart Pushbutton / Four Status LEDs

Ethernet Interface Module

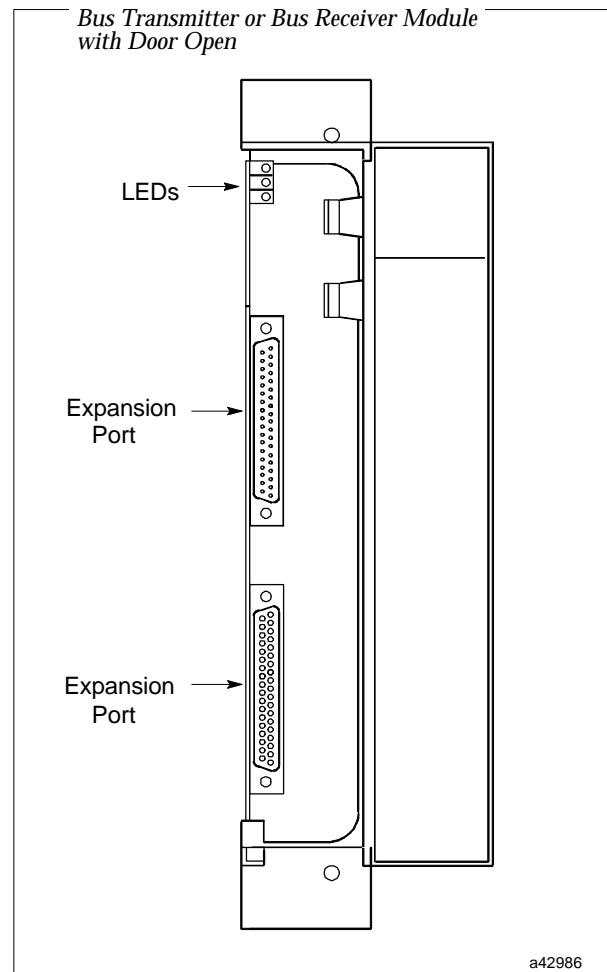# Bus Transmitter & Bus Receiver Modules

Bus Transmitter and Receiver Modules permit expansion from the main GMR CPU rack to a maximum of 7 additional racks, using up to 50 feet (15 meters) of interconnecting cable.

Model # (IC697)	BEM713(BTM) and BEM711(BRM)
Expansion Racks Supported	7 Maximum
Parallel Programmed Interface (included on BTM)	High Performance 500 Kbytes/Second
Time to Store 16 Kbyte Program	20 to 30 seconds
Maximum Cable Length	50 Feet (15 Meters) Total
Effective I/O Data Rate	500 Kbytes/Second
Electrical Isolation	Non-isolated Differential Communications

NOTE

TOTAL LENGTH OF ALL INTERCONNECTING CABLES FROM BTM TO LAST BRM IS 50 FEET (15 METERS) MAXIMUM. ALL RACKS MUST BE AT SAME GROUND POTENTIAL (8 RACKS MAXIMUM).

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Bus Transmitter or Bus Receiver Module with Door Open

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The Bus Transmitter Module is used in the main CPU rack to begin the daisy chain of rack(s) using parallel I/O cables (IC600WDFXXX – where XXX = length in feet). The upper connector on the BTM can be used as a high–performance interface to the (running LM90–0 programming and configuration software). The bottom connector of the BTM is for daisy chain cable connections between the Main CPU rack and all expansion racks. LEDs at the top of the BTM module provide Module OK, Programmer Port Enabled, and Expansion Port Enabled status information.

The Bus Receiver Module is used in each of the expansion racks and is always installed in slot one. Both connectors in the BRM are for connections between racks. LEDs on the BRM module provide Rack Configured, Termination Installed and Expansion Port Enabled status information.
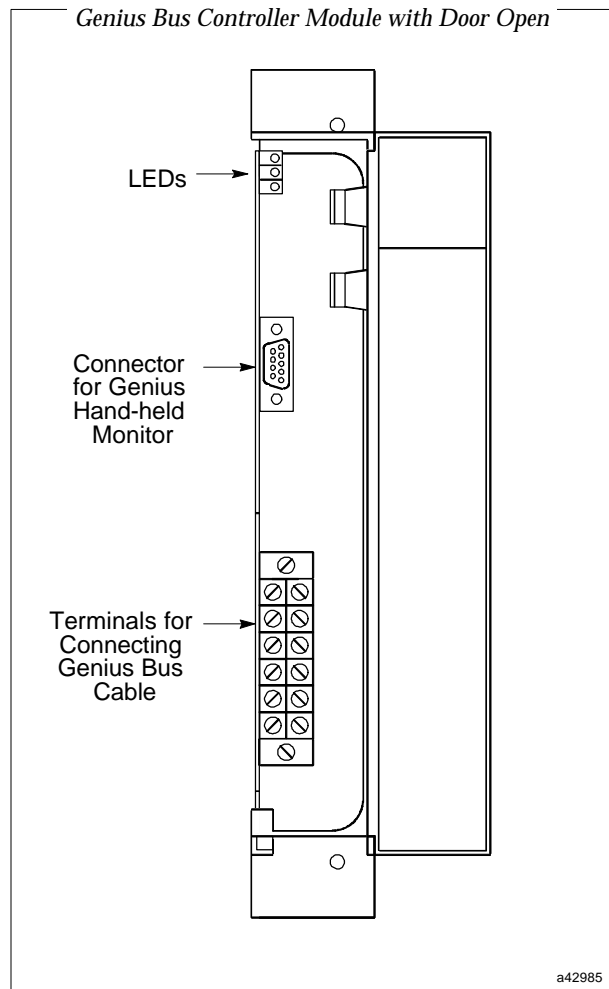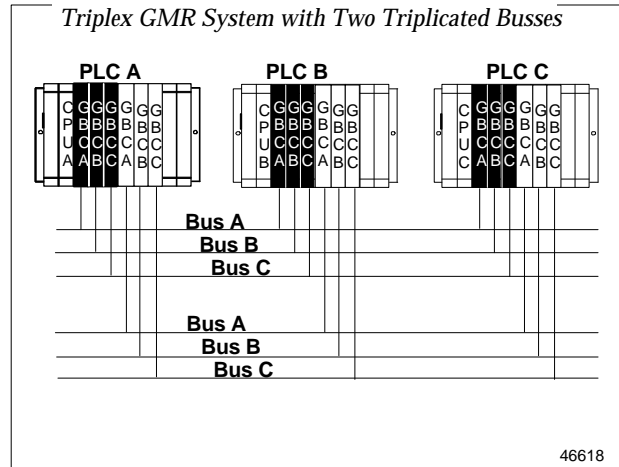
Genius Bus Controller Module

The Genius Bus Controller (GBC) is a single-channel controller that occupies a single rack slot in either the CPU rack or any expansion rack. Its primary purpose is to interface the I/O subsystem to the GMR CPUs. Multiple GBCs may be installed in each rack to suit the I/O capacity needs for an application.

The front of the module provides a port for direct connection of a Genius Hand-held Monitor and screw terminals for the Genius bus.. Two LEDs show Module OK and Channel One OK status information.

The Bus Controller scans I/O blocks asynchronously and transfers I/O data to the GMR CPU once per CPU scan over the backplane of the rack. The Bus Controller also passes fault information from the I/O devices to the GMR CPU, which time-stamps faults and queues them in a table.

Genius Bus Controller Module with Door Open

LEDs

Connector for Genius Hand-held Monitor

Terminals for Connecting Genius Bus Cable

a42985

Typically, three Genius Bus Controllers are used per GMR PLC for a triplex GMR bus. Two triplicated GMR Buses are shown in the following drawing of a triplex GMR system. Alternatively, two Genius Bus Controllers can be used for a duplex GMR bus or a single Genius Bus Controller for a simplex GMR bus or a "non-GMR bus".

Triplex GMR System with Two Triplicated Busses

PLC A   PLC B   PLC C

Bus A
Bus B
Bus C

Bus A
Bus B
Bus C

46618

Additional Genius Bus Controllers can be outside the scope of the GMR configuration but still part of a GMR system. Through the exchange of directed communications (datagrams) and global data, they can serve as communications nodes linking other devices and provide peer–to–peer information transfer. Such a network can provide communications between multiple PLCs and host computers.

| MODEL # (IC697)	BEM731
Devices Supported per Bus	28 Blocks Typical – 31 Maximum (including up to 3 GBCs and 1 HHM)
Communications Rates	153.6 Kbaud Standard, 153.6 Kbaud Extended, 76.8 Kbaud, 38.4 Kbaud
Maximum Cable Lengths	2000 feet @ 153.6 Kbaud Standard
	3500 feet @ 153.6 Kbaud Extended
	4500 feet @ 76.8 Kbaud
	7500 feet @ 38.4 Kbaud
Configuration	Via LM90–70 Programming and Configuration Software (No Hardware Switches or Jumpers)
Effect of Failure of One GBC in a group	None – Loss of IOC reported – other GBC(s) in the redundant group continue to operate

Genius I/O Network

The Genius I/O network interfaces Genius I/O blocks to the GMR PLC system. It serves as a communications interface to pass startup, diagnostic and application data between the CPUs of the GMR PLC system. The Genius network also provides an open–architecture interface to a variety of third–party devices including personal computers.

Typical bus cable is shielded twisted pair or twinaxial cable. No special connectors are required; saddle-clamp screw connectors are provided on all devices. Each physical end of a bus is terminated with appropriate termination resistors which are provided. Fiber optics cable with modems can be used for long distance requirements or if additional isolation is required.

The Genius network operates at 4 speeds up to 153.6K baud. The maximum length of a network depends on the speed selected; it can be up to 7,500 feet. Maximum bus cable lengths depend on which of four baud rates is selected and the cable type as shown in the chart below.

Each Genius serial bus conveys data by passing a "token" among the devices. When the token is received by a device it is that device's turn to communicate. A "bus scan" occurs when all devices on the bus have received the token one time. During one bus scan the GBC receives all inputs from all blocks, receives any fault information from all blocks, updates all outputs on the I/O blocks, sends any commands received from the CPU. The Genius bus scan is independent and asynchronous from the GMR CPU sweep.

Bus Scan Cycle a43528
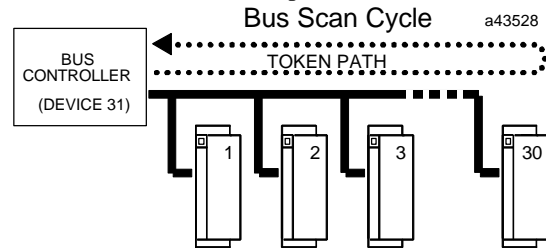
Cable # & Make	Outer Diameter	Terminating Resistor* –10% to +20% 1/2 Watt	Number of Conductors/ AWG	Dielectric Voltage Rating	Ambient Temp Rating	Maximum Length Cable Run, feet/meters at baud rate			
						153.6s	153.6e	76.8	38.4 ●
(A)9823 (B)9182 (C)4596 (M)M39240	.350in 8.89mm	150 ohms	2 / #22	30v	60ºC	2000ft 606m	3500ft 1061m	4500ft 1364m	7500ft 2283m
(B)89182	.322in 8.18mm	150 ohms	2 / #22	150v	200ºC	2000ft 606m	3500ft 1061m	4500ft 1364m	7500ft 2283m
(B)9841 (M)M3993	.270in 6.86mm	*120 ohms	2 / #24	30v	80ºC	1000ft 303m	1500ft 455m	2500ft 758m	3500ft 1061m
(A)9818C (B)9207 (M)M4270	.330in 8.38mm	100 ohms	2 / #20	300v	80ºC	1500ft 455m	2500ft 758m	3500ft 1061m	6000ft 1818m
(A)9109 (B)89207 (C)4798 (M)M44270	.282in 7.16mm	100 ohms	2 / #20	150v	200ºC	1500ft 455m	2500ft 758m	3500ft 1061m	6000ft 1818m
(A)9818D (B)9815	.330in 8.38mm	100 ohms	2 / #20			1500ft 455m	2500ft 758m	3500ft 1061m	6000ft 1818m
(O)911264**	.260in 6.60mm	100 ohms	2 / #22 flexing	250v	80ºC	1500ft 455m	2000ft 606m	3000ft 909m	4500ft 1364m
((E)532185 BBDN	.approx 50in 12.7m	100 ohms	4 pairs #24 (solid)	>150v	80ºC	1500ft 455m	2000ft 606m	3000ft 909m	4500ft 1364m
(A)9818 (B)9855 (M)M4230	.315in 8.00mm	100 ohms	4 (two pair) #22	150v	60ºC	1200ft 364m	1700ft 516m	3000ft 909m	4500ft 1364m
(A)9110 (B)89696 (B)89855	.274in 6.96mm	100 ohms	4 (two pair) #22	150v	200ºC	1200ft 364m	1700ft 516m	3000ft 909m	4500ft 1364m
(A)9814C (B)9463 (M)M4154	.243in 6.17mm	75 ohms	2 / #20	150v	60ºC	800ft 242m	1500ft 455m	2500ft 758m	3500ft 1061m
(A)5902C (B)9302 (M)M17002	.244in 6.20mm	75 ohms	4 (two pair) #22	300v	80ºC	200ft 60m	500ft 152m	1200ft 333m	2500ft 758m

Notes: A = Alpha, B = Belden, C = Consolidated, E = Essex, M = Manhattan, O = Olflex

● = Limited to 16 taps at 38.4 Kbaud, ** = Suitable for applications requiring high flexibility, continuous flex or vibration.

Genius I/O Blocks

Genius I/O blocks provide a full range of I/O types and densities. All block types may be used in a GMR system as non-critical or simplex I/O. A subset of the available blocks may be used as GMR I/O. Genius I/O blocks make it possible to distribute I/O in quantities as low as 6 points, Distributed and remote placement of the I/O at the point of control reduces problems associated with large amounts and lengths of control wiring. Genius I/O blocks can also be grouped at a central location (e.g. in a main control panel).

Genius I/O Block

a44485
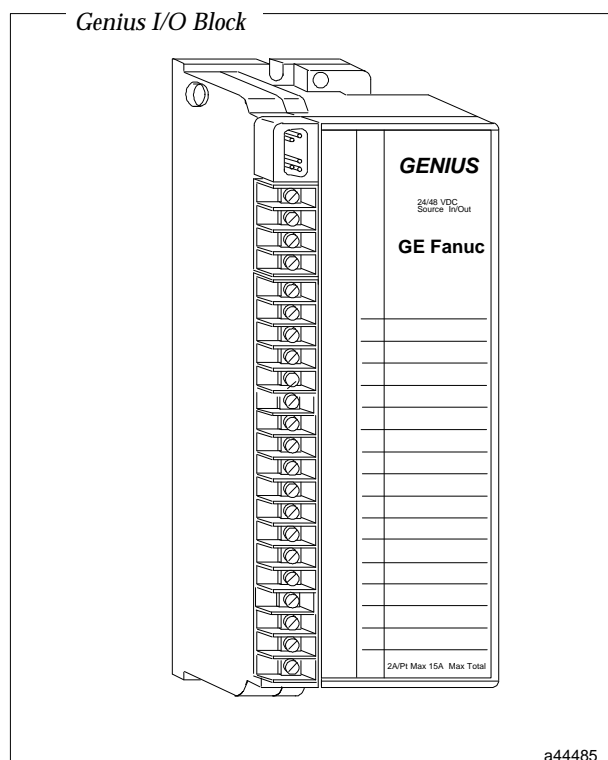
Each Genius I/O block is a standalone unit with built-in power supply, microprocessor and Genius network communications circuitry. Each block is made of cast aluminum and weighs about 4 pounds (1.8Kg). The size of most block types is approximately 9" (22cm) high x 3.5" (9cm) wide x 4" (10cm) deep.

Each block consists of a matching terminal assembly and electronics assembly. The terminal assembly forms the base of the block and is electrically and mechanically keyed to accept only an electronics assembly of the same type. All field connections are made to the terminal

assembly. All active components are located in the electronics assembly portion of the block, which can be removed without disturbing the field wiring.
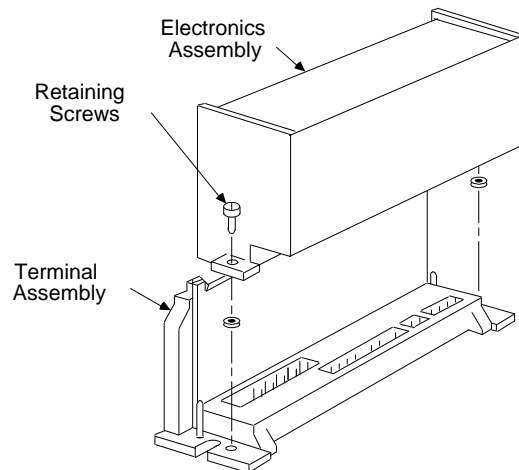
Genius blocks have no switches or jumpers and are software-configured via a Hand-Held Monitor (HHM). This "soft" configuration is stored in the terminal assembly so there is no need to reconfigure if an electronics assembly is changed. Genius blocks are unique in that many types allow each circuit to be configured as either an input or an output, providing excellent flexibility and the ability to easily customize the I/O system to the application. In the tables that follow, you will see these block types listed in both the input section and the output section.

In addition to individual circuit indicators on most blocks, every block provides two diagnostic LEDs which show the health of the block and its individual circuits, and show whether a block is online or has a forced circuit.

The I/O data for each block is communicated over the Genius bus with the Genius Bus Controllers in GMR PLCs, Blocks can be located up to 7500 feet (or more by using fiber optics Modems) and form a truly distributed I/O system.

All blocks can be used in a GMR system as simplex I/O. Those identified in the tables that follow can also be used as triplex, duplex or in the case of some outputs, in a Hot Stand By (HSB) mode. Optional field termination boards are available to facilitate the wiring of TMR blocks.

Genius Discrete Input Block Specifications

The blocks listed on this page may be used as TMR input blocks or as simplex input blocks in a GMR system. For these blocks, the duplicate and triplicate input data is received at all GMR CPUs and then voted just prior to executing the application program to ensure the highest integrity of the input data used. Selected discrete input blocks can diagnose stuck-on and stuck-off input circuit electronics and diagnose circuit-to-circuit shorts. Some blocks also provide supervised input diagnostics (input shorted to +24Vdc).

A failure of a block or circuit results in both the appropriate block diagnostic LED indication and the fault being logged into fault tables of each PLC. TMR inputs continue to operate with the remaining blocks or "legs" of the input group. Failed TMR input blocks may replaced hot (power on) without disturbing the functioning portion of the input group or any other part of the system.

MODEL # (IC660)	BBD020*	BBD021*	BBD024*	BBD025*
Number of Points (With Autotest)	15	15	31	31
Number of Points (W/O Autotest)	16	16	32	32
Nominal Voltage	24/48Vdc	24/48Vdc	12/24Vdc	5/12/24Vdc
Source or Sink Operation	Source	Sink	Source	Sink
DC Voltage Range	18–56	18–56	10–30	10–30 & 4.9–5.3
Required DC Power (Max.)	300ma	300ma	300ma	300ma
Block Isolation	1500V	1500V	850V	850V
Point Status LEDs	1 per point	1 per point	1 per point	1 per point
Diagnostic LEDs	————Unit OK (Block or Point Fault Indication)————— ——I/O Enabled (On–Line and Forced Point Indication)——			
Supervised Input Diagnostic	Yes	Yes	n/a	n/a
P.S. Dropout Time	10 ms	10 ms	4ms @ 12V 20ms @ 24V	4ms @ 12V 20ms @ 24V
Operating Modes	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX
Input Autotest (Stuck On/Off)	Yes	Yes	Yes	Yes
Input Autotest (Channel–to–Channel Short)	Yes	Yes	Yes	Yes
Loss of Block Diagnostic	Yes	Yes	Yes	Yes
Selectable Filter Time	5–100ms	5–100ms	1–100ms	1–100ms
Input Impedance (Typical)	5.6 K ohms	5.6 K ohms	3.3 K ohms	3.3 K ohms
On Threshold (12Vdc Power)	n/a	n/a	8–12Vdc	0–4Vdc
On Threshold (24Vdc Power)	16–24Vdc	0–8Vdc	18–24Vdc	0–6Vdc
On Threshold (48Vdc Power)	32–48Vdc	0–16Vdc	n/a	n/a
Off Threshold (12Vdc Power)	n/a	n/a	0–6Vdc	6–12Vdc
Off Threshold (24Vdc Power)	0–7Vdc	17–24Vdc	0–12Vdc	12–24Vdc
Off Threshold (48Vdc Power)	0–14Vdc	34–48Vdc	n/a	n/a
Weight	————————————4 lbs. (1.8 kg)————————————			

* These blocks can operate as inputs or outputs in any combination when in HSB or Simplex Mode

Discrete Input Block Specifications Continued

The following blocks can be used as simplex input blocks in a GMR system.

Simplex input blocks also provide a variety of diagnostic capabilities depending on the block type. Please refer to the Genius I/O User's Manuals for more details.

MODEL # (IC660)	BBD101*	BBD102*	BBD103*	BBD110
Number of Points	8 Grouped	8 Isolated (4 Groups)	8 Isolated (4 Groups)	16 Grouped
Nominal Voltage	115Vac	115Vac 125Vdc	115Vac 125Vdc	115Vac
Operating Modes	SPLX/HSB	SPLX/HSB	SPLX/HSB	SIMPLEX
AC Voltage Range (47–63Hz)	93–132	93–132	93–13	93–132
DC Voltage Range	n/a	105–132	105–132	n/a
P.S. Dropout Time	1 Cycle	1 Cycle 10ms DC	1 Cycle 10ms DC	1 Cycle
Block Isolation	1500V	1500V	1500V	1500V
Point Status LEDs	1 per point	1 per point	1 per point	1 per point
Diagnostic LEDs	————Unit OK (Block or Point Fault Indication)———— ———I/O Enabled (On–Line and Forced Point Indication)———			
Open Input Diagnostic	Yes	Yes	Yes	Yes
Shorted Input Diagnostic	No	No	No	Yes
Loss of I/O Power Diagnostic	Loss of Block	Yes	Yes	Loss of Block
Selectable Filter Time	10–100ms	10–100ms	10–100ms	10–100ms
Input Impedance (Typical)	13 K ohms	13 K ohms	13 K ohms	11.6 K ohms
AC On Threshold (Normal Mode)	95 VRMS	95 VRMS	95 VRMS	programmable
AC Off Threshold (Normal Mode)	60 VRMS	60 VRMS	60 VRMS	programmable
DC On Threshold (Normal Mode)	n/a	90 Vdc	90 Vdc	n/a
DC Off Threshold (Normal Mode)	n/a	55 Vdc	55 Vdc	n/a
Weight	————————————4 lbs. (1.8 kg)————————————			

* These blocks can operate as inputs or outputs in any combination

Genius Discrete Output Block Specifications

The Genius blocks listed below may be used as GMR Output blocks or as Hot Standby or simplex blocks in a GMR system Output data is received individually from each GMR CPU by each output block in a group and then to ensure the highest integrity of the data used, the output block group votes the data before driving critical loads on or off.

Most output blocks employ electronic overload and short circuit protection, which allow an output circuit to be reset without the need to replace a fuse and cause a fault

to be logged in the fault table of each GMR CPU. Please refer to the Genius I/O user's manuals for more details. A failure of a block or circuit results in both the appropriate block diagnostic LED indication and fault logged into fault tables of each PLC. TMR outputs continue to operate with the remaining blocks or "legs" of the output group. Failed TMR output blocks may replaced hot (power on) without disturbing the functioning portion of the output group or any other part of the system.

MODEL # (IC660)	BBD020*	BBD021*	BBD024*	BBD025*
Weight	——————————————4 lbs. (1.8 kg)——————————————			
Nominal Voltage	24/48Vdc	24/48Vdc	12/24Vdc	5/12/24Vdc
Source or Sink Operation	Source	Sink	Source	Sink
Operating Modes	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX
Number of Points	16	16	32 20ms @ 24V	32 20ms @ 24V
DC Voltage Range	18–56	18–56	10–30	10–30 & 4.9–5.3
Required DC Power (Max.)	300ma	300ma	300ma	300ma
P.S. Dropout Time	10 ms	10 ms	4ms @ 12V	4ms @ 12V
Block Isolation	1500V	1500V	850V	850V
Point Status LEDs	1 per point	1 per point	1 per point	1 per point
Diagnostic LEDs	————Unit OK (Block or Point Fault Indication)———— ——I/O Enabled (On–Line and Forced Point Indication)——			
Diagnostics Available: Loss of Block Short Circuit Overload No Load Failed Switch Overtemp Output–to–Output Short Short to +24 Vdc Short to 0 Vdc	Yes Yes Yes Yes Yes Yes Yes Yes Yes	Yes Yes Yes Yes Yes Yes Yes Yes Yes	Yes Yes No No Yes No Yes Yes Yes	Yes Yes No No Yes No Yes Yes Yes
Steady State Output Current	2 amps	2 amps	0.5 amps	0.5 amps
Max. Inrush Current (for 10 ms)	10 amps	10 amps	4 amps	4 amps
Total Current per Block @35°C	15 amps	15 amps	16 amps	16 amps
Output Off Leakage Current	1.0 ma	1.0 ma	10 μa	10 μa
Output Voltage Drop	2.0 V max.	2.0 V max.	2.0 V max.	2.0 V max.
Minimum Load with No–Load Enabled – TMR	100 ma	100 ma	n/a	n/a

* These blocks can operate as inputs or outputs in any combination when in HSB or Simplex Mode

Discrete Output Block Specifications Continued

The blocks listed below, used individually, can operate in either a simplex mode, duplex mode or Hot Stand By (HSB) mode. HSB is a mode in which a block uses output data from only one CPU unless that CPU fails, in which case the block uses output data from an alternate CPU.

MODEL # (IC660)	BBD101*	BBD102*	BBD103*	BBR100 BBR101
Number of Points	8 Grouped	8 Isolated (4 Groups)	8 Isolated (4 Groups)	16 Isolated (4 Groups)
Nominal Voltage	115Vac	115Vac 125Vdc	115Vac 125Vdc	115/230Vac
Operating Modes	SPLX/HSB	SPLX/HSB	SPLX/HSB	SPLX/HSB
AC Voltage Range (47–63Hz)	93–132	93–132	93–132	5–250
DC Voltage Range	n/a	105–132	105–132	5–220
P.S. Dropout Time	1 Cycle	1 Cycle 10ms DC	1 Cycle 10ms DC	1 Cycle
Block Isolation	1500V			1500V
Point Status LEDs	1 per point			1 per point
Diagnostic LEDs	————Unit OK (Block or Point Fault Indication)———— ——I/O Enabled (On–Line and Forced Point Indication)———			
Diagnostics Available: Loss of Block Loss of I/O Power Short Circuit Overload No Load Failed Switch Overtemp	Yes No Yes Yes Yes Yes Yes	Yes Yes Yes Yes Yes Yes Yes	Yes Yes Yes No No No Yes	Yes No No No No No No
Steady State Output Current	2amps RMS	2 amps	2 amps	2 amps
Max. Inrush Current (for 2 cycles AC or 10 ms DC)	25amps peak	25 amps	25 amps	2 amps
Total Current per Block @35°C	15 amps	15 amps	15 amps	125VA/pnt.
Output Off Leakage Current	< 7 ma	7 ma AC 2 ma DC	7 ma AC 2 ma DC	0.1 ma
Output Voltage Drop	2.5 V max.	2.5 V max.	2.5 V max.	2.0 V max.
Minimum Load with No–Load Enabled	50 ma	50 ma	50 ma	n/a
Weight	————————4 lbs. (1.8 kg)————————			

* These blocks can operate as inputs or outputs in any combination

Genius Analog Input Blocks

All of the listed block types may be used as TMR Analog input blocks. These blocks include those that can handle Voltage, Current, R.T.D., and Thermocouple input signals. TMR Analog input blocks function in a group of up to three blocks (of the same type). The duplicate and triplicate input data is received at all GMR CPUs and then voted just prior to executing the application program to ensure the highest integrity of the input data used. Voting on triplicated data is mid-value select with the vote adapting to average, select-high or select-low in the event of a failure. A second failure results in further vote adaptation to either use the last operational input or go to a preconfigured minimum, maximum or hold-last-state value.

A failure of a block or circuit results in both the appropriate block diagnostic LED indication and the fault being logged into fault tables of each PLC. TMR analog inputs continue to operate with the remaining blocks or "legs" of the input group. Failed TMR analog input blocks may replaced hot (power on) without disturbing the functioning portion of the input group or any other part of the system.

All analog input blocks provide a variety of diagnostic capabilities. In addition, the blocks perform automatic self–calibration of internal circuitry. Please refer to the Genius I/O user's manuals for more details.

| **AC MODEL # (IC660)**	**BBA100**	**BBA104**	**BBA106**	**BBA101**	**BBA103**
DC MODEL # (IC660)	**(BBA020)**	**(BBA024)**	**(BBA026)**	**(BBA021)**	**(BBA023)**
Number of Points	4In/2Out	4In/2Out	6 In	6 In R.T.D.	6 In T.C.
Operating Modes	TMR/HSB SIMPLEX	TMR/HSB SIMPLEX	TMR/ SIMPLEX	TMR/ SIMPLEX	TMR/ SIMPLEX
Input Range(s) or Linearization (RTD) or T.C. Types (T.C.)	4–20ma 0–10Vdc –10–+10Vdc 0–5Vdc –5–+5Vdc	4–20ma	4–20ma	Platinum Nickel Copper Linear	Type J, K, T, E, B, R, S, N
Nominal P.S. Voltage (AC)	115	115	115	115	115
Nominal P.S. Voltage (DC)	(24/48)	125 (24/48)	125 (24/48)	125 (24/48)	125 (24/48)
AC Voltage Range (47–63Hz)	98–132	93–132	93–132	93–132	93–132
DC Voltage Range	(18–56)	105–145 (18–56)	105–145 (18–56)	105–145 (18–56)	105–145 (18–56)
P.S. Dropout Time	1 Cycle 10ms DC	1 Cycle 10ms DC	1 Cycle 10ms DC	1 Cycle 10ms DC	1 Cycle 10ms DC
Block Isolation	1500V	1500V	1500V	1500V	1500V
Common Mode Rejection	60dB 0–1Khz	45dB 50,60Hz	45dB 50,60Hz		
Common Mode Voltage	+/– 170V				
Input Resolution	12 bits (+ sign)	1μa	1μa	0.1°C	<+/–4μv
Accuracy (@ 25°C)	+/–0.2% Typ	0.1%	0.1%	+/–0.5°C Typ	<+/–10μv
Input Filter Ranges (ms)	0–1024	16.6–400	16.6–400	400–1600	2000
Diagnostic LEDs	———————————————Unit OK (Block or Point Fault Indication)——————————— ———————————I/O Enabled (On–Line and Forced Point Indication)——————				
Diagnostics Available: Loss of Block Under/Overrange High/Low Alarm Open Wire Input Shorted Wiring Error Internal Fault	Yes Yes Yes Yes No No No	Yes Yes Yes Yes No No No	Yes Yes Yes Yes No No No	Yes Yes Yes Yes Yes Yes Yes	YEs Yes Yes Yes No No Yes
Weight	————————————————4 lbs. (1.8 kg)————————————————				

Genius Analog Output Block Specifications

All of the listed block types may be used as Hot Standby (HSB) or simplex analog output blocks. These blocks include those that can handle Voltage (+/–10v, 0–10v, +/–5v and 0–5v) and Current (4–20ma) type loads. Hot Stand By is a mode in which a block uses output data from only one CPU unless that CPU fails, in which case the block uses output data from an alternate CPU.

All analog output blocks provide a variety of diagnostic capabilities depending on the block type. In addition the blocks perform automatic self-calibration of internal circuitry. Please refer to the Genius I/O user's manuals for more details. A failure of a block or circuit results in both the appropriate block diagnostic LED indication and the fault being logged into fault tables of each PLC.

| AC MODEL # (IC660)	BBA100	BBA104	BBA105
DC MODEL # (IC660)cd	(BBA020)	(BBA024)	(BBA025)
Number of Points	4In/2Out	4In/2Out	6 Out
Operating Modes	HSB/SPLX	HSB/SPLX	HSB/SPLX
Output Range(s)	4 to 20ma 0 to 10Vdc –10 to +10Vdc 0 to 5Vdc –5 to +5Vdc	4–20ma	4–20ma
Nominal P.S. Voltage (AC)	115	115	115
Nominal P.S. Voltage (DC)	(24/48)	125 (24/48)	125 (24/48)
AC Voltage Range (47–63Hz)	98–132	93–132	93–132
DC Voltage Range	(18–56)	105–145 (18–56)	105–145 (18–56)
P.S. Dropout Time	1 Cycle 10ms DC	1 Cycle 10ms DC	1 Cycle 10ms DC
Block Isolation	1500V	1500V	1500V
Common Mode Rejection	60dB 0–1Khz	45dB 50,60Hz	
Common Mode Voltage	+/– 170V		
Accuracy (@ 25°C)	+/–0.2% Typ	0.15%	0.15%
Output Resolution	12 bits (+ sign)	6μa	6μa
Output Update Frequency	4ms	6–8ms	25ms
Output Load (Voltage Mode)	>2000ohms	n/a	n/a
Output Load (Current Mode)	0–300ohms	0–850ohms	0–850ohms
Diagnostic LEDs	–Unit OK (Block or Point Fault Indication)– –I/O Enabled (On–Line and Forced Point Indication)—		

Diagnostics Available:
  Loss of Block
  Under/Overrange
  Feedback Error
	Yes
	Yes
	No
		Yes
		Yes
		Yes
			Yes
			Yes
			Yes

Weight	————————4 lbs. (1.8 kg)————————		

Genius Hand-Held Monitor

The Hand-Held Monitor (HHM) is a convenient maintenance, configuration and operator interface tool for use with Genius I/O blocks, Field Control I/O Stations, and networks. Its main functions in a GMR system are to initially configure each Genius block and Field Control I/O Station, to assist in verifying I/O wiring and the operation of each I/O point, and to monitor the performance of an I/O network. Longer-term, it can be used as a maintenance and troubleshooting tool to track down faults and read detailed fault information from any I/O block or Field Control I/O module. It is typically used temporarily and not permanently-connected to a system. The HHM connects to any Genius I/O network at any I/O block, Field Control I/O Station, or Genius Bus Controller (GBC). The ability to connect the HHM at any point on a network provides remote monitoring of any device. A Monitor/Configure keyswitch allows the configuration of the Hand-Held Monitor to either restrict or allow the HHM to access certain functions such as clearing faults, making I/O block or module configuration changes, and forcing of I/O circuits. The HHM display is menu–driven and utilizes four function keys to select menu items. The HHM can be easily upgraded by replacing a socketed PROM which defines its functions.


Genius Hand-held Monitor
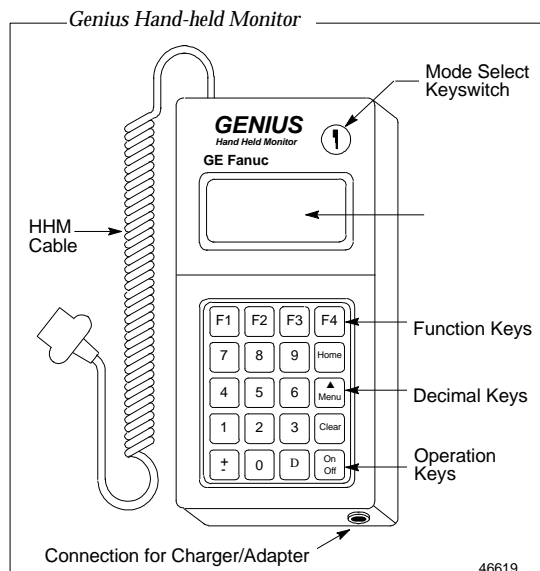
After system initialization, the HHM is a versatile start-up and maintenance tool. At any time, the HHM itself can be configured and locked so that functionality may be restricted to preset parameters. The HHM may be battery operated for up to 6 hours, or run off the AC charger/adapter unit. In battery operation, an auto-off circuit can be enabled to prolong battery life.

The HHM can also be continuously powered via an AC charger/adapter from a 115 or 230 Vac power source.
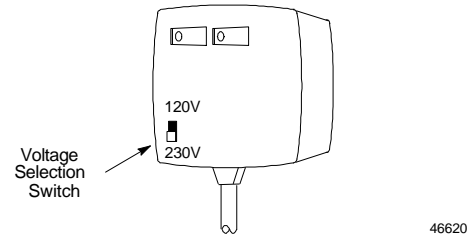
The NiCad battery pack can be easily replaced with freshly-charged pack for continued operation. An optional auto-shutoff feature prevents unintentional battery drain if a key is not pressed within 10 minutes.
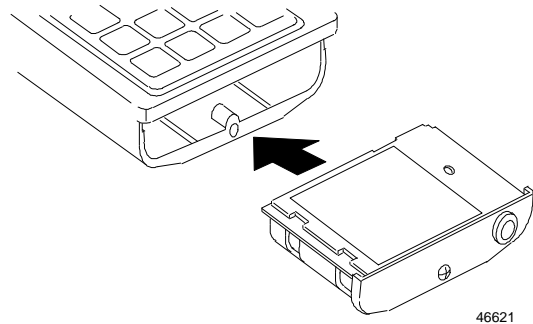
MODEL # (IC660)	HHM501
Display	4 line /16 character each line (0.2" – 5mm high)– LCD
Keyboard	20 key sealed membrane with tactile feedback
Keyswitch	2 position Monitor/Configure (with 2 keys)
Battery	NiCad pack providing 6 hours of operation with a full charge
Battery Charger	115/230Vac 15%, 47–63 Hz
Communications Cable	5 feet (1.5 meter) coiled
Weight	1.3 lbs. (0.6 Kg) without case , 1.8 lbs. (0.8 Kg) with case
Size (HxWxD)	8"x3.75"x1.25" without case, 10.85"x4.3"x2.25" with case
Display Languages	English, German, French, or Italian
Communication Data Rates	153.6 Kbaud Standard, 153.6 Kbaud Ext., 76.8 Kbaud, or 38.4 Kbaud

Genius Block GMR Termination Boards and Interface Modules

Termination boards and interface modules which can be used to simplify the integration of Genius blocks into redundant groups have been developed by Silvertech Limited. Termination boards and interface modules are available for 2- or 4-block discrete output groups and for 2- or 3-block discrete and analog input groups. The use of termination boards and interface modules is optional.

The interface modules perform basic grouping and conditioning of I/O device signals. The termination boards interface these signals to the Genius blocks, performing any additional signal conditioning if necessary.

Interface modules are DIN-rail mountable, with connectors for the I/O devices and termination board wiring. 34-wire ribbon cables (the mating connector and cable are not supplied) are used to connect interface modules with termination boards. The interface module segregates I/O wiring from internal panel wiring.

Termination boards attach to the side of each Genius block in a group. The board is held in position by its connection pins which are inserted into the screw terminals of the Genius block. Spacers on the termination board provide the necessary clearance between the board and the Genius block. The termination board also has a connector for power and ground wiring (where appropriate).

The illustration below represents an input interface module with three ribbon connectors; the output interface module has four.
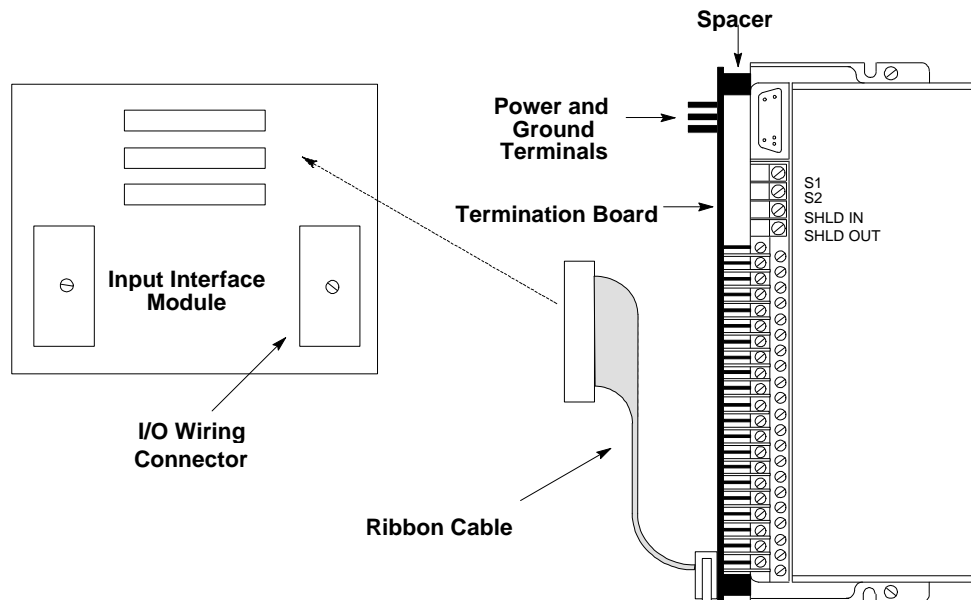
Discrete Input Termination Boards and Interface Modules

Discrete input termination boards are available for 16-point and 32-point sink and source Genius blocks. Complementary discrete input interface modules are available with polarized locking two-part connectors for I/O wiring.

Discrete input termination boards and interface modules incorporate all the diodes needed for the input autotest feature; no other diodes are required. In addition, the termination board includes circuitry to support the asynchronous input autotest feature. The tristate, or supervised, input feature of 16-point blocks can be used with these termination boards.

The discrete input interface module provides the grouping and distribution of the power and input signals. Each input is protected from a short circuit in the power wiring by a self-resetting thermistor. No fuse replacement is needed.

Input autotest may be disabled by jumpering two terminals on the termination boards. All 16 or 32 points are then available as inputs.

16-Point Discrete Input Termination Boards and Interface Modules

Operating voltage	20V to 32V DC
Temperature range	0 degrees C to +60 degrees C
Humidity	5% to 95% non-condensing
Connectors: Interface Module	One ELCO male 8016 series, 38-pin exposed contacts. Three 34-pin IDC connectors for ribbon cable
Size: Termination Boards	219mm length X 95mm width X 30mm depth
Size: Interface Modules	145mm length X 109 mm width X 101mm depth (including mating connector, including mounting bracket)
External Inputs	GMR Mode: 15/16 normally closed switches with zener diodes in series for tristate inputs (15 with autotest). Non-GMR Mode: 15/16 normally open switches with zener diodes in parallel for tristate inputs (15 with autotest).
Open Switch Voltage	Bistate or tristate GMR Mode: supply voltage . Tristate non-GMR Mode: zener voltage
Closed Switch Current	Bistate: 11mA at 24V supply . Tristate, GMR Mode: 7mS at 24V supply. Tristate, non-GMR Mode: 11mA at 24V supply

Silvertech part numbers
   GBC1-SC-DI16
   GBC1-SK-DI16
 	
   IMC3-SC-DO16
   IMC3-SK-DO16
 	
   CBL1-CK-RRnn
   CBL1-CK-EEnn
   CBL1-CK-EBnn
	Termination Board for 16-circuit Source block
	Termination Board for 16-circuit Sink block
	
	Interface Module for 16-circuit Source block group.
	Interface Module for 16-circuit Sink block group.
	
	34-way ribbon cable, termination board to interface module
	Field device connection cable with 2 ELCO 8016 connectors
	Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

Specifications for 32–Point Discrete Input Termination Boards and Interface Modules

Operating voltage	16V to 30V DC
Temperature range	0 to +60 degrees C
Humidity	5% to 95% non-condensing
Connectors: Interface Module	Two 32-point ELCO male 8016 series, 38-pin exposed contacts. Three 34-pin IDC connectors for ribbon cable
Size: Termination Boards	219mm length X 110 mm width X 30mm depth
Size: Interface Modules	145mm length X 109 mm width X 101mm depth (including mating connector, including mounting bracket)
External Inputs	32 switched inputs with Short Circuit protection31 with autotest
Open Switch voltage	Supply voltage – 1V
Closed Switch current	7mA per point per Genius Block. 21mA max. with 3 blocks at 24V.

Silvertech part numbers
   GBC1-SC-DI32
   GBC1-SK-DI32
 	
   IMC3-SC-DI32
   IMC3-SK-DI32
 	
   CBL1-CK-RRnn
   CBL1-CK-EEnn
   CBL1-CK-EBnn
	Termination Board for 32-circuit Source block
	Termination Board for 32-circuit Sink block
	
	Interface Module for 32-circuit Source block group.
	Interface Module for 32-circuit Sink block group.
	
	34-way ribbon cable, termination board to interface module Field device connection cable with 2 ELCO 8016 connectors
	Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

Analog Input Termination Boards and Interface Modules

An analog input termination boards is available for the 6-point current input Genius block. A complementary analog input interface module is available with a polarized locking two-part connector for I/O wiring.

The analog input interface module converts the input current into a voltage signal via a precision resistor for distribution to the termination boards. The resistor is fully protected from short circuits in the power wiring. The termination board incorporates a high input impedance voltage-to-current converter for each point which is powered by the point power supply.

Specifications for Analog Input Termination Boards and Interface Modules

Operating voltage	18V to 56V DC
Temperature range	0 to +60 degrees C
Humidity	5% to 95% non-condensing
Connectors: Interface Module	One ELCO male 8016 series, 38-pin exposed contacts. Three 34-pin IDC connectors for ribbon cable
Size: Termination Boards	219mm length X 95mm width X 30mm depth
Size: Interface Modules	145mm length X 109 mm width X 101mm depth (including mating connector, including mounting bracket)
External Inputs	6 point isolated 4-20mA current input for sink or source operation
Input Impedance	230 Ohms $\pm$ 5%
Input Protection	Thermistor limited to less than 100mA typical
Signal Accuracy	$\pm$0.2% over temperature

Silvertech part numbers
    GBC1-CK-0I6
    IMC3-CK-AI6
        CBL1-CK-RRnn
        CBL1-CK-EEnn
        CBL1-CK-EBnn
	Termination Board for 6-circuit blocks
	Interface module for 6-circuit input block group
	34-way ribbon cable, termination board to interface module
	Field device connection cable with 2 ELCO 8016 connectors
	Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

Discrete Output Termination Boards and Interface Modules

Discrete output termination boards are available for 16-point and 32-point sink and source Genius blocks. Complementary discrete output interface modules are available with polarized locking two-part connectors for I/O wiring.

Both the 16- and 32-point discrete interface modules group the output signals and incorporate a diode for each point to prevent reverse load leakage current. It is highly recommended that an external kickback suppression diode be fitted to the field loads.

The 16-point discrete output uses a single termination board type which operates with either sink or source blocks. The 32-point source block termination board incorporates a self–indicating fuse, in accordance with TÜV recommendations, which is visible from the installed position. A blown fuse will be revealed during the output autotest.

The termination boards and interface module can easily be configured for either a 4-block or 2-block output arrangement.

Specifications for 16-Point Discrete Output Termination Boards and Interface Modules

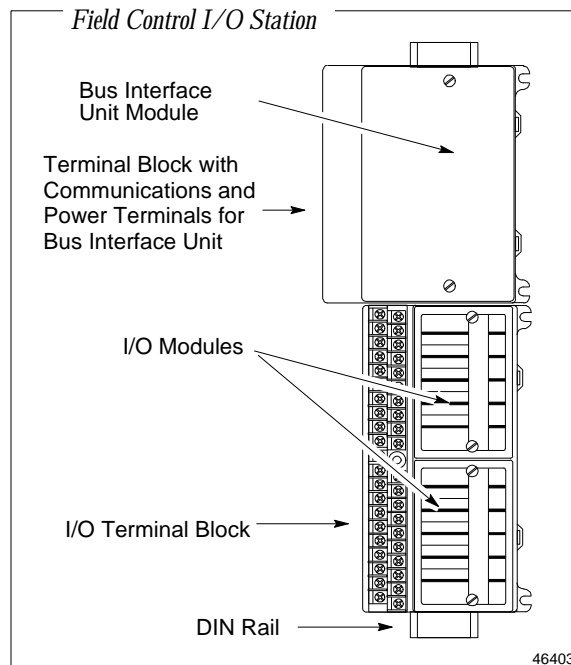|	
Operating voltage	20V to 36V DC
Temperature range	0 degrees C to +60 degrees C
Humidity	5% to 95% non-condensing
Connectors: Interface Module	One ELCO male 8016 series, 38-pin exposed contacts. Four 34-pin IDC connectors for ribbon cable
Size: Termination Boards	219mm length X 95mm width X 30mm depth
Size: Interface Modules	145mm length X 109 mm width X 101mm depth
Outputs	16 loads at 2 Amps per channel max, 15 Amps total at 35°C
Load Voltage at 1A	Supply Voltage –2V typical
Minimum Load	100mA with No Load Reporting enabled
Silvertech part numbers 　　GBC1-CK-DO16 　　IMC4-CK-DO16 　　CBL1-CK-RRnn 　　CBL1-CK-EEnn 　　CBL1-CK-EBnn	Termination Board for Source or Sink block Interface Module for 16-circuit output block group. 34-way ribbon cable, termination board to interface module Field device connection cable with 2 ELCO 8016 connectors Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

Specifications for 32-Point Discrete Output Termination Boards and Interface Modules

Operating voltage	10V to 30V DC
Temperature range	0 degrees C to +60 degrees C
Humidity	5% to 95% non-condensing
Connectors: Interface Module	Two ELCO male 8016 series, 38-pin exposed contacts. Four 34-pin IDC connectors for ribbon cable.
Size: Termination Boards	219mm length X 110mm width X 30mm depth
Size: Interface Modules	145mm length X 109 mm width X 101mm depth
Outputs	32 loads at .5 Amps per channel max
Load Voltage at .5A	Supply Voltage –1V typical
Fusing	0.5A indicating fuses, Bussman type GMT
Silvertech part numbers 　　GBC1-SC-DO32 　　GBC1-SK-DO32 　　IMC4-CK-DO32 　　CBL1-CK-RRnn 　　CBL1-CK-EEnn 　　CBL1-CK-EBnn	Termination Board for 32-circuit Source block Termination Board for 32-circuit Sink block Interface Module for 32-circuit output block group. 34-way ribbon cable, termination board to interface module Field device connection cable with 2 ELCO 8016 connectors Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

Field Control Bus Interface Units and I/O Modules

Field Control modules, which are mounted on separate terminal assemblies, are interfaced to a Genius bus by a Genius Bus Interface Unit. Together, the Bus Interface Unit and its modules are referred to as an "I/O Station."

A Field Control I/O Station can be used in a GMR system as GMR inputs or as non-GMR I/O. It can not be used for GMR outputs or non-voted GMR inputs and it cannot be autotested.

Field Control I/O Station

Bus Interface Unit Module

Terminal Block with Communications and Power Terminals for Bus Interface Unit

I/O Modules

I/O Terminal Block

DIN Rail

46403

I/O Terminal Blocks provide universal field wiring terminals for two I/O modules, allowing I/O module types to be mixed on the same I/O Terminal Block. The I/O Terminal block is mounted on a DIN rail. The DIN rail, which is an integral part of the grounding system, must be mounted to a panel.

As many as eight Field Control I/O modules (four I/O terminal blocks) can be connected to one **Bus Interface Unit.** One optional 21-inch (0.53 meter) cable (IC670CBL002) can be used per Field Control station. The remaining connections must be made using the shorter connectors supplied with the bases.

Bus Interface Units

The **Bus Interface Unit** provides the I/O scanning, diagnostics, and communications capabilities needed to link the I/O modules to the control system. In addition, the Bus Interface Unit may provide many characteristics for I/O

modules, such as fault reporting, output defaults, analog range selection, and analog scaling.

The BIU has four status LEDs and a connector for a Hand-held Monitor. The BIU provides logic power for the modules in the station. External power must be supplied for field wiring of I/O devices. The BIU mounts on a separate terminal block, to which all of the bus wiring is connected. The configuration of the I/O station is stored in the BIU terminal block

BIUs IC670GBI002F or GBI102A or later support Hot Insertion/Removal of I/O modules. Modules can be removed and replaced while station power is applied without affecting the BIU and other modules in the I/O Station. Separate power must be off to the module being inserted or removed. Hot Insertion/Removal requires I/O modules having catalog number suffix J and above and I/O Terminal Blocks IC670CHS101, 102, or 1034.

Bus Interface Unit IC670GBI002 operates on 24VDC. IC670GBI102 operates on 115VAC/125VDC.

Field Control I/O Modules

Field Control I/O modules are available in a wide range of I/O types and densities. All module types may be used in a GMR system as non-critical or simplex I/O. Field Control analog input modules may be used as TMR I/O.


Field Control Analog Input Module

Status LED

46406
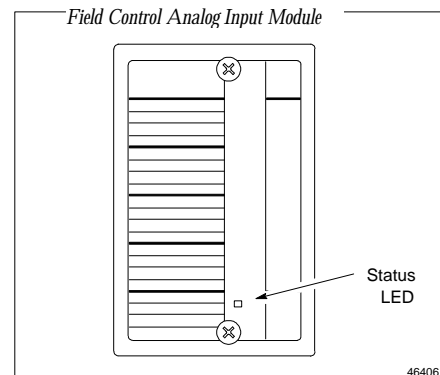
Field Control I/O modules are small rugged components with sturdy aluminum housings. Modules are approximately 3.25 inches (8.2 cm) high x 2 inches (5.25 cm) wide. They are 2.90 inches (7.3 cm) deep

I/O Module LEDs are easily visible through the transparent central portion of the label. Analog input modules have one module status LED. Discrete modules also have individual circuit LEDs that show the on/off status of each input or output circuit.

I/O Terminal Blocks

I/O Terminal Blocks are generic wiring bases for Field Control I/O modules. They provide I/O module mounting, backplane communications, and terminals for user connections.

Modules screw onto the terminal block for vibration resistance. I/O modules can be removed from the I/O Terminal Block without disturbing field wiring.

Field Control I/O Terminal Block
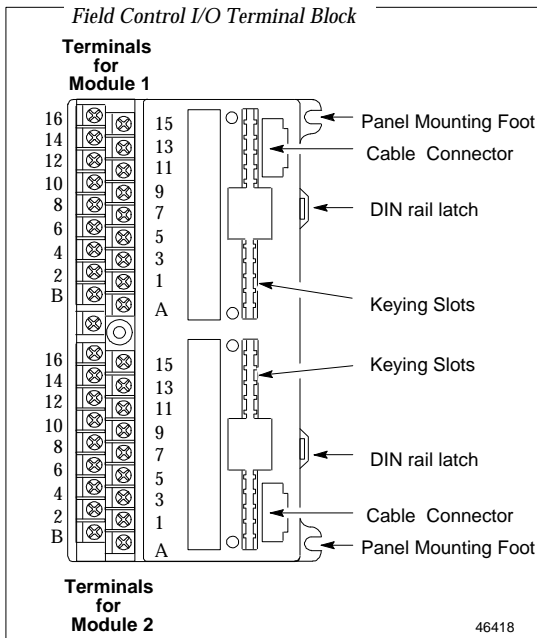
The I/O Terminal Block has two separate sets of **module terminals.** Each set corresponds to a "slot" in a conventional rack-type PLC.

The **cable connectors** provide easy attachment of the cable that carries communications signals.

The **DIN rail latches** clip the I/O Terminal Block to a DIN rail

The **keying slots** permit protective module keying.

Terminal Styles

I/O Terminal Blocks are available with the I/O terminal styles shown below. Different I/O Terminal Block types can be intermixed within a station.

Barrier Terminals **Box Terminals** **Wire to Board Connectors**

46418
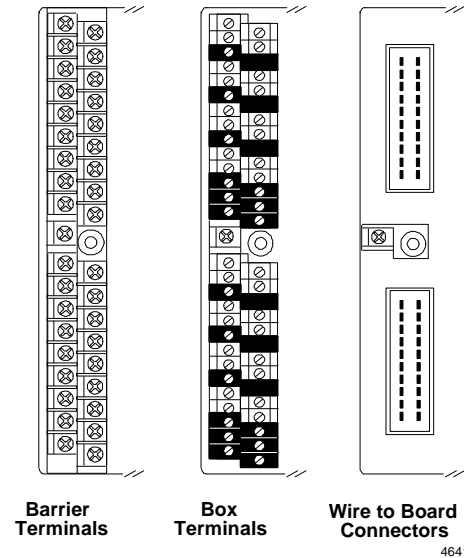
The **I/O Terminal Block with Barrier Terminals** (catalog number IC670CHS101) has 37 terminals. Each terminal can accommodate one or two wires up to AWG #14 (avg 2.1mm^2 cross section).

The **Terminal Block with Box Terminals** (catalog number IC670CHS102) has 51 terminals, each of which accommodates one AWG #14 (avg 2.1mm^2 cross section) to AWG #22 wire (avg 0.36mm^2 cross section), or two wires up to AWG #18 (avg. 0.86mm^2 cross section). An insulated external 5mm (0.2in) jumper such as Altech #8879 can be used to connect adjacent points. When an external jumper is used, the wire capacity is reduced from AWG #14 (2.10mm^2) to AWG #16 (1.32mm^2).

The **I/O Terminal Block with Connectors** (catalog number IC670CHS103) has two 20-pin male connectors for I/O wiring. The mating connector is Amp part number 178289-8. The connectors are keyed to prevent wrong insertion. Any tin-plated contact in the AMP D–3000 series can be used with the connector (Amp part number 1-175217-5 for high contact force receptacle for 20-24 gauge (0.20–0.56mm^2) wires), 1-175218-5 for high contact force receptacle for 16-20 gauge (0.56-1.42mm^2)). A kit containing two mating connector housings and contacts is available as GE Fanuc part number C670ACC003.
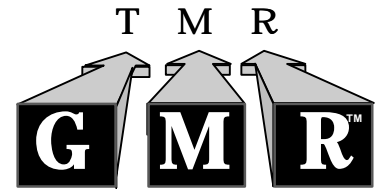
Field Control Module Specifications

The Bus Interface Units Field Control analog input modules and Terminal Blocks listed below may be in GMR input groups. TMR Analog inputs are provided by a group of up to three Field Control I/O stations with modules of the same type. The duplicate and triplicate input data is received at all GMR CPUs and then voted just prior to executing the application program to ensure the highest integrity of the input data used. Voting on triplicated data is mid-value select with the vote adapting to average, select-high or select-low in the event of a failure. A second failure results in further vote adaptation to either use the last operational input or go to a preconfigured minimum, maximum or hold-last-state value. A failure of a BIU, module, or circuit results in both the appropriate diagnostic LED indication and the fault being logged into fault tables of each PLC. TMR analog inputs continue to operate with the remaining "legs" of the input group.

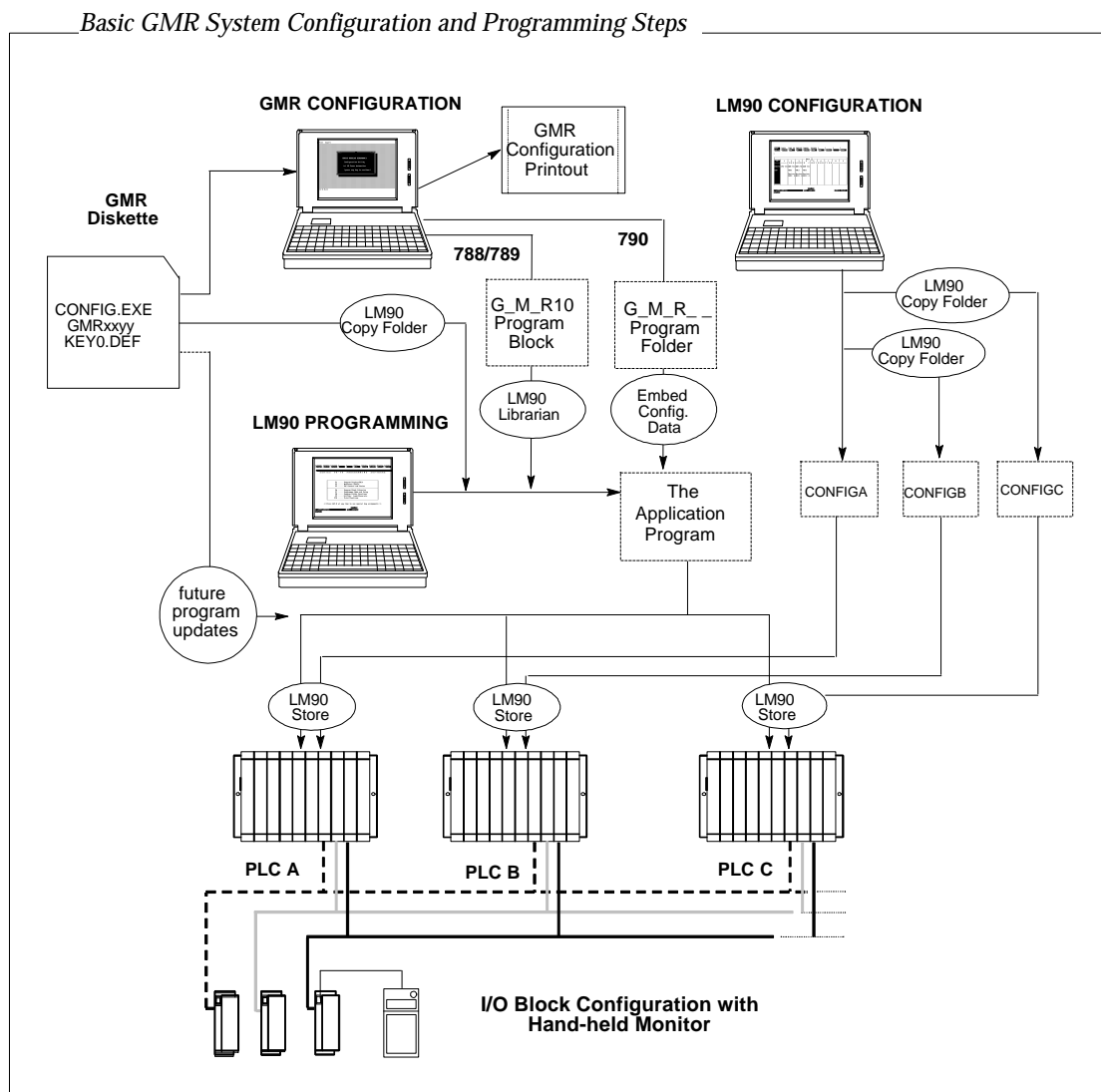|	**Field Control Analog Input Modules**				**Bus Interface Units**	**I/O Terminal Blocks**
Catalog Number	IC670ALG230	IC670ALG240	IC670ALG620	IC670ALG630	IC670GBI002 IC670GBI102	(IC670CHS 101, 102, and 103)
Number of Points	8 In	16 In	4 In RTD	8 Thermocouple or Millivolt Inputs	--	--
Operating Modes	TMR/ SIMPLEX	TMR/ SIMPLEX	TMR/ SIMPLEX	TMR/ SIMPLEX	TMR/ SIMPLEX	TMR/ SIMPLEX
Input Range(s) or Linearization (RTD)	0–20ma 4–20ma	0–20ma 4–20ma 0–24ma	Platinum, Copper, Nickel, Nickel/Iron, Resistance	Inputs from J, K, T, E, S, R, B, N, G, C, D, Platinel II Thermocouples Spans from +/-19.5mV to +/-625mV	--	--
Nominal P.S. Voltage	24VDC	24VDC	Powered from BIU	Powered from BIU	24VDC (GBI002) 115VAC, 125VDC (GBI102)	-- --
Voltage Range	18–30VDC)	20–28VDC	--		18-30VDC (GBI002) 90-135VAC, 105-150VDC (GBI102)	--
Isolation	1500VAC for 1 min, 250 VAC continuous	1500VAC	1500VAC for 1 min, 250 VAC continuous	1500VAC for 1 min, 250 VAC continuous	--	--
Common Mode Rejection	--	86db	120dB / 50, 60Hz	120dB / 50, 60Hz	--	--
Common Mode Voltage	None	None	250V RMS	250V RMS	--	--
Input Resolution	5μa	381 nanoamps (16 bits)	15 bits (+ sign)	15 bits (+ sign)	--	--
Accuracy (@ 25°C)	+/–0.05% Typ	0.05%	+/–0.15% Typ	+/–0.15% Typ	--	--
Input Filter Ranges (ms)	RC	10ms/20ms digital	--	--	--	--
Diagnostic LED	———— Module status ————					
Diagnostics Available: Loss of Block Under/Overrange High/Low Alarm Open Wire Input Shorted	Yes Yes Yes Yes No	Yes Yes Yes Yes No	Yes Yes Yes Yes Yes	Yes Yes Yes Open T'couple Thermistor error	--	--

Configuring & Programming a GMR System

The purpose of this section is to explain the basics of GMR system software setup and programming.

The illustration below is an overview of configuration and programming for three GMR 788/798 or 790 PLCs. Both the special GMR Software and the Logicmaster 90-70 Software contribute to the system configuration and to the completed application program. Genius I/O blocks and Field Control BIUs in the system are independently configured.

Basic GMR System Configuration and Programming Steps

GMR CONFIGURATION

GMR Configuration Printout

LM90 CONFIGURATION

GMR Diskette

CONFIG.EXE
GMRxxyy
KEY0.DEF

788/789

790

LM90 Copy Folder

G_M_R10 Program Block

G_M_R _ _ Program Folder

LM90 Copy Folder

LM90 Copy Folder

LM90 Librarian

Embed Config. Data

LM90 PROGRAMMING

The Application Program

CONFIGA

CONFIGB

CONFIGC

future program updates

LM90 Store

LM90 Store

LM90 Store

PLC A

PLC B

PLC C

I/O Block Configuration with Hand-held Monitor

GMR Configuration

The GMR characteristics of a system are set up using special GMR software on a personal computer.

The GMR configuration is the same for the redundant PLCs; there is only one GMR configuration for the system.

The GMR configuration presents the configuration items as choices on menu screens like the examples on this page.

*Typical GMR Configuration Screen*

The GMR Configuration Software automatically supplies default values. Only items that are different from the defaults need to be changed. Configurable items include:

- The number of CPUs, CPU type, ability to enable/disable online programming, ability to shut down if only one PLC remains operating, timeout period from 1 second to 18 hours.

- I/O limits for the system
- Initialization data for the system

- Fault actions for the system
- All GBC (bus controller) groups, with all Genius I/O blocks that will use GMR features
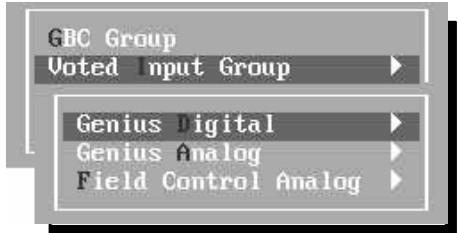
- I/O addresses and other features of GMR block groups:

- For each circuit, synchronous or asynchronous Autotest, at intervals ranging from 1 minute to more than 45 days.


- How long inputs may be discrepant before the CPU places a message in the I/O Fault Table and sets a fault contact. The range is 1 second to 18 hours.
- Starting addresses and lengths for any memory areas to which data can be written to through a CMM, PCM, or Ethernet Communications Module.
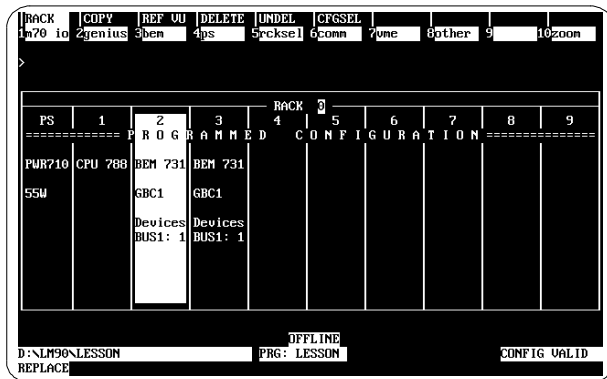
PLC System Configuration

The overall PLC system configuration is completed using the Logicmaster 90-70 software, which also runs on a personal computer. Modules are quickly selected from lists by function key. It is possible to completely configure the system offline with no PLC hardware present.
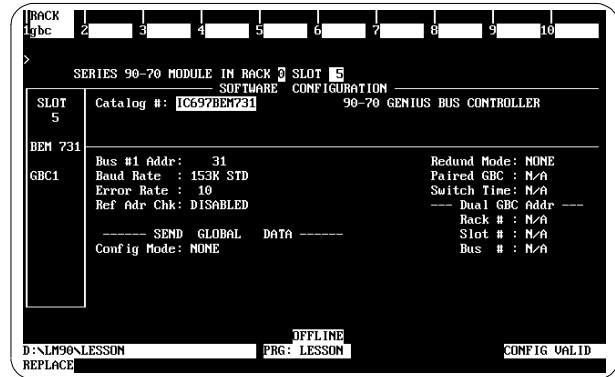
Typical Module Type Selection Menu
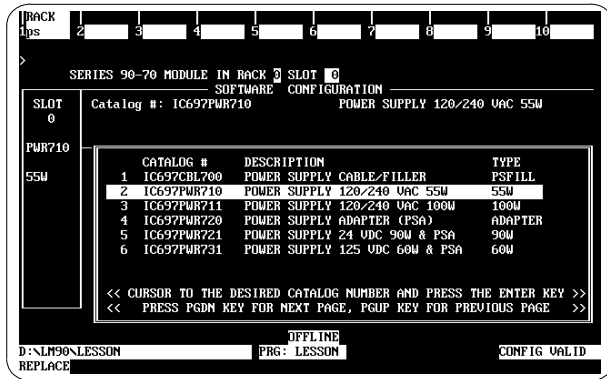
After selecting a module, it appears on a screen that represents that rack being configured.

Example Rack Definition Screen

Zooming into a slot shows a detailed description of the module configuration:

Detail Screen for a Module

Automatic Configuration Documentation

The configuration information for the GMR system can be sent to a printer so a hard copy of the current configuration documentation is easily prepared. The information may also be exported to documentation software under the DOS or Windows operating systems.

I/O Configuration

Genius I/O blocks and Field Control Bus Interface Units in the system are configured separately to assign parameters such as address, type, diagnostics, operation, communication, and mode settings.

Programming

The Logicmaster 90-70 software is also used to create the Relay Ladder Logic GMR application program. An example screen of logic during edit is shown below. The top of the Logicmaster screen always shows the current assignments of the function keys, which are used to select program functions. For example, on the program editing screen illustrated below, the second row shows Contacts. Each Contact can be selected with one key press. The status information at the bottom of the screen can be turned off for even more program display area.

Example Relay Logic with Contacts
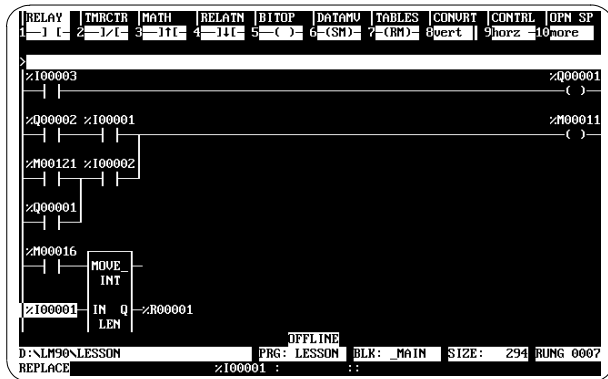
The Series 90-70 PLC provides a large and extremely versatile set of coils, contacts, relational functions, logical functions, and many advanced functions for use in the application program. They are described in the table that begins on page 5-10.

The same application program is used for each GMR PLC, eliminating the need for individual logic programs and simplifying user programming.

Application programming assistance is available from your GE Fanuc sales office, or GE Fanuc's 24 hour support hotline @ 804 978–5747.

Through Logicmaster 90, the GMR CPU supports structured programming techniques. Program logic can be separated by functionality, equipment areas, or other logical sections. The GMR programmer may write an efficient program with reduced effort using structured programming tools, which include:

■ Function Blocks for complex functions

■ Custom Parameterized Subroutine Blocks

■ Program Blocks

Function Blocks for Complex Functions

Function blocks simplify programming complex functions in the GMR application program using Relay Ladder Logic. Multiple parameters are easily included in a function block, in a clearly-understood fashion. The illustration screen below shows two Addition function blocks.

Example Function Block
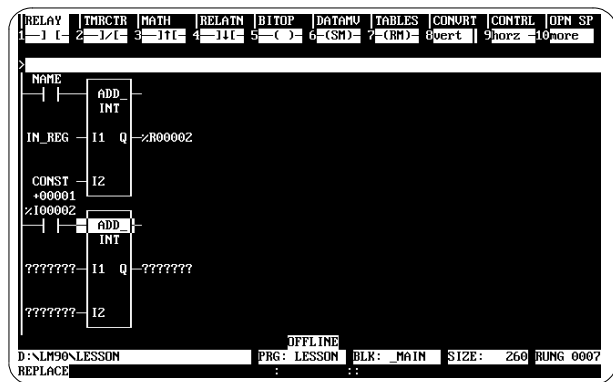
For more complex function blocks, a ZOOM feature opens a window on the instruction.

Program Blocks

Program blocks can be used to organize program sections. Up to 255 program blocks can be declared in the main program block. Program blocks may be individually "Locked". That aids software security while allowing access to required functions such as specific timers, counters, and other data.
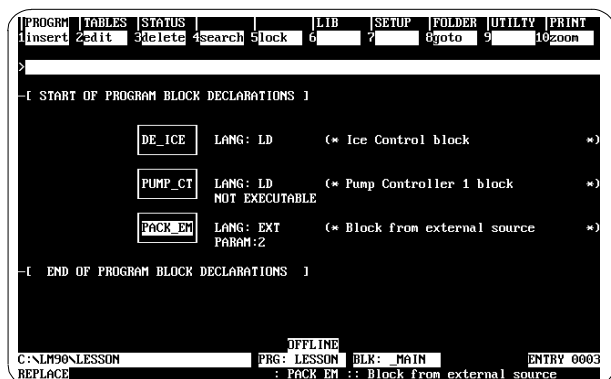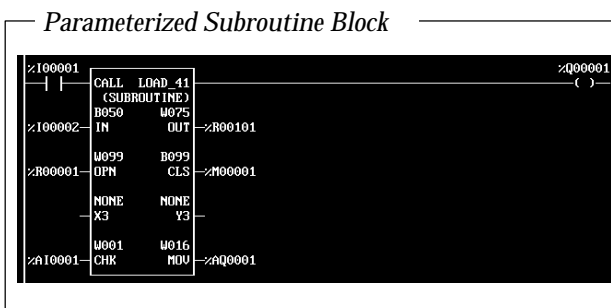
Program Block Declarations

```
[PROGRM][TABLES][STATUS]              [LIB][SETUP][FOLDER][UTILTY][PRINT]
[1insert 2edit 3delete 4search 5lock  6     7     8goto  9     10zoom]
>
─[ START OF PROGRAM BLOCK DECLARATIONS ]


          [DE_ICE]   LANG: LD      (* Ice Control block           *)

          [PUMP_CT]  LANG: LD      (* Pump Controller 1 block     *)
                     NOT EXECUTABLE

          [PACK_EM]  LANG: EXT     (* Block from external source  *)
                     PARAM:2

─[  END OF PROGRAM BLOCK DECLARATIONS  ]



                              OFFLINE
C:\LM90\LESSON                PRG: LESSON  BLK: _MAIN      ENTRY 0003
REPLACE                       : PACK_EM :: Block from external source
```

Each program block may be executed from the main GMR application program block based upon time, scan, or logical pre-conditions. Additional subprogram blocks can be called from within program blocks. Nesting of program blocks is generally limited to two layers for safety-related application logic. In non-critical portions of the program, there can be up to eight nested layers.

Parameterized Subroutine Blocks

A parameterized subroutine block is a user–definable function block with up to seven input/output parameter pairs. A parameterized subroutine block allows the re–use of logic within the same GMR program, which simplifies programming and reduces the overall amount of logic. A parameterized subroutine block can have up to 16K bytes of logic with up to 1000 local nicknames and descriptions.

Parameterized Subroutine Block

```
%I00001                                          %Q00001
─┤ ├──[CALL  LOAD_41                              ─( )─
        (SUBROUTINE)
        B050   W075
%I00002─IN     OUT ─%R00101

        W099   B099
%R00001─OPN    CLS ─%M00001

        NONE   NONE
       ─X3     Y3

        W001   W016
%AI0001─CHK    MOV ─%AQ0001
```

Programming Languages

The main part of the GMR application program is created in familiar Relay Ladder Logic. Additional program blocks can be in Relay Ladder Logic or in 'C'. Program Blocks in 'C' are created externally and imported into the main Relay Ladder Logic program.
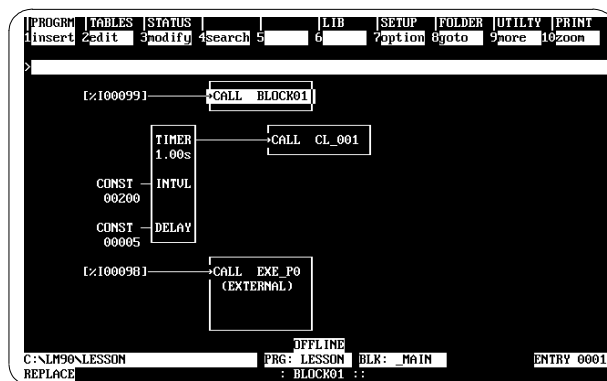
Coprocessing modules may be added and programmed in:

C

MegaBASIC   Toolkit provided by GE Fanuc.

Programming languages other than Relay Ladder Logic are restricted to non-critical portions of the program. Logic for non-safety functions must be in separate program block(s).

Timed Interrupts

The timed interrupt feature enables the interrupt declaration editor to specify timed execution of program blocks (including external blocks). A time base of 1.0, 0.10, 0.01, or 0.001 seconds may be selected for each of the 16 timed interrupts. The following example screen shows various types of interrupts in the program logic.

Timed Interrupts Calling Program Blocks

```
[PROGRM][TABLES][STATUS]              [LIB][SETUP][FOLDER][UTILTY][PRINT]
[1insert 2edit 3modify 4search 5     6     7option 8goto  9more  10zoom]
>

      [%I00099]──────────►CALL  BLOCK01

                  ┌─────┐  ►CALL  CL_001
                  │TIMER│
                  │1.00s│
         CONST ─  │INTVL│
         00200    │     │
         CONST ─  │DELAY│
         00005    └─────┘
      [%I00098]──────────►CALL  EXE_P0
                           (EXTERNAL)


                              OFFLINE
C:\LM90\LESSON                PRG: LESSON  BLK: _MAIN      ENTRY 0001
REPLACE                       : BLOCK01 ::
```

Time of Day/Date Clock

A time of day clock can be set to synchronize with Distributed Control Systems, the programmer PC CPU, and other devices. It is battery-backed.
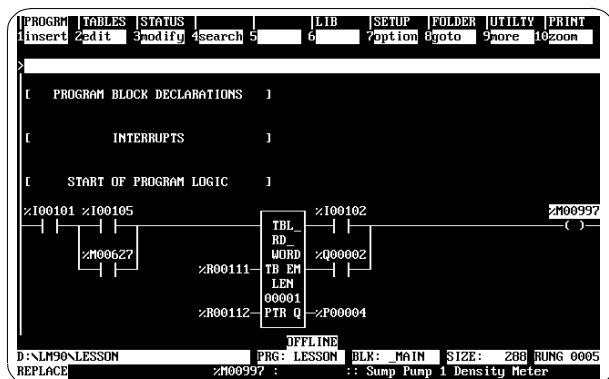
Program Annotation

Each contact or data variable in the GMR application program is given a 1 to 7 character nickname, (e.g. tag number, etc.). Each reference can have a four line by 7 character 'label'. The nickname and label can be entered in the program, imported from a cut / paste utility (such as found in Windows), or through the Logicmaster Variable Declaration table, illustrated below.
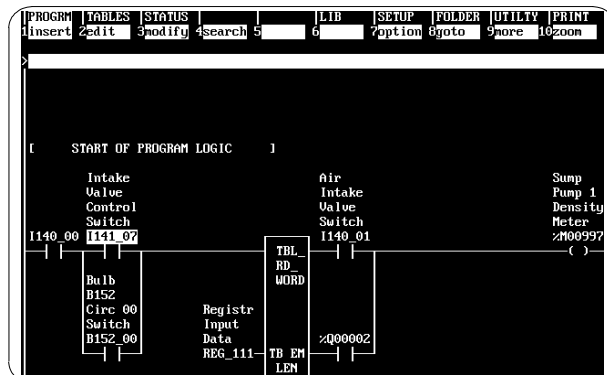
Example Variable Declaration Table

Rung comments (expanded text documentation) may be added to describe the logic contained within individual rungs. Program annotation display can be selectively turned off or on, as shown in the next two example screens.

Logic Display with Partial Annotation

Logic Display with More Annotation

Program Searches

The Search function will quickly find an identifier name, and/or a reference address, and/or a nickname, and/or an instruction anywhere in the program.
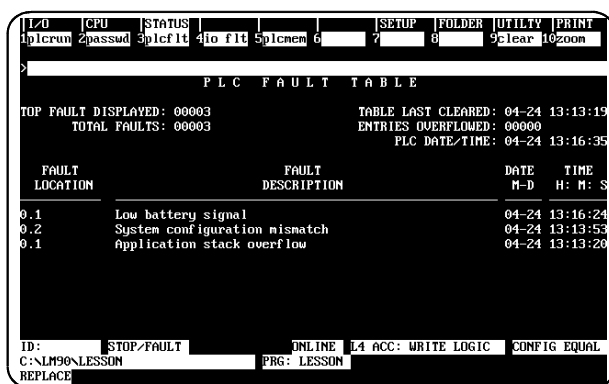
Example Search Screen

Program Diagnostics

The GMR system provides extensive diagnostic capabilities by combining standard Genius I/O diagnostics with the special autotesting and discrepancy reporting features of the GMR software.
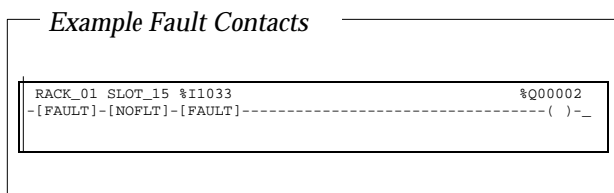
Fault Tables

Each PLC provides a full range of fault table and program access to fault and status information in two detailed Fault Tables. Both tables are available through Logicmaster 90 software, CIMPLICITY Intouch operator interface software, and the Access Display System with no additional programming. Upon the detection of a fault or system status change, a location, description and time appear in the appropriate fault table. Pressing a function key displays additional descriptive information about a fault. Options allow for a print log for permanent recording.

Typical PLC Fault Table Display

```
I/O     CPU    STATUS                SETUP  FOLDER  UTILTY  PRINT
1plcrun 2passwd 3plcflt 4io flt 5plcmem 6      7      8      9clear 10zoom

>
                  P L C   F A U L T   T A B L E

TOP FAULT DISPLAYED: 00003          TABLE LAST CLEARED: 04-24 13:13:19
        TOTAL FAULTS: 00003         ENTRIES OVERFLOWED: 00000
                                    PLC DATE/TIME: 04-24 13:16:35

   FAULT                    FAULT                       DATE    TIME
   LOCATION                 DESCRIPTION                 M-D    H: M: S

0.1            Low battery signal                       04-24 13:16:24
0.2            System configuration mismatch            04-24 13:13:53
0.1            Application stack overflow                04-24 13:13:20




ID:            STOP/FAULT            ONLINE L4 ACC: WRITE LOGIC  CONFIG EQUAL
C:\LM90\LESSON                       PRG: LESSON
REPLACE
```

Fault and No Fault Contacts

To integrate specific diagnostics actions into the application program, discrete or analog fault and non–GMR configured analog alarm bits can be associated with voted or physical inputs and simplex and fault–tolerant outputs. The following example shows Fault Contacts associated with a specific rack and circuit and a No Fault Contact associated with a specific slot.

Example Fault Contacts

```
RACK_01 SLOT_15 %I1033                        %Q00002
-[FAULT]-[NOFLT]-[FAULT]--------------------------------( )-_
```

Fault bits are reset when a fault is cleared from the fault table.

GMR Program Protection

To assure integrity, the GMR system provides selectable levels of hardware and software protection for the application program.

The entire program and GMR software can be hardware-locked using the keyswitch at the top of each CPU module. An LED on the CPU provides visual confirmation that the keyswitch is locked.

For additional protection, a range of four privilege levels can be used to restrict access to specific software functions. Each level may have a unique password assigned. The example shown below applies to a TÜV TMR system:

Access Level	Software Security Access Description
4	Change Password, Write or Modify Program Logic and/or Configuration
3	Write or Modify Program Logic and/or Configuration,
2	Write to data memory, i.e. change timer and counter values, presets, ...
1	Read PLC data only, except passwords. No PLC memory changes.

Protection even extends to individual Program Blocks within the application program, which can be locked and passworded. This flexible program protection scheme makes it possible to allow authorized users to access non–critical sections of the program while preventing entry into areas of the logic that must not be changed.

System Scan Time

Estimated scan time depends on the PLC system, I/O system, program complexity, and several other factors. Appendix B gives information about estimating scan times.

Embedded Protocol Communications

A variety of communication protocols, media and connectivity types are available for interfacing to a wide range of intelligent devices.

Automatic Program Documentation

Logicmaster 90 includes the ability to produce many types of documentation about the GMR application program. The Logicmaster Print Menu is used to specify the content and format of the printout.

Logicmaster Print Menu
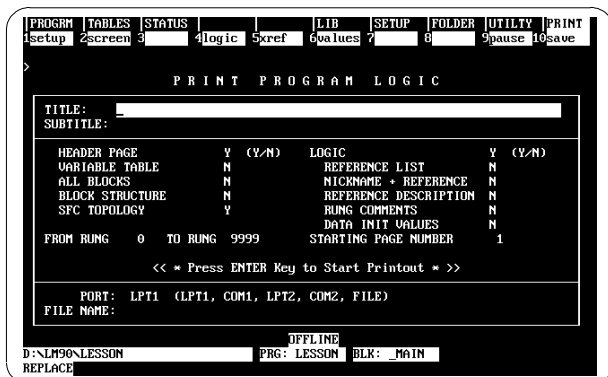
Selecting items from this menu customizes the printout to include configuration data, program logic, cross references, variables, and program annotation for the entire GMR program or a selected section of the program. The example below shows portions of a rack configuration printout and an individual module configuration printout from the Logicmaster software. The configuration made using the GMR software is also printed out (not shown here).

Partial Configuration Printout
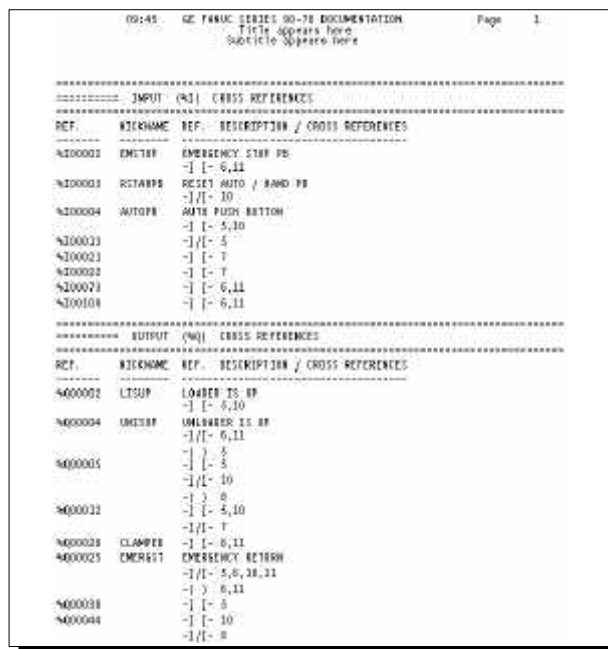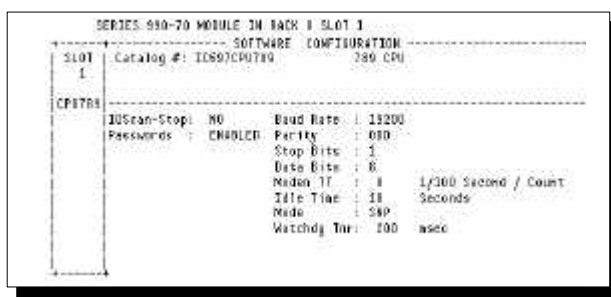
Partial Program Logic Printout
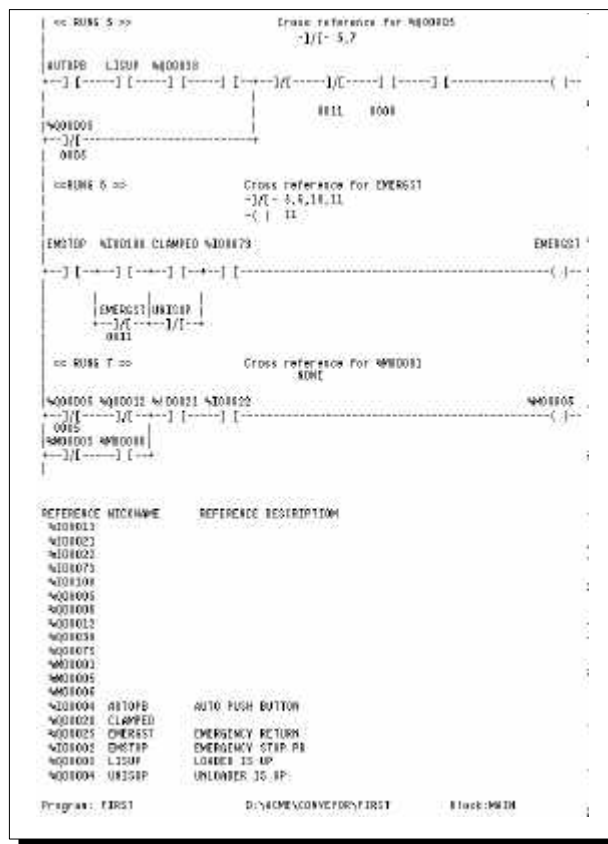
Online Programming and Storing of the GMR Application Program

Online application program storing may be done from a PC through a standard serial port (without any reconnection of cables), and to all CPUs connected on the multidrop cable provided in the GMR programmer's kit.

The download utility file included with the GMR software allows multiple CPUs to have programs stored conveniently. The utility is prompt-driven. Single keystroke entries move the utility through the downloading steps.

Because online changes are considered potentially dangerous, the GE Fanuc TMR system provides an alternative method of downloading. Using this alternate method, a single CPU may receive the new program alone. If there are any discrepancies, they are reported via the CPU fault tables. If any undesired response is observed, the program may be modified without any averse effect on the control system operation.

NOTICE: Once a critical system has been implemented, TÜV requires that online programming be disabled during the final commissioning [TW1]. This is done using the GMR configuration software utility.

After storing the configuration and program logic to the CPU, the system hardware is checked upon initialization. The configuration data is checked with the actual hardware system to insure it matches. GMR configuration mismatches are reported through the Logicmaster 90 fault tables, with a location and description of the fault. The GMR configuration utility allows the source code to be saved in a separate file for future review, update and

revision to the system. A hard copy printout of the GMR configuration is a valuable reference to configuration, I/O addressing assignment and overall system memory map.

Offline Program Downloading

Once commissioned, a TÜV approved system normally receives new program changes offline. All CPUs are downloaded without cable reconnection through the single connection from the programmer while in STOP mode. When the CPUs are placed in RUN mode, the checksums are compared to assure that the same program exists in all CPUs.

The programmer may be located local to the CPU racks. For some applications, remote programming and/or monitoring may be accomplished via a network, phone modem, or other means. .

Additional Reference Material

The following reference manuals are available in printed form and on CD-ROM:

- *Genius Modular Redundancy (GMR) User's Manual* (GFK-1277). The current revision of this document supersedes information in other manuals.)
- *Genius I/O System and Communications Manual* (GEK-90486-1)
- *Genius Discrete and Analog Blocks User's Manual* (GEK-90486-2)
- *Series 90-70 PLC Installation and Operation Manual* (GFK-0262).
- *Logicmaster 90-70 User's Manual* (GFK-0263).
- *Series 90-70 Genius Bus Controller User's Manual* (GFK-0398).

Multidrop Programmer Connection Between Programmer and GMR PLCs

PLC A   PLC B   PLC C

Multidrop Cable

RS-232/422 Converter

Multidrop cable is catalog number IC690CBL714 (1 cable). Two cables are needed for 3 CPUs.
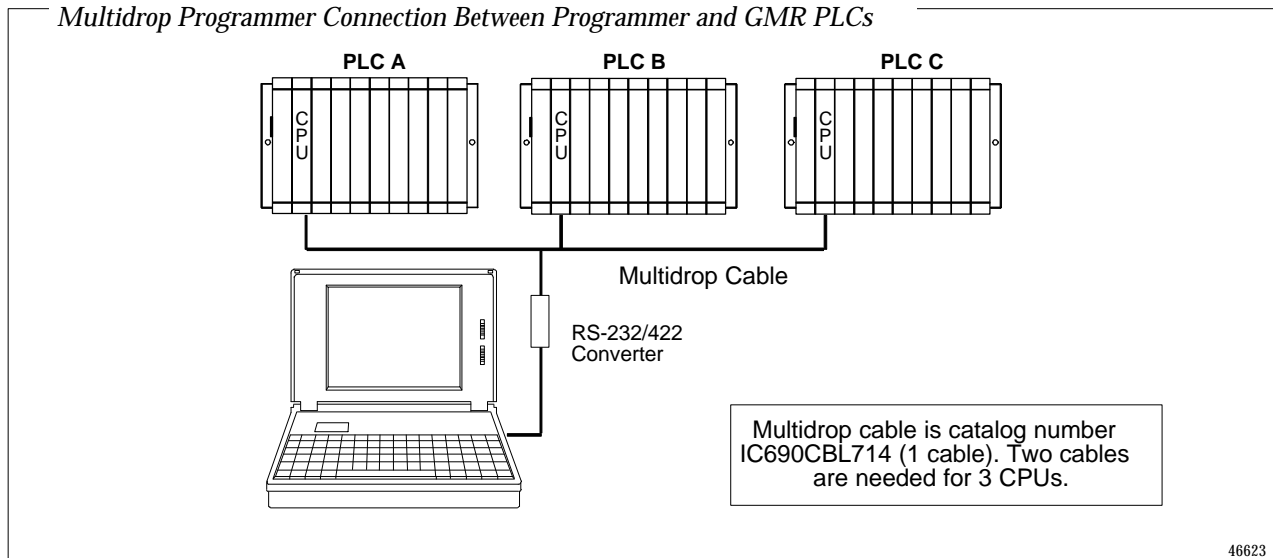
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Program Functions

The GMR system can take advantage of the extensive set of coils, contacts, and program functions that are available for the Series 90-70 PLC. These include standard coils and contacts, fault and alarm contacts, logical and relational functions, math functions, bit operations, timers and counters, and many other advanced functions as listed in the following table.

All Series 90-70 instructions can be used in the non–safety portion of the GMR application program. The comprehensive set of **TÜV**-supported ladder program functions, indicated in the righthand table column, can be used to create complete Emergency Shutdown (ESD), Safety Interlock System (SIS), or Critical Safe Control (CSC) safety system programs.

Contacts

			TÜV Approved?
–| |–	**Normally Open**	Passes power if the associate reference is ON.	yes
–|/|–	**Normally Closed**	Passes power if the associated reference is OFF.	yes
–|↑|–	**Positive Transition**	Passes power if the reference is ON and was OFF for the previous scan.	yes
–|↓|–	**Negative Transition**	Passes power if the reference is OFF and was ON for the previous scan.	yes
–|**fault**|–	**Fault**	Passes power if the associated discrete point or rack/slot/ module has a fault.	yes
–|**noflt**|–	**No Fault**	Passes power if the associated discrete point or rack/slot/module does not have a fault.	yes
–|**hialr**|–	**High Alarm**	Passes power if the associated analog point has a high alarm fault.	yes
–|**loalr**|–	**Low Alarm**	Passes power if the associated analog point has a low alarm fault.	yes
<+>–––	**Continuation**	Passes power to the right if the preceding continuation coil is set ON.	yes

Coils

–( )–	**Normally Open**	The associated reference is set ON if the coil receives power.	yes
–(/)–	**Negated**	The associated discrete reference is set ON if the coil does not receive power.	yes
–(↑)–	**Positive Transition**	If the associated discrete reference is OFF when the coil receives power, the reference will be set ON for one logic scan. This coil can be used as a one–shot.	yes
–(↓)–	**Negative Transition**	If the associated discrete reference is ON and the coil is not receiving power, the reference will be set ON for one logic scan.	yes
–(S)–	**SET**	The associated discrete reference is set ON if the coil receives power. It remains set until reset by an –(R)– coil.	yes
–(R)–	**RESET**	The associated discrete reference is set OFF if the coil receives power. It remains reset until set by an –(S)– coil.	yes
–(SM)–	**Retentive SET**	The associated reference is set ON if the coil receives power. The reference remains set until reset by an –(RM)– coil. Its state is retained through power failure and **STOP–TO–RUN** transitions.	yes
–(RM)–	**Retentive RESET**	A discrete reference is reset OFF if the coil receives power. It stays reset until set by an –(SM)– coil. Its state is retained through power failure and **STOP–TO–RUN** transitions.	yes
–(/M)–	**Negated Retentive**	A discrete reference is set ON if the function does not receive power. The state is retained through power failure and **STOP–TO–RUN** transitions.	yes
–(M)–	**Retentive**	A discrete reference is set ON if the coil receives power. The state is retained through power failure and **STOP–TO–RUN** transitions.	yes
–––<+>	**Continuation**	If power to the coil is ON, the continuation coil sets the next continuation contact ON. If power is OFF, the continuation coil sets the next continuation contact OFF.	yes

Timers and Counters

TÜV Approved?

ondtr	**On–Delay Stopwatch Timer**	Accumulates time while receiving power. The current value is reset to zero when the Reset input receives power	yes
ofdt	**Off–Delay Timer**	Accumulates time while NOT receiving power.	yes
tmr	**On–Delay Timer**	Accumulates time while receiving power The current value is set to zero when there is no power flow.	yes
upctr	**Up Counter**	Increments by 1 each time the function receives transitional power.	yes
dnctr	**Down Counter**	Counts down from a preset value every time the function receives transitional power.	yes

Relational Operations

eq	**Equal**	Tests for equality between two numbers.	yes
ne	**Not Equal**	Tests for non–equality between two numbers.	yes
gt	**Greater Than**	Tests for one number greater than another.	yes
ge	**Greater Than or Equal To**	Tests for one number greater than or equal to another.	yes
lt	**Less Than**	Tests for one number less than another.	yes
le	**Less Than or Equal To**	Tests for one number less than or equal to another.	yes
cmp	**Compare**	Compares two numbers and determines if one is less than, equal to, or greater than the other.	yes

Math Functions

add	**Addition**	Adds two numbers.	yes
sub	**Subtraction**	Subtracts one number from another.	yes
mul	**Multiplication**	Multiplies two numbers.	yes
div	**Division**	Divides one number by another, yielding a quotient.	yes
mod	**Modulo Division**	Divides one number by another, yielding a remainder.	yes
sqrt	**Square Root**	Finds the square root of an integer value.	yes
abs	**Absolute Value**	Finds the absolute value of an integer, double precision integer, or real value.	yes

Data Conversion Functions

to bcd–4	**Convert to BCD–4**	Converts a value to 4–digit BCD format.	yes
to bcd–8	**Convert to BCD–8**	Converts a value to 8–digit BCD format.	yes
to uint	**Convert to UINT**	Converts a value to unsigned integer format.	yes
to int	**Convert to INT**	Converts a value to signed integer format.	yes
to dint	**Convert to DINT**	Converts a value to double precision integer format.	yes
to real	**Convert to Real**	Converts a value to real value format.	yes
trun to int	**Truncate to Integer**	Truncates to a 16–bit signed number.	yes
trun to dint	**Truncate to Double Precision Integer**	Truncates to a 32–bit signed number.	yes

Bit Operations			TÜV Approved?
and	**Logical AND**	Performs logical AND of two bit strings.	yes
or	**Logical OR**	Performs logical OR of two bit strings.	yes
xor	**Logical Exclusive OR**	Performs logical Exclusive OR of two bit strings.	yes
not	**Logical Invert**	Performs logical inversion of a bit string.	yes
shl	**Shift Left**	Shifts a bit string left.	yes
shr	**Shift Right**	Shifts a bit string right.	yes
rol	**Rotate Left**	Rotates a bit string left.	yes
ror	**Rotate Right**	Rotates a bit string right.	yes
bittst	**Bit Test**	Tests a bit within a bit string.	yes
bitset	**Bit Set**	Sets one bit within a string to true.	yes
bitclr	**Bit Clear**	Sets one bit within a string to false.	yes
bitpos	**Bit Position**	Locates a bit set to true within a bit string.	yes
mkcomp	**Masked Compare**	Performs a masked compare of two arrays.	yes

Data Table Functions

			TÜV Approved?
tblrd	**Table Read**	Increments the pointer by 1, then reads the entry currently being pointed to in the table.	yes
tblwr	**Table Write**	Increments the pointer by 1, then writes into the location being pointed to in the table.	yes
liford	**LIFO Read**	Removes the entry at the pointer location and decrements the pointer by 1.	yes
lifowr	**LIFO Write**	Increments the pointer by 1 then adds an entry above the pointer location.	yes
fiford	**FIFO Read**	Removes the first entry from the table.	yes
fifowr	**FIFO Write**	Increments the pointer by 1, then adds an entry above the pointer location.	yes
sort	**Sort**	Sorts an array into ascending order.	yes
arrmov	**Array Move**	Copies a specified number of data elements from a source array to a destination array.	yes
srh eq	**Search Equal**	Searches an array for values equal to a specified value.	yes
srh ne	**Search Not Equal**	Searches an array for values not equal to a specified value.	yes
srh gt	**Search Greater Than**	Searches an array for values greater than a specified value.	yes
srh ge	**Search Greater Than or Equal**	Searches an array for values greater than or equal to a specified value.	yes
srh lt	**Search Less Than**	Searches an array for values less than a specified value.	yes
srh le	**Search Less Than or Equal**	Searches an array for values less than or equal to a specified value.	yes
arrrng	**Array Range**	Tests an input value against two arrays of delimiters.	yes

Data Move Functions

			TÜV Approved?
move	**Move**	Moves one or more bits of data within PLC memory.	yes
blkmov	**Block Move**	Moves a block of up to 7 constants to a PLC memory.	yes
blkclr	**Block Clear**	Clears (0) one or more bytes/words of PLC memory.	yes
shfreg	**Shift Register**	Shifts one or more words or bits of data through a block of PLC memory.	yes
bitseq	**Bit Sequencer**	Sequences a 1 through a group of bits in PLC memory.	yes
swap	**Swap**	Swaps two types of data in a word, or two words in a double word.	yes
comreq	**Communication Request**	Sends a communications request to a smart module in the PLC.	yes
vme rd	**VME Read**	Reads data from a third–party VME board at a specified VME address.	yes
vme wr	**VME Write**	Writes data to a third–party VME board at a specified VME address.	yes
vme rmw	**VME Read/Modify/Write**	Updates a data element on a third–party VME board using the read/modify/write cycle on the VME bus.	yes
vme ts	**VME Test and Set**	Handles semaphores located on third–party VME boards.	yes
vme cfgrd	**VME Configuration Read**	Reads the configuration for a VME module.	*
vme cfgwr	**VME Configuration Write**	Writes the configuration to a VME module.	*

Program Control Functions

call	**Call**	Causes a program execution to go to a specified program block or external block.	*
do io	**Do I/O**	Services a specified range of inputs or outputs immediately. Optionally, a copy of the scanned I/O can be placed in internal memory.	*
sus io	**Suspend I/O**	Suspends all normal I/O updates except those specified by the Do I/O instructions.	*
mcr	**Master Control Relay**	Starts a master control relay range. All logic rungs between the MCR and its subsequent ENDMCR will be executed with no power flow.	yes
endmcr	**End Master Control Relay**	Ends a Master Control Relay range.	yes
jump	**Jump**	Jumps to a specified location indicated by LABEL in the logic.	yes
label	**Label**	The target location of a JUMP instruction.	yes
commnt	**Comment**.	A rung explanation.	yes
svcreq	**Service Request:**	A special PLC service function.	yes (except functions 1, 3, 4, 6, 8, 14, 19) *
pidisa	**ISA Algorithm**	Selects the standard ISA PID algorithm.	*
pidind	**Independent Algorithm**	Selects the non–interacting independent PID algorithm.	*
for/endfor/exit	**Start, End, Exit FOR loop.**	Used to repeat rung logic a specified number of times while varying the value of the FOR INDEX VAR in the loop.	*
sfcres	**SFC Reset**	Resets the SFC topology and, if the OVR input is active, clears all overrides.	*

*   Can be used only for operations that are not required by the GMR system and which are not safety-related. These portions of the system may receive I/O status from TÜV or non-TÜV approved I/O, including certain other Genius blocks, non-approved rack-based modules, or any other allowable Genius and Series 90 Family components not specifically approved for use in a safety application.

## System Data Types Supported, and Typical Use in a GMR System

In order to process information, execute logic comparisons, and move information within the CPU, several data types are available for use in the GMR application program. The table below indicates the various types and notation used for the referenced bit and word–oriented operations. It also indicates which memory types can potentially be written to by a communications module.

The ability to exchange data between DCS systems, field bus systems, computer and other intelligent host devices, as well as slave devices is important for any technically–current system. By default, all memory areas are write–protected. The GMR configuration utility restricts access to safety critical areas of the memory. Areas that can be written to are segregated by type, address starting location, and size in length. This greatly reduces the possibility that a 'WRITE' command from an external device will be placed in a critical area of memory.

Type	Description	Can Write Access be Enabled?
%R	**System registers.** 16–bit word references that store program data such as the results of calculations.	yes
%AI	**Analog input registers**. A 16–bit analog input register holds the value of one analog input or other value.	yes
%AQ	**Analog output registers**. A 16–bit analog output register holds the value of one analog output or other value.	yes
%P	**Program registers.** 16–bit word references which store program data from the _MAIN block. This data can be accessed from all program blocks.	no
%L	**Local registers.** 16–bit word references which store program data unique to a block.	no
%I	**Input references.** Bit references located in the input status table, which stores the state of all inputs received from input modules during the last input scan. A reference address is assigned to discrete input modules using the configuration software.	yes
%Q	**Physical output references.** Bit references located in the output status table, which stores the state of the output references as last set by the application program. This output status table's values are sent to output modules at the end of the program scan. A reference address is assigned to discrete output modules using the configuration software. The coil check function of Logicmaster 90–70 software checks for multiple uses of %Q references with relay coils or outputs on functions.	yes
%M	**Internal references.** A bit reference that may be either retentive or non–retentive. The coil check function of Logicmaster 90–70 software checks for multiple uses of %M references with relay coils or outputs on functions.	yes
%T	**Temporary references.** These bit references are never checked for multiple coil use, so they can be used many times in the same program even when coil use checking is enabled. %T may be used to prevent coil use conflicts while using the cut/paste and file write/include functions. Because this memory is intended for temporary use, it is never retained through power loss or **RUN–TO–STOP–TO–RUN** transitions and is not used with retentive coils.	yes
%S–%SC	**System status references.** The %S, %SA, %SB, and %SC bit references are used to access special PLC data such as timers, scan information, and fault information. For example, the %SC0012 bit can be used to check the status of the PLC fault table.	no
%G–%GE	**Global data references.** These bit references are used to access data shared among several PLCs. They can be used on contacts and retentive coils because the memory is always retentive. %G - %GE cannot be used on non–retentive coils. **%G** Global Data memory **%GD** Global Data memory **%GE** Global Data memory	yes
	%GA Global Data memory **%GB** Global Data memory **%GC** Global Data memory	no
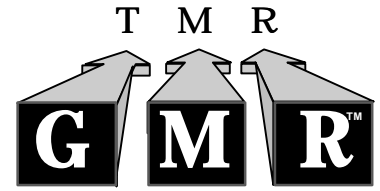
The purpose of this section is to provide an overview of application communications capabilities that can be incorporated into a Genius Modular Redundancy system. Individual communications modules are summarized here, and described in more detail in Section 4.
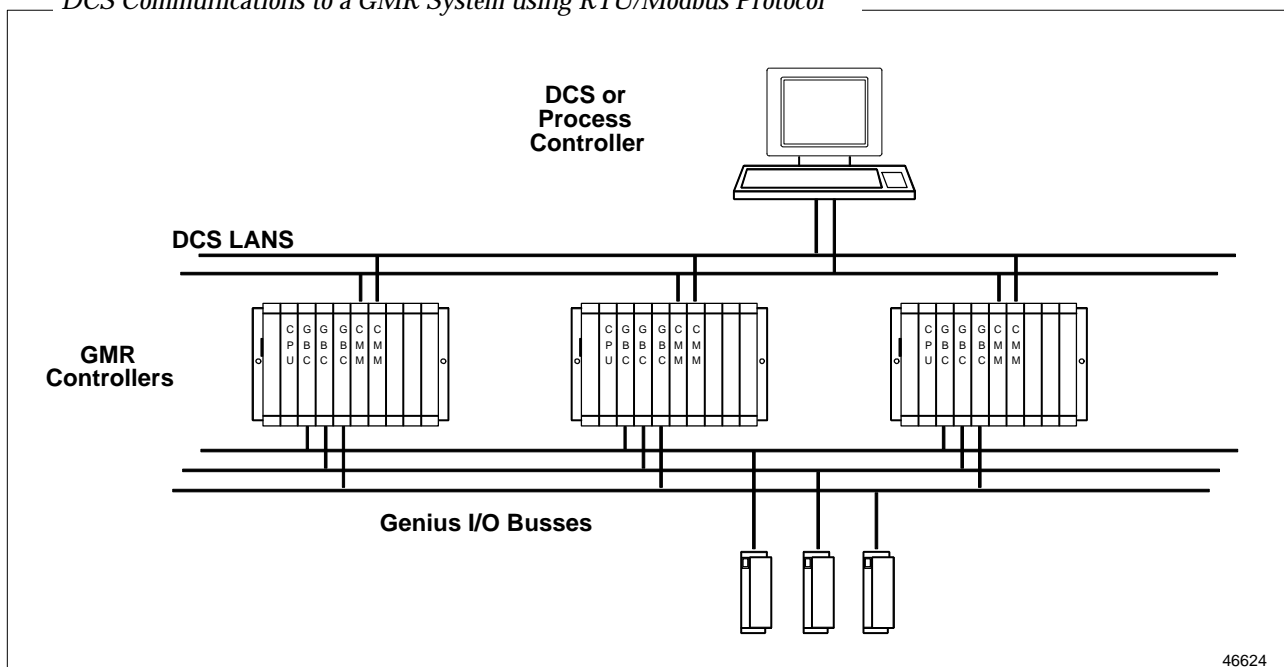
GMR with Distributed Control Systems and HMI Systems

Safety systems such as GMR generally interface to a process controller or Distributed Control System. The GMR system is usually independent and isolated from the Distributed Control System to ensure that its safety functions are protected from failures of the process controller. GMR has a built-in Limited Memory Write feature which ensures that only those areas of memory specifically made accessible to external interfaces can have data written to it. All safety related data and logic

are thereby protected. Despite the independence of the safety system, the DCS operator must still be aware of alarm and fault information so that corrective maintenance can be applied expediently.

The following diagram represents a typical GMR installation with an RTU Modbus link between the PLCs and the Distributed Control System.

DCS Communications to a GMR System using RTU/Modbus Protocol

DCS or Process Controller

DCS LANS

GMR Controllers

C P U | G B C | G B C | C M M | C M M

C P U | G B C | G B C | C M M | C M M

C P U | G B C | G B C | C M M | C M M

Genius I/O Busses

46624

Communications Modules for a GMR System

A variety of communications options for the Series 90-70 PLC can be used to link GMR PLCs to other devices such as host computers, personal computers, or other devices.

Communications Coprocessor Module (CMM): The Communications Coprocessor Module provides Communications Control (CCM), RTU Modbus (RTU) and Series Ninety (SNP) communications protocols.

CCM   Functions in CCM mode are: read/write of register, input and output tables; bit set/clear of inputs and outputs; read scratch pad; Q sequence commands for fast reads; and modify diagnostic status word. In the master and peer CCM configurations the CMM module initiates communications with other devices through the application program.

RTU   As the industry standard communications for operator interface and DCS, the RTU Modbus link provides access to all I/O and register data within the GMR PLCs. In the RTU Slave protocol, the following functions are provided: read input and output tables; read analog input; read register table; read scratch pad; read exception status; force a single or multiple outputs; preset a single or multiple registers; report device type and perform loopback maintenance.

SNP   Each serial port on the CMM can be configured to provide SNP master or slave capability. The SNP protocol on the CMM module provides read and write access to registers, inputs, outputs, analog inputs, analog outputs, %T, %M, %P, %L and %G variable types. Full Series Ninety datagram capability and many status and control functions are also supported. An "autodial" feature is provided to control a Modem. SNP–X extensions to the SNP protocol provide high performance read and write access to the same variable types listed above.   SNP-X is especially useful for high-speed data acquisition and control in multidrop configurations. In the master SNP configurations the CMM module initiates communications with other devices through application program communications requests.

The CMM provides both the RS-232 and RS-485 Interfaces and communicates with the CPU over the backplane. It is typical in a GMR system to use one CMM in each of up to three CPUs, however each CPU can support multiple CMMs mounted in either the CPU rack or an expansion rack**.**

Programmable Coprocessor Module (PCM): This module functions as a coprocessor to the CPU. It can be programmed to perform operator interface, real-time computations, data storage and custom protocols for data acquisition or data communications functions. CCM2 functions provided by the PCM module are: read/write of register, input and output tables; bit set/clear of inputs and

outputs; read scratch pad; Q sequence commands for fast reads; and modify diagnostic status word. In the master and peer CCM configurations, the PCM module initiates communications with other devices through application program requests. This module has two serial ports which are both RS-232 and RS-422/485 compatible. Both ports operating simultaneously can each support up to 19.2 Kbaud full-duplex communications.

The PCM has up to 95 Kbytes of user memory. In addition, a PCM can accommodate an optional expansion memory daughterboard up to 512 Kbytes in size. Both types of memory are backed by a replaceable lithium battery.

Factory LAN Ethernet Controller Module: The Ethernet Controller module provides direct connection between the Series 90-70 PLC and IEEE 803.2 CSMA/CD LANs.

The Ethernet Controller supports three alternative communication protocols:

TCP/IP-ETHERNET   Allows communications with hosts and/or LM90–70 programming and configuration software using GE Fanuc's SRTP over a 4-layer TCP/IP (Internet) protocol stack. For the highest system throughput, GE Fanuc also offers the Ethernet Interface for the GMR system. The highly popular TCP/IP protocol is available to facilitate the integration of the GE Fanuc TCP/IP driver within a third-party DCS. In addition to data monitoring the Ethernet Interface also provides remote programming services using the Logicmaster 90 software. Redundant communications can be implemented by utilizing two Ethernet cards in each PLC.

MMS-ETHERNET   Allows communications with hosts and/or LM90-70 programming and configuration software using MMS (Manufacturing Message Specification – ISO 9506) on a 7-layer OSI protocol stack.

SRTP   Allows communications only with LM90-70 programming and configuration software using SRTP over a 4–layer OSI protocol stack.

Genius Bus Controller (GBC): The highly–robust Genius communications system is supported by most operator interface manufacturers such as Intellution, Factorylink, and others. The Genius LAN provides a medium–speed option to access the database of the GMR PLCs over a single twisted–pair media. In particular, the Global Data service is highly efficient for applications requiring performance approaching that of Ethernet. Redundant communications can be implemented by providing two Genius Bus Controllers for communications in each PLC.

Human–Machine Interfaces for a GMR System

GMR systems often include some type of Human-Machine Interface (HMI) for data gathering and display.

Example Operator Display

The complexity of the HMI depends on the needs of the application. A simple HMI might collect data from one GMR PLC only. A very complex HMI might collect and process data from three GMR PLCs, emulating the GMR voting process itself.

Operation of the Human-Machine Interface is independent of the GMR system. Regardless of the level of complexity of the HMI, the integrity of GMR system operation is not compromised. The GMR configuration software provides a selectable level of write access to data memory in a GMR PLC. By default, write access is not permitted. Depending on the needs of the application, limited write access can be allowed to certain areas of data memory.

Monitoring Data from One GMR PLC

The most basic type of a Human-Machine Interface for a GMR system communicates with one of the GMR PLCs, monitoring data from that PLC only. In addition to basic I/O data, the HMI can monitor the status data that is exchanged by the GMR PLCs on the Genius bus.

This type of a Human-Machine Interface is very easy to incorporate into a GMR system, by adding a communications module to one of the GMR PLCs. A second communications module can also be installed in the same PLC for redundancy, as shown by the next diagram. Any compatible MI can be used to obtain the data from that PLC.

Simple Human-Machine Interface to a GMR System

Genius bus

46625
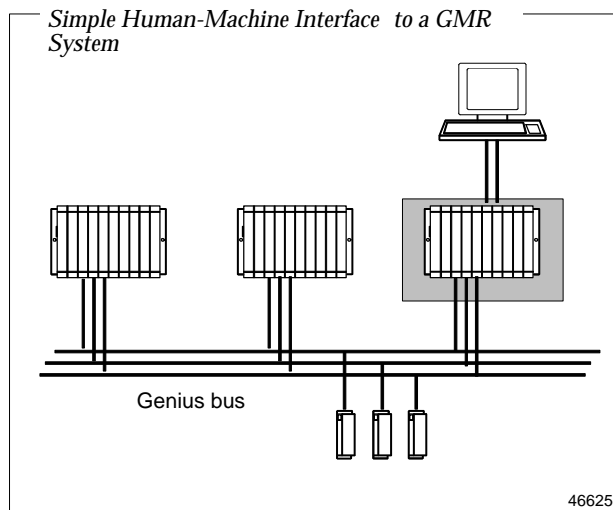
Monitoring One PLC with Switching

This type of HMI requires the ability to switch communications from one PLC to another (either automatically or as the result of operator action). In this type of system, if the PLC that usually communicates with the HMI becomes unavailable, the HMI can switch to the backup PLC and continue to provide data. In addition to basic I/O data, the HMI can monitor the status data that is exchanged by the GMR PLCs on the Genius bus.

This type of HMI is also easy to implement, by adding communications modules in two of the PLCs. Two communications modules can be used in each PLC, as shown in the illustration below, for redundancy.

Simple Human-Machine Interface with Switching

Genius bus

46626
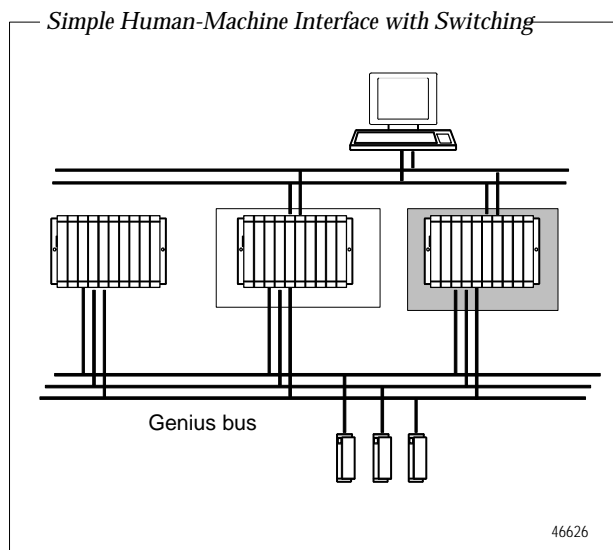
Monitoring and Data from Three GMR PLCs

Most HMI systems can provide this functionality, which uses a communications module in each PLC, or two communications per PLC, as shown here.

This type of interface can potentially provide large amounts of raw data from all three PLCs to the operator. In addition to basic I/O data, the HMI can monitor the status data that is exchanged by the GMR PLCs on the Genius bus.

*Human-Machine Interface for Gathering GMR PLC Data*

Genius bus

46627
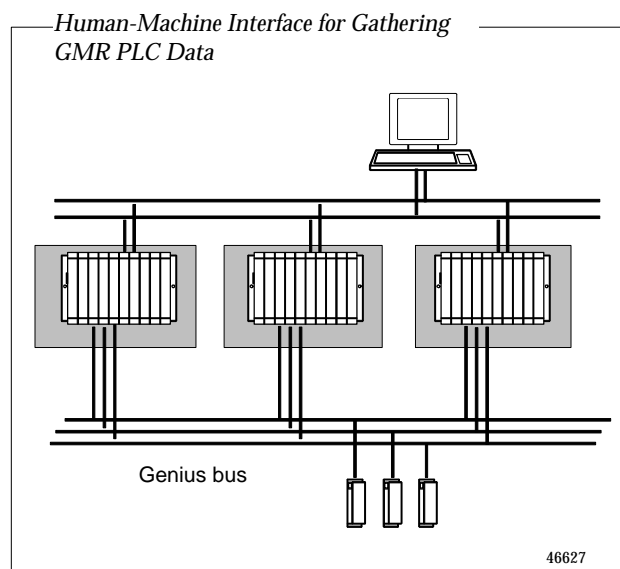
Monitoring All PLCs and Emulating the Voting Process

The most powerful type of HMI system processes the raw data obtained from the GMR PLCs, mimicking the actual voting carried out by the PLCs. This type of system uses a sophisticated HMI or an general-purpose HMI plus a data concentrator and an additional PLC with special application logic to process the collected data. (The additional PLC might be a cost-effective Series 90-30 PLC).

This type of system gives a detailed picture of what is happening to data in the GMR PLCs, and at the level of the Genius blocks themselves.

The illustration shows two communications modules used in each PLC and two host systems for redundancy of the HMI system.

Complex Human-Machine Interface with Voting

46628
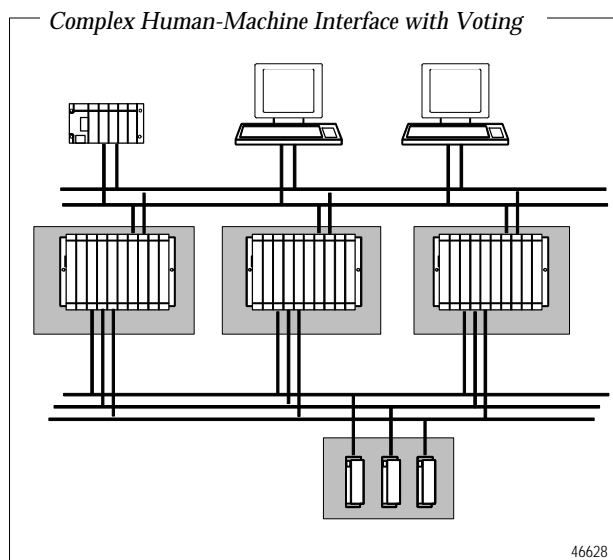
Sequence of Events (SOE) Recording

SOE (Sequence Of Events) Logging can be accomplished using standard documented library functions in the GMR software diskette. The SOE establishes the correct sequence of ten "current" events per user category, time and date stamps these from a possible 128 user assigned events. This table is reset from the user request, or may be automated for operation with a DCS, HMI, or other device. Additionally, a "historical" log will maintain the last First Out events for the past 10 occurrences.

In order to establish a Sequential Order of Events when a trip, request, or shutdown occurs, an application program is available from GE Fanuc to store the information in the PLC CPUs . Contact GE Fanuc for details. The date and time stamps may be read into a DCS, HMI, or other system asynchronously without concern for losing the sequence information.)

Appendix A *Memory Allocation*
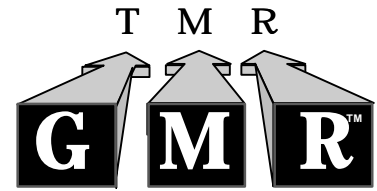
PLC memory in the GMR system is used to store the following:

- GMR System Software

- Application Program Data (e.g. %R, %P, %L, %AI, %AQ)

- Point Fault (Diagnostic) Data

- Application Program

This appendix includes a worksheet for calculating the amount of memory that will be available for the application program.

Total Memory in the GMR CPU

GMR CPM790 CPUs include a memory daughterboard that provides a total of 1 megabyte of battery-backed RAM memory. 512 Kbytes of this memory can be used only for "standalone C" programs and a portion of it is occupied by the GMR System Software. Of the remaining 512 Kbytes 19,840 bytes are used for the "G_M_R09 User Interface Program Block" leaving 504,448 bytes for the application program and data.

GMR CPU788 and CPU789 CPUs utilize a memory daughterboard which provides a total of 512K (524,288) bytes of battery-backed RAM memory. Of this 512K of memory 336,788 bytes is used by the GMR System Software, leaving 187,500 bytes for the application program and data.

Memory Available for the Application Program

When the worksheet on the next page is completed, the resulting value will be the number of bytes remaining and available for use by the application program. If the required application program functionality is well known, (to the point of knowing roughly the type and quantity of instructions to be used), the size of the application program in bytes can be estimated.

Use this worksheet to determine the total number of bytes of memory used by %R, %AI, %AQ, %P, %L, and associated point faults, if used. Then, add all the totals together. To determine the amount of memory left for the application program, subtract the grand total from the number of bytes for the memory size being used.

GMR Memory Allocation Worksheet

|		Totals
%R Memory	Multiply amount of % R used * _____ x 2 Bytes = * Amount of %R used is in 1K increments based on configuration.)	_____
%P Memory	%P Block Memory Used = (%P allocated) * 2 + 79 Bytes = * When %P used is in the range 1 to 128, the %P allocated = 160 Otherwise, compute the number of %P allocated: {[(# of %P used) - 128] / 32 rounded up to whole integer} * 32 + 160	_____
%L Memory	%L Block Memory Used = (%L allocated) * 2 + 79 Bytes = * When %L used is in the range 1 to 64, the %L allocated = 96. Otherwise, compute the number of %L allocated: {[(# of %L used) - 64] / 32 rounded up to whole integer} * 32 + 96	_____
%AI Memory	(If point fault DISABLED) = # %AI used x 2 (Bytes)	_____
or	(If point fault **ENABLED**) = # %AI used x 3 (Bytes)	_____
%AQ Memory	(If point fault **DISABLED**) = # %AQ used x 2 (Bytes)	_____
or	(If point fault **ENABLED**) = # %AQ used x 3 (Bytes)	_____
(If point fault **ENABLED**, add ………………… 3072 Bytes		_____
GRAND Total (Bytes)		_____
CPU Memory Total Bytes For CPU790: 524,288-19,840 (G_M_R09 block) = 504,448 **or** For CPU788 or 789: 524,288-323,936 (GMR System S/W) = 200,352		_____
Subtract Grand Total (From Above)	-	_____
Application Program Memory Available (in Bytes)	=	

Note

%P or %L allocation for a program block cannot be changed while Logicmaster 90-70 software is online, unless no %P or %L is currently used in that block. To change the current %P or %L allocation, Logicmaster 90-70 software must be offline. The resulting program must then be stored to the PLC in **STOP** mode.
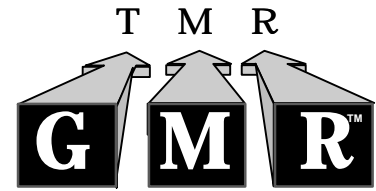
CPU Scan Time

The application program in GMR CPUs normally executes in a repetitive fashion until it is stopped by a command from the programmer or a command from another device. The sequence of operations necessary to execute a program one time is called a sweep or a scan. In addition to executing the application program, the scan includes the operations of executing the GMR system software, obtaining data from input devices, sending data to output devices, performing internal housekeeping, servicing the programmer, and servicing other communications devices.

The time required for the portion of the scan related to the execution of the GMR system software depends on GMR configuration parameters such as Input and Output table sizes. Typical times required for the execution of the GMR system software for either the CPU788 or CPU789 are shown below. In this example, there are six bus controllers in each PLC.

With Table sizes of:		With Table sizes of:	
Voted %I = 64		Voted %I = 256	
Voted %AI = 64		Voted %AI = 256	
Logical %Q = 64		Logical %Q = 256	
Scan Time Contribution =		Scan Time Contribution =	
CPU788/789:	79 ms	CPU788/789:	88 ms
CPM790:	22 ms	CPM790:	24 ms

The scan time contribution for the execution of the GMR system software for your system could be more or less depending on the table sizes you configure. Also this time varies by +/– 10ms for the CPU788 and 789 (+/- 2ms for the CPM790) during single scans when the GMR system software performs diagnostics on the CPU subsystem and I/O subsystems.

Typical GMR CPU total scan times range from 22 milliseconds to 300 milliseconds (or higher) depending

on configuration, size of the application program and instructions used in the application program. To estimate the total scan time and/or scan time contributions for the other operations that take place during a scan please refer to the *Series 90-70 Programmable Controller Reference Manual* (GFK-0265) Appendix A: "CPU Performance Data." That appendix includes worksheets to assist you in estimating scan time for your own system. If you are estimating total scan time using these worksheets, you must add the scan time associated with executing the GMR system software (as noted above) separately.

Genius Bus Scan Time

The GMR system utilizes Genius I/O as its input and output subsystem. Genius I/O blocks operate on a serial communications network that interfaces to the GMR CPU subsystem through Genius bus controllers. This serial token–passing type of network has its own scan time which is separate and asynchronous from the CPU scan time discussed above. This "Genius bus scan time" is the time required for all devices on a Genius network to communicate on the network one time. The Genius bus scan time can be estimated if all of the devices (and their configurations), to be put on a bus are known. Typical Genius bus scan time range from 5 milliseconds to 60 milliseconds (or higher) depending on the configuration. Please refer to GEK-90486-1, the *Genius I/O System and Communications User's Manual*, Chapter 9: "Timing Considerations" for further details on estimating Genius Bus scan times.

I/O Response Time

If input, output or total input–to–output response time estimates are desired, both the CPU and Genius Bus scan times must be taken into account. Please refer to GEK-90486-1, the *Genius I/O System and Communications User's Manual*, Chapter 9: "Timing Considerations", for details on estimating I/O response times.

Appendix C

Computer Requirements for Configuration & Programming

T M R

GMR™
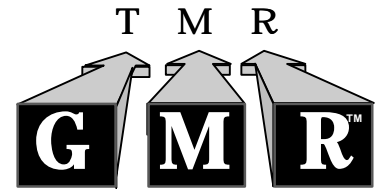
This appendix describes equipment needed to configure and program a GMR system.

General Computer Requirements

The configuration and programming software used for GMR require an IBM or IBM compatible personal computer.

Minimum requirements for running the Logicmaster software are:

- An Intel 80386 or higher microprocessor.
- A hard disk with at least 4 Megabytes of space available.
- At least 2 megabytes of RAM memory (see additional information at right).
- MS-DOS Version 5.0 or later.

Both monochrome and color monitors are supported.

Printer Requirements

Use of an optional printer is recommended for program and configuration documentation purposes.

Computer Memory Requirements for the Logicmaster 90-70 Software

Specific memory requirements for running the Logicmaster 90-70 software depend on its version.

- The Release 6.5 version of Logicmaster 90-70 software for GMR requires;
    - A minimum of 545 K (558,080) bytes of available conventional RAM memory to run.
    - At least 1024 Memory (LIM EMS 3.2 or higher).
- Running Logicmaster 90-70 v 6.5 under a DOS shell in windows 95 or NT requires:
    - A minimum of 590K bytes of available DOS application memory plus an additional 49K of High Memory Area (HMA), Upper Memory Block (UMB), or Expanded Memory (EMS).
- The Expanded COM Port version of Logicmaster 90-70 software requires:
    - Either a minimum of 590 K (604,160) Bytes MS-DOS application memory, or 545 K (558,080) bytes of MS-DOS application memory plus an additional 49 Kbytes of High Memory Area (HMA), Upper Memory Blocks (UMB), or Expanded Memory (EMS) for the communications driver.
    - At least 1024 Kbytes of Lotus/Intel/Microsoft Expanded Memory (LIM EMS 3.2 or higher).
- For the Standard Serial COM Port version of the Logicmaster software, a computer with a serial COM port serviced by the National Semiconductor 16550 UART chip is recommended.

For more information, please refer to chapter 7, section 4, "Standard Serial COM Port" in the *Logicmaster 90-70 Programming Software User's Manual,* GFK-0263.
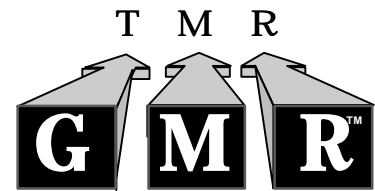
1v1 <or> 1oo1 Voting:

One-out-of-One Voting. A single path, signal, or command that is used exclusively to set a bit or data. The output follows the commanded state.

1v2 <or> 1oo2 Voting:

One-out-of-Two Voting. For applications where the safe state is OFF, when the voting is 1oo2 either vote in an OFF state causes the final element to be de-energized OFF.

2v2 <or> 2oo2 Voting:

Two-out-of-Two Voting. For applications where the safe state is OFF, when the voting is 2oo2 both votes must be in an OFF state to cause the final element to be de-energized OFF.

2v3 <or> 2oo3 Voting:

Two-out-of-Three Voting. When the voting is 2oo3, when two of the three votes are in an OFF state the final element is de-energized OFF.

A

Address:

A reference type and numerical offset, which together refer to a specific memory location that is accessible to the application program. For example, for the address *%Innnnn*, *%I* is the reference type and *nnnnn* is the offset.

Alarm and Fault Contacts:

Programmable contacts available to the application program, which are associated with I/O references. Fault and Alarm contacts can change operations based upon point or device failures or exceeded alarm values.

Analog:

An electrical signal with more than two states representing force, pressure, temperature, flow, etc.

Application Program:

A program written by the user for control of a machine or process (known as the "application").

Autotest:

Automatic test routines in a GMR system. They check the complete system from input modules to output modules and even detect failures in the I/O wiring. Autotesting does not affect the normal state of the field devices. Use of autotesting is optional; it can be implemented as needed in a GMR system.

Availability:

The probability that a component or system will operate from a time, $t = 0$, until a given time, at time $= t_n$

B

Backplane:

A printed circuit board at the back of a rack. The board has connectors into which modules are inserted.

Battery Backup:

Th use of a battery to protect information stored in volatile memory against power loss. Data protected by battery backup includes data values, logic states, the application program, and clock settings.

Block:

See Genius I/O Block and Genius I/O.

Bus:

See Genius Bus.

Bus Controller:

See Genius Bus Controller.

Bus Group:

A group of two or three Genius Bus Controllers, and their busses which have GMR-configured blocks attached.

C

"C" Block:

An application Program Block written in the "C" programming language.

Channel:

When applied to analog signals, a channel consists of the single input signal or output signal electrical conversion, either analog-to-digital or digital-to-analog.

Checksum:

A mathematical computation done on a range of bits from a set parallel pattern, performed to see whether the data has changed. This is done in the GMR CPU to verify that the program logic has not been altered. It is dynamically checked.

CIMPLICITY:

A family of operator MMI (Man-Machine Interface) products ranging from small single stations to large multi-station systems.

CMF:

Common Mode Failure. *See Common Cause*

Cold Start:

When one or more CPUs are initiated, if they are the only CPUs in a system (that is, no other CPUs are currently present), the startup sequence for diagnostic and error detection goes from offline to operational for all activated components.

Configuration:

The process of defining the hardware architecture and system component settings such as communication parameters, diagnostic limits, and variable scaling.

Configuration Software

The portion of the Logicmaster 90 programming software used to configure the I/O and many system parameters.

Common Cause: failures, faults;

An unreliable or error-based signal from one part of the system that causes the whole system to become inoperable or unstable. No Common Mode of Failure (CMF) is considered acceptable.

Covert Fault:

A hidden, latent, or undetected fault that may affect overall system availability and reliability. Diagnostic detection of covert faults increases reliability and availability and reduces MTTR.

CPU Sweep:

The process by which the CPU repeatedly executes the application program, updates the I/O status, handles communications and other tasks, and performs internal diagnostics.

CPU (Central Processing Unit)

The master module in the main PLC system rack which executes the application program.

D

Data Communications:

The ability to electronically transfer system data between the CPU and other intelligent master and slave devices.

Data Memory:

Areas of memory that are used by the application program to store data.

Datagram:

A message sent from one Genius device to another. The message length can be up to 128 8-bit bytes.

De-energize–to–Trip:

Most elements in a GMR system are engineered to be energized operational. For such elements, the safe state is to be de-energized upon a signal or voted signal.

Degradation Path:

The method used to keep an area of a fault-tolerant system operational when some part of it is lost.

Detected Failure:

An apparent (not covert) failure. The failure is detectable because it causes a change of operation request. For a control or ESD system, this is the safe state.

Diagnostic Coverage:

The extent to which a system is able to diagnose improper operation and failed system components.

Diagnostics:

Active mechanisms that can detect both covert and apparent faults.

Discrepancy:

Disagreement among corresponding votes in a voting system.

Discrepancy Filter:

A selectable time delay that may be applied to corresponding elements in a voted group in real-time transitional systems. The delay allows system asynchronicity at the field device, I/O scan, and logic execution level. If a discrepancy occurs, it is not reported until the selected amount of time has passed.

Discrete:

One-bit application data that is capable of indicating two states. The term "discrete" includes both real and internal I/O.

Distributed Control System (DCS):

A proprietary control system designed for the process industry. The DCS system usually has embedded algorithms for continuous and batch control.

Distributed Inputs/Outputs:

Digital signals representing both discrete and analog inputs and outputs that are exchanged between the CPU and external devices. The external devices may be widely-distributed at remote locations. Data transfer occurs over twisted pair 'twinax' wire or fiber optic cables with modems.

Duplex:

Two parallel elements in a voting system.

Duplex: mode, default:

A voting mode in which outputs may be voted 1oo2 or 2oo2. Duplex mode provides fault degradation to simplex operation if one system CPU fails. If both CPUs fail a pre-selected default FTS (fail–to–safe) state is used by each output.

E

Edison Testing Labs (ETL):

An OSHA-approved testing laboratory. In conjunction with Wilson Fire, the GMR system has NFPA approval as certified by ETL.

Energize–to–Trip:

Typically non-ESD applications such as Fire and Gas protection systems use this convention. In normal operation, most elements are engineered to be de-energized operational. The safe state is then considered to be energized upon a signal or voted signal.

Ethernet: Protocol, LAN;

Ethernet is a published communication format that uses a high-speed LAN and a CSMA/CD (Collision Sense Multiple Access Collision Detection) non-deterministic protocol. GMR CPUs can exchange data with other system devices via TCP/IP Ethernet modules.

Expansion Cable:

A cable that transmits the parallel I/O bus signals between a Series 90-70 PLC main rack and its expansion racks. The maximum total length of the expansion cables from the main rack to the last expansion rack is 50 feet (15 meters).

F

Factory Mutual (FM):

An OSHA-approved testing and certification lab. GMR PLCs and I/O products are certified by FM for use in Class I Division II incendiary environments without additional enclosures.

Fail-safe:

The ability of an element to go to a safe state when a system failure has occurred.

Fail-to-danger:

The inability of a system to be able to respond safely due to a failure within the control hardware.

Fault Contacts:

See Alarm and Fault Contacts

Fault Degradation:

The ability of a group of components in a GMR system to adjust to the loss or failure of corresponding components. The two permissible degradation paths are:

$$3-2-1*-0 \quad <or> \quad 3-2-0$$

The method of fault degradation is selected during GMR configuration of each group. When the fault degradation path reaches 0, outputs default to individually-selected safe states. *Note: TÜV limits use of 1oo1 mode to a predefined time period. Non-TÜV systems may be set 1oo1 for indefinite periods of time.

Fault Tables:

The Series 90-70 PLC has two Fault Tables, the PLC Fault Table and the I/O Fault Table. Both are valuable aids in maintaining and repairing the system. The Fault Tables show the exact location of each fault, its type, an explanation, and the date and time the fault occurred. The tables are retentive until reset or cleared.

Fault Tolerance:

If a single element fails, the ability of a system to remain functional as if no fault had occurred. The diagnostics will report the fault to the proper fault table.

Final Control Element:

The actuator, indicator, or other electrical field device controlled by an output point.

Firmware:

A series of instructions contained in ROM (Read Only Memory) of a CPU which are used for internal processing functions. These instructions provide the structure for application program operations.

Forcing I/O:

Deliberately changing an I/O point value, regardless of the actual input value or commanded output value. The Genius Hand-held Monitor (HHM) can be configured to perform I/O forcing. The PLC's I/O Fault Table indicates both forces and released forces.

G

Genius Bus:

The LAN (local area network) used for Genius communications. Genius bus protocol is an enhanced type of IEEE 802.4 token-passing scheme. Each transmission is voted 2oo3 by the receiving device to assure data integrity. The bus operates at up to 153.6Kb without special connectors or amplifiers. A single Genius LAN supports up to 32 devices, and up to 31 LANs may be included in one Series 90-70 PLC.

The bus uses twisted pair cable. It may be multidrop-wired up to 7500'. Longer busses are possible using fiber optic cable and modems.

Genius Bus Controller:

The PLC module that interfaces the GMR Series 90-70 PLC with a Genius bus, acting as the master communications module. I/O blocks in a system communicate with the Bus Controller over the Genius bus.

Genius I/O:

An family of intelligent distributed I/O products including many types of Genius I/O blocks, Genius Bus Controllers, and other devices.

Genius I/O Block:

An electrical signal interface module capable of reporting inputs and controlling outputs for both digital and analog devices. A Genius block converts signals from user devices to/from the logic levels used by the CPU. Each block is self-contained, with a built-in communications processor, block power supply, and I/O control. Genius blocks may be mounted locally or remotely, and are rated for use in hazardous locations. Extensive block diagnostics report failures, even in the I/O device system, back to the Bus Controller.

Genius LAN:

See Genius Bus.

Global Data:

Data that is broadcast on the Genius LAN each bus scan. Global Data may be received by any intelligent connected device.

GMR:

An acronym for Genius Modular Redundancy. GMR is a triple modular redundant (TMR) and flexible high integrity system. It has scaleable configuration for:

- single, dual, or triple input support,
- single, dual, or triple CPU support,
- fail safe, fault tolerant, and fault tolerant/fail safe output support.

H

"H" Pattern Output:

A fault-tolerant output whose state is controlled by two parallel sink Genius blocks and two parallel source Genius blocks.

Hot Backup:

A redundant component ready to and capable of coming online without causing a "bump" in the process. Typically this requires synchronization and online supervisory diagnostics.

Hot Standby:

A redundant device ready to be manually or automatically placed online. Hot Standby devices help shorten the MTTR cycle.

I

"I" Fault Tolerant for Control Operational:

A Fault Tolerant circuit when used in safety circuits that are normally de-energized to "safe". *See Fault Tolerant..*

I/O Fault Table:

A diagnostic table in the Series 90-70 PLC that lists I/O faults. Each fault is described, and identified by time, date, and location.

I/O Module:

A rack-mounted or remotely-installed assembly that interfaces field input and output devices such as actuators and sensors to a controller, such as a Series 90-70 PLC.

Initialization Data:

At system startup, a GMR CPU synchronizes selected areas of %R and %M memory with the corresponding memory in the other GMR CPU(s). %M memory is usually used for latches, while %R memory is used for timers and counters.

Input Discrepancy:

See Discrepancy.

ISO 9001:

Certification that certain required procedures for quality and customer satisfaction are in place and are being continually followed. GE Fanuc has received ISO 9001 certification.

L

Ladder Diagram:

See Relay Ladder Logic

Latent Fault:

See Covert Fault

Limit Discrepancy:

The percent by which an analog input may deviate from the full-scale deflection values set up for that channel. Minimum and maximum full-scale deflection values for each input are configured for the application.

Logic:

The user application program.

Logicmaster 90:

The programming and configuration software used with Series 90 PLCs.

M

Mean–time–between–failures (MTBF):

The mean number of hours a device or system may be expected to operate before a failure. The number is based upon a large group of physical field samples.

Mean–time–to–repair (MTTR):

An average time required to repair equipment after a failure. It is based upon user experience, the type of equipment installed, the locations of the devices or components, and the availability of replacements.

Mid-value Select:

When three values of a triplex analog input are measured, the GMR voting mechanism discards the high and low values and uses the middle value as the voted input. This mid-value voting method avoids the inaccuracy that results from averaging methods when a failure in one reading has occurred.

Module:

A replaceable electronic subassembly usually plugged into connectors on a backplane and secured in place, but easily removed. In the Series 90-70 PLC, a module consists of a printed circuit board with appropriate connectors and terminals and a protective faceplate.

N

No Load Diagnostic:

A diagnostic that detects of a no–load condition when one occurs. The information is automatically supplied to the CPU. The No Load diagnostic is provided by a current discriminator built into the "Smart Switch" output circuit in the Genius block.

O

Off-Line Mode:

A selectable mode of the Logicmaster programming and configuration software. Off-line mode is used for program development. In Off-line mode, the programmer does not communicate with the PLC, although the two may be physically connected. In Off-line mode, program power flow display and reference values are not updated.

On-Line Mode:

A selectable mode of the Logicmaster programming and configuration software. On-Line mode provides full CPU communications, allowing data to be both read and written.

On-Line Repair:

A repair made without interrupting system operation. In a GMR system, Genius I/O electronic modules may be replaced without disconnecting the power supply. In addition, Series 90 racks are completely isolated from each other. Therefore, "spare slots" and "spare devices" are not required in the installation.

On-Line Testing:

An integrated ability to do complete electrical testing without bypassing the system.

Open Architecture:

The rack-based non-proprietary design of the GMR system. Open architecture makes it possible to include many kinds of application-specific modules, including custom modules, in the overall GMR system.

Output Autotest:

See Autotest.

Output Block:

A Genius I/O module that converts logic-level signals received from the CPU to signals for controlling output devices.

Output Devices:

Physical devices such as motor starters, solenoids, etc., that are controlled by the PLC.

Overload and Short circuit detection:

The Genius I/O blocks used for GMR can provide stepped overload and instantaneous short circuit electronic protection per point. If an overload or short circuit occurs, an output circuit diagnoses the condition, turns itself off for protection, then reports the fault to the I/O Fault Tables in the CPUs. In fault-tolerant configurations, each leg is individually protected. This prevents the type of common-mode failure that can occur in systems with single slow-operating fuses.

P

Parallel Communications:

A method of communications in which data is transferred on several wires simultaneously.

Peripheral Equipment:

Devices external to the PLC (for example, personal computers and printers) with which the PLC can communicate.

PLC (Programmable Logic Controller):

A solid–state control device designed to operate in an industrial environment. The PLC receives signals from user-supplied control devices, such as switches and sensors. It implements them in a precise pattern determined by application programs stored in user memory. The PLC then provides output signals for control of processes or user-supplied devices such as relays or motor starters. PLCs are usually programmed in relay ladder logic.

PLC Fault Table:

A fault table listing PLC faults. Each fault is described and identified by time, date, and location.

Program Block:

Structured programming techniques can be used to separate areas of a GMR application program into functional blocks. Program blocks can be "called" from the main program or from other program blocks. Program blocks may contain logic in one of several available programming languages.

Programmer:

The computer used to run the Logicmaster 90 programming and configuration software.

R

Rack:

The "chassis" of the Series 90-70 PLC, consisting of a baseplate and structural frame. Modules install in mating connectors on the baseplate and are supported by the rack frame.

RAM:

An acronym for Random Access Memory. RAM is a solid-state memory that allows individual bits to be stored and accessed at random. In the Series 90-70 PLC, RAM stores the application program files and related data. RAM memory must receive constant power to retain its contents. Therefore, a backup battery is provided to prevent data loss. The backup battery used in the Series 90-70 PLC is a long–life lithium battery. The backup battery is mounted in the CPU module.

References:

The logical annotation used in an application program for representing data types and locations.

Relay Ladder Logic (RLL):

A programming language that uses a boolean representation in electrical schematic format to represent application program logic.

Reference Type:

Memory type definitions for the Series 90-70 PLC. For example, %I represents discrete inputs and %Q represents discrete outputs. The % symbol identifies the characters that follow it as a reference.

Register:

A group of 16 consecutive bits located in register (%R) memory. Register memory is used for temporary storage of numerical values and for bit manipulation.

Reliability:

The probability that the system will not fail, and will perform as originally installed at time $t=0$, during the required operational period.

Remote I/O:

I/O which may be located at a considerable distance from the PLC.

Removable Terminal Connector:

A removable assembly that attaches to the front of a printed wire board or module. It contains the screw terminals to which field wiring is connected.

Restart Pushbutton:

A pushbutton on the front of a PCM, ADC, or GDC module that can be used to reinitialize or reset it.

RTU Protocol:

An acronym for Remote Terminal Unit protocol, which is a serial communications standard for industrial controls.

RUN Mode:

The mode a PLC is in when it executes an application program.

S

Smart Switch:

A component of the principal types of Genius blocks used in GMR input and output subsystems. The Smart Switch provides configurable features and comprehensive diagnostics.

SNP:

An acronym for GE Fanuc Series Ninety Protocol serial communications.

Soft Configuration:

The ability to configure the GMR hardware system off–line using a personal computer.

STOP Mode:

The mode in which the PLC no longer executes the application program. In the Series 90-70 PLC, there are two types of Stop mode: STOP/NO IOSCAN and STOP/IOSCAN. In STOP/NO IOSCAN mode, the CPU communicates only with the programmer and certain special modules, recovers faulted boards, reconfigures boards and executes background tasks. In STOP/IOSCAN mode, the CPU can also monitor I/O. The STOP/IOSCAN mode makes it possible to monitor and debug I/O without executing the application program.

Supervised Inputs:

A method of monitoring inputs for short circuits during GMR system operation.

System Architecture:

The overall configuration of a system, including the types of components it contains and the ways they interact. GMR provides very flexible configurations for implementing a wide variety of control solutions.

T

"T" Fail Safe for Safety De-energized:

"T" creates an electrical Fail Safe circuit when used in safety circuits that are normally energized to "safe".. *See Fail Safe.*

Test Interval:

The time between autotest executions. This time interval can be modified.

Threshold Discrepancy:

The amount by which an individual analog input may deviate from the voted input value.

Triple Modular Redundancy (TMR):

A system architecture that is both fault-tolerant and failsafe. GMR *is* a TMR system.

Triplex:

Systems or subsystems that utilize three sets of components to perform the same operation

Tri-state Inputs:

A physical input that is configured and installed to report three independent discrete states to the CPU. Tristate inputs provide a level of supervision and/or diagnostics unavailable in simple On/Off state monitoring.

Also see Supervised Inputs

TÜV Rheinland:

TÜV is the acronym for Technisher Überwachungs-Verin. TÜV is an independent German technical inspection agency and test laboratory. It is widely recognized and respected for its testing and approval of electronic components and systems for use in safety-critical applications.

U

Underrange Fault:

The fault caused by an analog signal that is lower than the lowest value typically read for that signal.

User Memory:

The portion of system memory in which the application program and data are stored. In the Series 90-70 PLC, user memory is battery-backed CMOS RAM.

V

VME:

An acronym for Versa Module European.

Vote Adaptation:

A configurable and automatic change in a voting algorithm based on failure(s) of components in a system. *See Fault Degradation.*

Voted Input:

The voted result of a single, dual, or triple input received in the Input Status Table. All "raw" and voted points are available to the application program.

W

Warm Start:

The initializing of a CPU when one or more CPUs are already on-line.

Watchdog Timer:

A timer in the CPU used to ensure that certain hardware and software conditions are met within a predetermined time. The watchdog timer value is configurable, based on application program needs.

Word:

A measurement of memory length, usually 16 bits long.

Write Access:

Certain areas of data memory in the PLC may be written-to by intelligent external devices such as computers, DCS devices, and MMI devices. In a GMR system, the use and extent of write access can be tailored for the application.

To safeguard the data in the safety-related portion of the application program, TÜV specifies restrictions on the areas and size of data to which write access may be permitted.

Z

Zener Diode:

A special semiconductor that provides high conduction when current is applied in one direction and a specific voltage drop when current is passed in the reverse direction.

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