Genius Modular Redundancy (GMR)

GE Fanuc Automation

Programmable Control Products

Genius® Modular Redundancy

User's Manual

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Warnings, Cautions, and Notes as Used in this Publication

Warning

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.

Caution

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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CIMSTAR	Modelmaster	Series Five	VersaPoint
Field Control	Motion Mate	Series 90	VersaPro
GEnet	PowerMotion	Series One	VuMaster
			Workmaster

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Chapter 1

Introduction to GMR

Genius Modular Redundancy (GMR™) has been developed by GE Fanuc Automation, North America in partnership with Silvertech International PLC of the United Kingdom. GE Fanuc and Silvertech have for many years provided high-integrity safety system solutions to a wide spectrum of industries including: Oil & Gas Exploration and Production, Hydrocarbon Processing, Semiconductor, Transportation and Power Generation. Together they have captured this expertise in the GMR integrated system solution.

GMR Provides Scaleable Solutions

Based upon GE Fanuc's globally-available hardware, a GMR system can best be described as a number of modular subsystems, integrated to form a flexible and powerful whole. The number and type of subsystems is completely scaleable to the requirements of the application. Utilizing field-proven Series 90™-70 PLC, Genius® I/O, VersaMax™, and Field Control™ I/O products, GMR is able to provide variable redundancy from the input modules through one, two or three PLC CPU processors to the output modules. GMR implements advanced diagnostics throughout the systems to detect overt and covert failures, allowing system uptime to exceed 99.999% and reducing mean time to repair (MTTR) by pinpointing faults as they occur.

This flexibility also means less-critical inputs and outputs may be configured for simplex or duplex operation while maintaining triplicated elements for instrument loops requiring the highest levels of process integrity. The result is a system that provides the customer with a single hardware platform to implement both base regulatory control, and safety system functionality. A key feature of the GMR system is that non-redundant, less critical process control can be configured in the same system as redundant or triplicated safety-critical sections. While a (limited) number of GE Fanuc PLC products have been TÜV-approved for use in the redundant areas, all GE Fanuc PLC components can be used in the same system.

GMR Makes it Possible to Meet Global Standards

New global standards and regulations such as OSHA CFR 29 and IEC1511 are driving industry to look at the application of safety systems in a new and challenging manner. Industries may be required to perform this analysis and apply the required level of protection or "Safety Integrity Level - (SIL)" to the design of their process protection systems. Many manufacturers have turned to GE Fanuc for cost-effective solutions that allow them to remain competitive in the global marketplace. By configuring the GMR system to meet the precise requirements of SIL-1,2,and 3 for the application, the customer can remain in complete compliance while assuring the highest levels of performance and cost effectiveness.

Along with new global standards has come the realization that all PLC systems are not created equal. In the early 1990s industry turned to TÜV as an important global resource. TÜV is an independent German technical inspection agency and test laboratory, globally recognized and respected for their testing and approval of electronic components and systems for use in safety critical applications. TÜV has the knowledge and experience to provide testing for applications requiring maximum reliability, fault tolerance and safety. TÜV verifies proper system operation to international standards for fault insertion, environmental and electrical noise testing.

The versatility and strength of Genius Modular Redundancy make it an ideal choice for rigorous emergency shutdown and human life protection systems. It is backed by GE factory support and worldwide distribution network. For additional information contact your local GE Fanuc distributor or call 1 800-GE Fanuc.

TUV-Approved GMR Subsytem Configurations

TÜV has certified GMR to Safety Integrity Levels (SIL) according to ANSI/ISA S84.01, IEC 61508, DIN V19250, DIN/VDE 801 and other international standards relating to the design of Programmable Electronic System (PES) Technologies.

GE Fanuc has received TÜV type approval for the GMR system, for use in safety-relevant systems where the safe state is de–energized (e.g. ESD systems) or the demand state is energized (e.g. Fire & Gas systems, Boiler Management systems). The type approval certificate at the time of printing is 968/EZ 106.00/00. Refer to the GE Fanuc website (http://www.gefanuc.com/criticalcontrol) for the latest information on GMR type approvals.

Processor Configuration Options

Processor Redundancy	Description	Expected Safety Function SIL Rating	Expected Safety Function DIN Class Rating
Simplex	Single Processor	1	2/3
Simplex D	Single Processor with dual Genius bus using 1oo1d, H-block, I-block or T-block outputs	2	4
Duplex (1oo2d / 1oo2)	Dual processor with output voting 2oo2 / 1oo2 ⇒ 1oo1 using 1oo1d, H-block, I-block or T-block outputs	2	4
Duplex (1oo2d / 1oo2)	Dual processor with output voting 2oo2 / 1oo2 ⇒ 1oo1 (with time restriction) ⇒ default using H-block, I-block or T-block outputs	3	5/6
Triplex (2oo3)	Triple processor with output voting 2oo3 using H-block, I-block or T-block outputs	3	5/6

Input Configuration Options

Detector Redundancy	Safety Function Voting	Input Unit Type	Minimum Input Channels per Detector	Minimum Number of Inputs Units	Expected Safety Function SIL Rating	Expected Safety Function DIN Class Rating
Simplex	1oo1	Digital	1	1	1	2/3
		Analog	1	1		
Simplex	1oo1	Digital	1	1	2	4
		Analog	2	2		
Duplex	1oo2	Digital	1	2	2	4
		Analog	1	2		
Duplex	1oo2d	Digital	1	2	2	4
		Analog	1	2		
Simplex‡	1oo1	Digital	2§	2	3	5/6
		Analog	3	3		
Duplex	1oo2	Digital	1	2	3	5/6
		Analog	2	2		
Duplex	1oo2d	Digital	1	2	3	5/6
		Analog	2	2		
Triplex or Higher	2ooN	Digital	1	3	3	5/6
		Analog	1	3		

‡ This configuration is only permitted under IEC 61508 if the input device conforms with the requirements of IEC 61508 Part 2 Table 2 Architectural Constraints on Type A Safety Related sub-systems and Table 3 Architectural Constraints on Type B Safety Related sub-systems.

§ GMR Input Voting must be set to 1oo2

Output Configuration Options

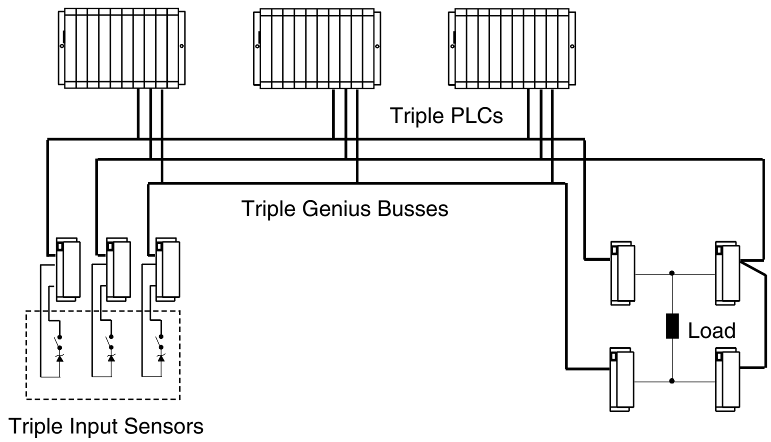
Actuator Redundancy	Safety Function Voting	Output Safe State	Output Configuration (per actuator)	Expected Safety Function SIL Rating	Expected Safety Function DIN Class Rating
Simplex	1oo1	Energized or De-energized	Single block	1	2/3
Simplex	1oo1	De-energized	1oo1d	2	4
Simplex‡	1oo2	De-energized	I-block / H-block	3	5/6
Simplex‡	1oo2	Energized	T-block / H-block	3	5/6
Simplex‡	1oo2d	De-energized	H-block	3	5/6
Simplex‡	1oo2d	Energized	H-Block	3	5/6
Duplex or Higher	1oo2	De-energized	Single¥, I-block, 1oo1d , H-block	3	5/6
Duplex or Higher	1oo2	Energized	Single¥, T-block, H-block	3	5/6

‡ This configuration is only permitted under IEC 61508 if it conforms with the requirements of IEC 61508 Part 2 Table 2 Architectural Constraints on Type A Safety Related sub-systems and Table 3 Architectural Constraints on Type B Safety Related sub-systems.

¥Output signals must be on different output units.

Parts of a GMR System

A GMR system consists of input devices gathering data from multiple or single sensors, multiple PLCs running the same application program, and groups of Genius blocks controlling shared output loads. Communications between the blocks and PLCs, and among the PLCs themselves is provided by redundant Genius busses.



The system may have:

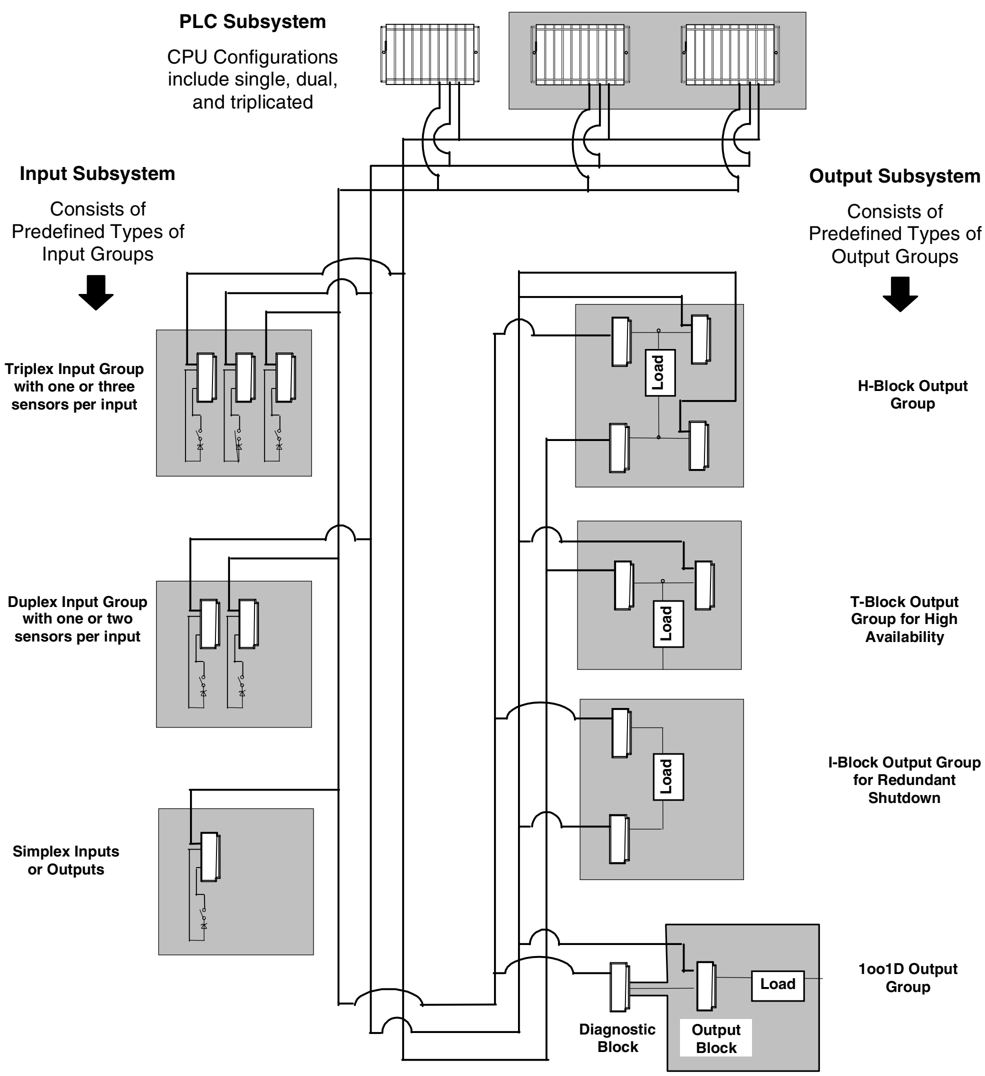
- Normally-on inputs with normally-energized outputs, as in emergency shutdown systems.
- Normally-off inputs with normally-deenergized outputs, as in fire and gas detection systems.

Genius Modular Redundancy provides:

- A high degree of self-test and monitoring with diagnostics
- Fault tolerance.
- Support for centralized or fully distributed systems.
- Scalable voting.

Subsystems in a GMR System

The basic parts of a GMR system are the input subsystem, the PLC subsystem, and the output subsystem. These subsystems can be designed to provide the exact mix of redundant and non-redundant discrete and analog equipment needed for a broad range of critical control applications.



The Input Subsystem

The input subsystem is the part of a GMR system that gathers input data and provides it to the PLCs. The input subsystem may include the following types of Input Groups:

- **Voted:** Genius discrete inputs
  Genius analog inputs
  VersaMax analog inputs
  Field Control analog inputs
- **Non-voted:** Genius discrete inputs
  Genius analog inputs
  VersaMax analog inputs
  Field Control analog inputs

Chapter 2 provides detailed information about the input subsystem.

The PLC Subsystem

A GMR system normally consists of one to three identical CPUs running identical application software. Each PLC is connected to the same input and output subsystems.

Each PLC receives all inputs and performs voting for discrete inputs and mid-value selection for analog inputs. Each PLC computes the required outputs as a function of the inputs and the application program logic. Each PLC then sends its own output data on the busses.

Integral to the operation of a GMR system is the GMR software. The GMR software provides both system configuration tools and system software functionality. Added to the program folder for a specific GMR application, the GMR system software controls input voting, special GMR memory mapping, diagnostic messaging, periodic autotesting, and other operating features of the PLC subsystem.

Chapter 4 provides detailed information about the PLC subsystem.

The Output Subsystem

The output subsystem is the part of a GMR system that provides output data. The GMR output subsystem may include the following types of Output Groups:

- H-Block Redundant Output Group
- T-Block Redundant Output Group
- I-Block Redundant Output Group
- 1out of 1 Diagnostic (1oo1D) Block Redundant Output Group
- Individual Genius blocks

Chapter 3 provides detailed information about the output subsystem.

Series 90-70 PLCs for GMR Systems

Three models of the Series 90-70 PLC CPU support GMR: CPM 790, CPU 789, and CPU 788. Information about minimum product versions needed for GMR version 4.02 is provided in the Important Product Information document that is included with the GMR software. Version information is also available online at www.gefanuc.com/criticalcontrol.

CPUs and Bus Controllers	Catalog Number
Series 90-70 PLC CPU	IC697CPU788 IC697CPU789 IC697CPM790
Series 90-70 PLC CPU Memory (788, 789 only)	IC697MEM735
Series 90-70 Bus Controller	IC697BEM731

The CPM790 CPU can be used in control applications where I/O is either static or not static under normal operating conditions.

Model 789 and 788 CPUs are appropriate for systems that have static or nearly static I/O under normal operating conditions.

If the GMR system includes either two or three PLC CPUs, they must be the same model.

Number of I/O Points in a GMR System

The I/O capacity of the system depends on whether the CPU is a model 788, model 789 or model 790. The table below shows the maximum numbers of total discrete I/O, voted inputs and voted outputs for each of the three GMR PLC types.

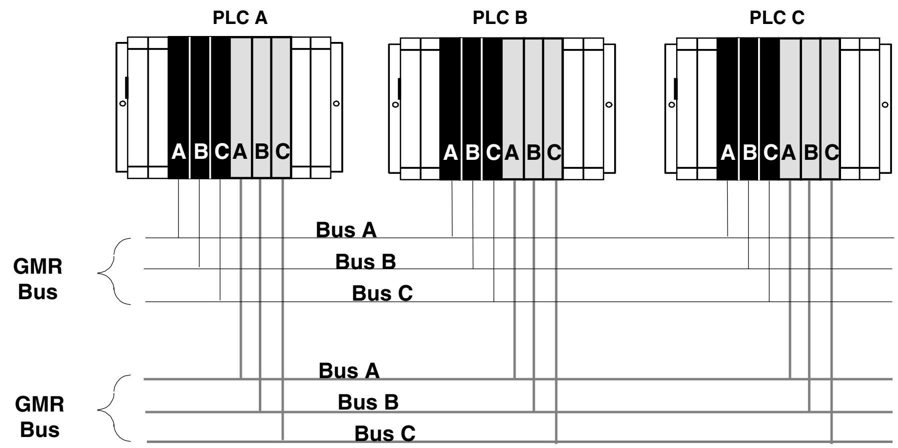
CPU Model	Total Discrete Physical I/O	Maximum Voted Inputs	Maximum Voted Outputs
789, 790	12288	2048	2048
788	352	112	80

For most applications, these limits will not be reached. If you need help estimating I/O sizes for a large application, contact GE Fanuc at 1-800-828-5747.

Busses and Bus Controllers

Each PLC requires one to three Bus Controllers per redundant GMR bus.

Larger systems may require more than one I/O subsystem. For example, the GMR system represented below has two GMR busses for a total of six independent Genius busses and 18 bus controllers.



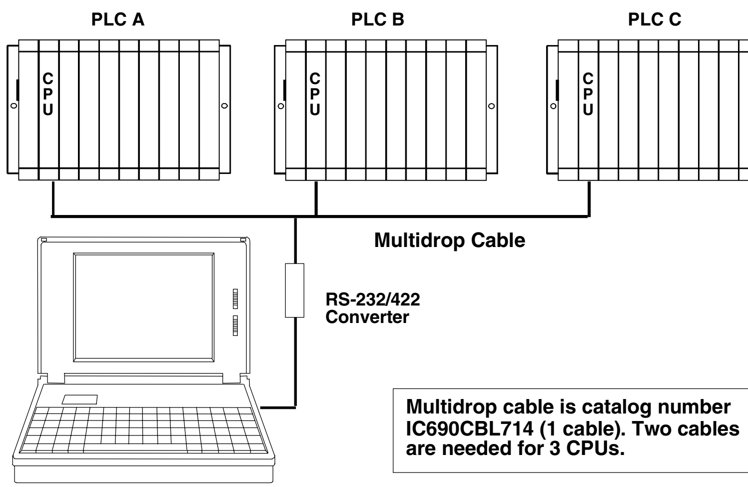
Each Genius bus uses a single twinax cable over distances of up to 7500 feet and data rates of up to 153.6K baud.

Each PLC may have up to 31 Genius Bus Controllers, in multiple racks.

Inter-processor Communications

The PLCs exchange initialization data at startup, then operate asynchronously. Each Genius bus scan, each PLC broadcasts 64 words of Global Data. This includes 8 words of system information and 56 words of Global Data are available for use by the application program. Redundancy is also built into Global Data communications. Each message is sent twice, using different busses.

The PLCs may also be joined in a multidrop Series Ninety Protocol (SNP) network. A host computer on the network can be used for gathering data from the system. In addition, the SNP network permits convenient program updates using the Logicmaster 90 programming software and the Program Download utility included with the GMR software. With the 790 CPU, Ethernet can be used for program handling and network communications.



All other normal Series 90-70 communications interfaces are also available. If required for the application, the host software should collect data from each CPU and perform the necessary voting.

Additional Bus Controllers for Communications

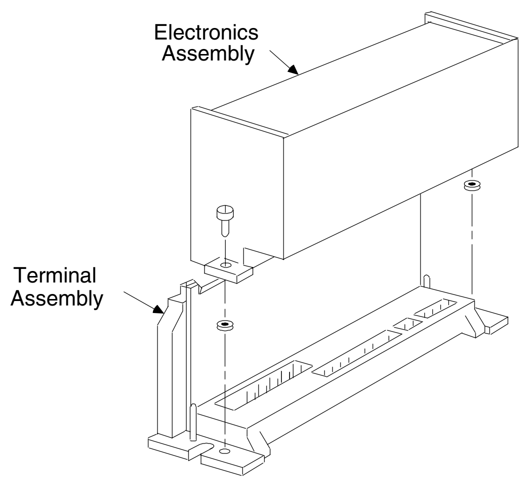
The Genius busses that support GMR input and output groups are also used for internal communications between PLCs, as mentioned above. These GMR Bus Controllers should not be used for datagram communications. Separate busses for communications can be used for datagrams or additional global data in the application program.

The Bus baud rate should be selected on the basis of the calculations in the Genius I/O System and Communications User's Manual (GFK-90486). *For correct GMR Autotesting, the Genius bus scan time should not be more than 60mS.*

Genius I/O Blocks for GMR Systems

Genius I/O blocks are the primary elements of the I/O subsystems. All Genius 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 voted/redundant 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).

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 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.



Many block 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. Detailed information about the full range of Genius I/O blocks is available in the *Genius I/O Blocks User's Manual,* GEK-90486-2.

The I/O data for each block is communicated over the Genius bus with the Genius Bus Controllers in GMR PLCs. Genius communications protocol is defined in the *Genius System Communications Manual,* GEK-90486-1.

Choosing Genius Blocks for GMR Subsystems

Specific Genius blocks have special features designed for GMR input groups and GMR output groups. *When configured for GMR operation (only)*, they perform output voting, support GMR autotesting, and provide diagnostic reports to up to three PLCs.

All types of Genius blocks can be included in a GMR system as "non-voted" blocks. Non-voted blocks are not part of any GMR input group or output group. They are included in the GMR configuration and they may be autotested.

Analog blocks can be used as either voted or non-voted inputs. However, analog blocks in GMR input groups are *not* autotested by the GMR software. Analog blocks cannot be used in GMR output groups. However, they do support standard Hot Standby Redundancy.

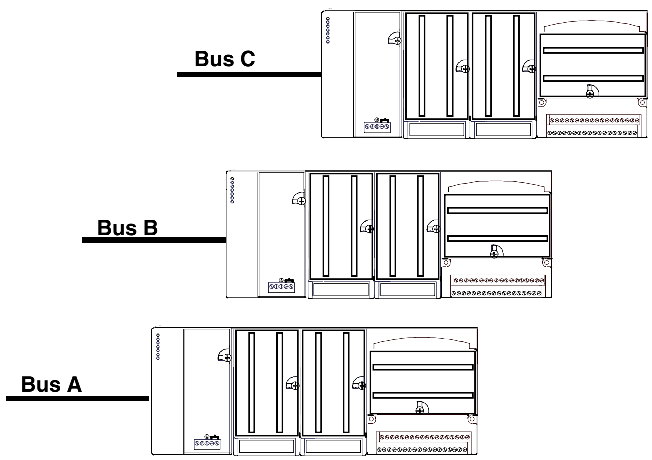
Block	Voted Input Group	I-Block GMR Output Group	T-Block GMR Output Group	H-Block GMR Output Group	1oo1D GMR Output Group	Non-Voted I/O
Genius Discrete DC						
IC660BBD020 (24/48VDC 16 Ckt Source) *	Yes	Yes	Yes	Yes	Yes	Yes
IC660BRD020 (24/48VDC 16 Ckt Source)			Yes			
IC660BBD021 (24/48VDC 16 Ckt Sink)*	Yes	Yes	Yes	Yes	Yes	Yes
IC660BBD022 (24VDC 16 Ckt Source)						Yes
IC660BBD023 (24VDC 16 Ckt Sink)						Yes
IC660BBD024 (12/24VDC 32 Ckt Source)*	Yes	Yes	Yes	Yes	Yes	Yes
IC660BBD025 (5/12/24VDC 32 Ckt Sink) *	Yes	Yes	Yes	Yes	Yes	Yes
Genius Discrete AC						
IC660BBD101 (115VAC 8 Ckt Grouped)	Yes					Yes
IC660BBS102 / IC660BBS100 (115VAC/125VDC 8 Ckt Isol)	Yes					Yes
IC660BBS103 / IC660BBS101 (115VAC/125VDC 8 Ckt Isol)	Yes				Yes	Yes
IC660BBD110 (115VAC 16 Ch. I/P only)	Yes					Yes
Genius Analog						
IC660BBA020 (24/48VDC 4 Ch. In, 2 Ch. Out)	Yes					Yes
IC660BBA021 (24/48VDC 6 Channel, RTD)	Yes					Yes
IC660BBA023 (24/48VDC 6 Channel T/C)	Yes					Yes
IC660BBA024 (24/48VDC 4 Ch. In, 2 Ch. Out)	Yes					Yes
IC660BBA026 (24/48VDC 6 Channel)	Yes					Yes
IC660BBA100 (115VAC 4 Ch. In, 2 Ch. Out)	Yes					Yes
IC660BBA101 (115VAC/;125VDC 6 Channel, RTD)	Yes					Yes
IC660BBA103 (115VAC/125VDC 6 Channel T/C)	Yes					Yes
IC660BBA104 (115VAC/125VDC 4 Ch. In, 2 Ch. Out)	Yes					Yes
IC660BBA106 (115VAC/125VDC 6 Channel In)	Yes					Yes

* Revision R or later required for use in GMR output groups.

VersaMax I/O Stations for GMR Systems

VersaMax I/O Stations with analog modules can be included in the GMR configuration and used as GMR analog input groups. However, they are not autotested by the GMR software. VersaMax I/O Stations with all types of VersaMax I/O modules can be used as non-voted I/O on other busses in the system.

A VersaMax I/O Station consists of a Genius Network Interface Unit and up to 8 I/O modules. The Network Interface Unit and I/O modules mount on terminal blocks called carriers, which provide electrical and field wiring connections. The following illustration represents an analog input group consisting of three VersaMax I/O Stations each having three analog input modules.



Power for module operation is provided by a power supply that mounts directly on the NIU itself. Additional “booster” power supplies can be included in the system if needed for modules with high current requirements.

The table below summarizes how a VersaMax I/O Station can be used for GMR:

GMR Analog Inputs	GMR Outputs	‘Non-voted” GMR Inputs	Autotest	Non-GMR I/O
yes	no	yes	no	yes

The Genius Network Interface Unit

The Genius Network Interface Unit functions as a single device on the bus, like an individual Genius block. It exchanges up to 128 bytes of input data and 128 bytes of output data each Genius bus scan. The intelligent processing capabilities of the Genius Network Interface Unit allow the configuration of features such as fault reporting, selectable input and output defaults, analog scaling and analog range selection for the modules in the station. In addition, the Genius Network Interface Unit performs diagnostic checks on itself and its I/O modules, and relays diagnostic information to the host (if configured for fault reporting). The I/O Station can be autoconfigured (using the default module features) or configured using the NIU Configuration Utility. For more information about the VersaMax Genius Network Interface Unit, refer to the *Genius NIU User's Manual*, GFK-1535.

Equipment for a VersaMax Analog I/O Station

The equipment that can be used in a VersaMax I/O Station that is used in a voted analog input group includes:

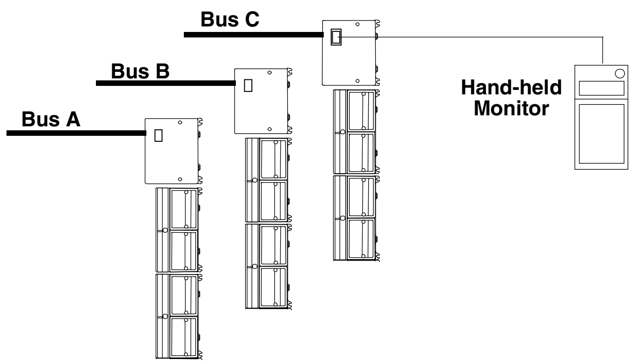
Genius Network Interface Unit	IC200GBI001
4 Channel Voltage/Current Input Module	IC200ALG230
8 Channel Voltage/Current Input Module	IC200ALG260
4 Channel RTD Input Module	IC200ALG620
Power Supply, 24V dc	IC200PWR001
Power Supply, 24V dc Exp. 3.3V	IC200PWR002
Power Supply, 120/240V ac	IC200PWR101
Power Supply, 120/240V ac Exp. 3.3V	IC200PWR102
Power Supply Carrier	IC200PWB001
I/O Carrier – barrier terminals	IC200CHS001
I/O Carrier – box terminals	IC200CHS002
I/O Carrier – connector	IC200CHS003
I/O Carrier – spring clamp terminals	IC200CHS005
Interposing Terminal Carrier	IC200CHS012
Cable – 0.5m	IC200CBL105
Cable – 1.0m	IC200CBL110
Cable – 2.0m	IC200CBL120
Cable – 3.0m	IC200CBL130

For more information about VersaMax I/O modules, refer to the *VersaMax Modules, Power Supplies, and Carriers User's Manual*, GFK-1504.

Field Control I/O Stations for GMR Systems

Field Control I/O Stations with analog modules can be included in the GMR configuration and used as GMR analog input groups. However, they are not autotested by the GMR software. Field Control I/O Stations with all types of Field Control I/O modules can be used as non-voted I/O on other busses in the system.

A voted analog input group can consist of 1 to 3 matching Field Control I/O Stations with a Genius Bus Interface Unit and up to 8 analog input modules (depending on I/O count).



The table below summarizes how a Field Control I/O Station can be used for GMR:

GMR Analog Inputs	GMR Outputs	'Non-voted" GMR Inputs	Autotest	Non-GMR I/O
yes	no	yes	no	yes

The Bus Interface Unit and I/O modules are enclosed in sturdy, compact aluminum housings. Bus Interface Unit and I/O modules bolt securely to separate Terminal Blocks, which provide all field wiring terminals. Terminal Blocks must be mounted on a DIN rail, which serves as an integral part of the grounding system. The DIN rail can also be mounted on a panel.

Genius Bus Interface Unit

The Bus Interface Unit functions as a single device on the bus, like an individual Genius block. It exchanges up to 128 bytes of input data and 128 bytes of output data each bus scan. The Bus Interface Unit performs diagnostic checks on itself and its I/O modules, and relays diagnostic information to the PLCs (if configured for fault reporting) and to a Hand-held Monitor. A Hand-held Monitor is required for configuring the I/O Station. For information about the Field Control Genius Bus Interface Unit, refer to the *Genius Bus Interface User's Manual*, GFK-0825.

Equipment for a Field Control I/O Station

The Field Control equipment that can be used in a GMR Voted Analog Input Group is listed below:

Genius Bus Interface Unit, 24V dc	IC670GBI002
8 Channel Current Input Module	IC670ALG230
16 Channel Current Input Module	IC670ALG240
4 Channel RTD Input Module	IC670ALG620
8 Channel Thermocouple Input Module	IC670ALG630
8 Channel Voltage Input Module	HE670ADC810
Terminal Block with box terminals	IC670CHS001
Terminal Block with barrier terminals	IC670CHS002
Terminal Block with connector terminals	IC670CHS003
Thermocouple Terminal Block	IC670CHS004

For information about the Field Control I/O modules, refer to the *Field Control I/O Modules User's Manual*, GFK-0826.

Number of Analog Modules in the I/O Station

Because the maximum input data length for the BIU is 128 input bytes, the actual number of input modules that can be present in the I/O station depends on each module's input data length. For example, a Field Control I/O Station can only include four 16-point analog input modules if all their inputs are used, and it is still necessary to configure a length of 0 for their %I discrete input bits (the default length is 88 bits).

	%AI words	%I bits
IC670ALG230: Current Source Analog Input Module	8	0
IC670ALG240: 16-Point Grouped Analog Input Module	16	88 (optional, configurable)
IC670ALG620: RTD Analog Input Module	4	32 (optional, configurable)
IC670ALG630: Thermocouple Analog Input Module	8	48 (optional, configurable)

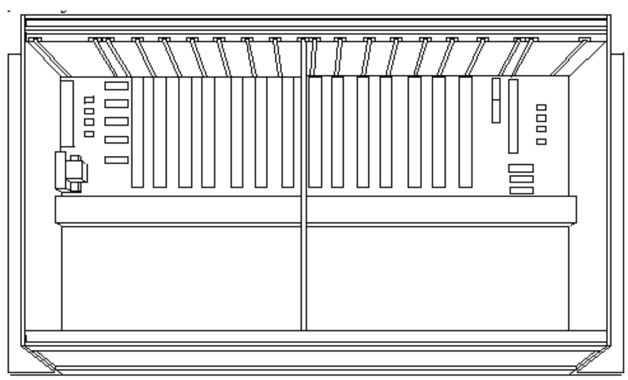
Duplex GMR Systems Using Integrated Redundant Racks

The GE Fanuc Integrated Redundant racks, IC697CHS770 (rear mounted version) and IC697CHS771 (front mounted version), can provide an alternative for duplex GMR Systems requiring two PLCs with two Genius Bus Controllers each.

An Integrated Redundant Rack is a single rack divided into two halves. Each half can accommodate a power supply, a CPU, and two bus controllers. For a more thorough discussion of this rack, please refer to GE Fanuc publication GFK-1447.

Features of an Integrated Redundant Rack

- Rear mount rack mounts in a 10" (254 mm) deep enclosure
- Front mount rack mounts in a standard 19" (483 mm) rack
- Accepts plug–in AC/DC and DC Series 90-70 PLC power supplies, or can use external supply (Power Supply Adaptor module required)



The Integrated Rack has two Power Supply slots and 12 backplane slots divided into two separate sections, each having a Power Supply slot and 6 backplane slots. Backplane connectors are spaced on 0.8 inch centers.

Integrated Redundant Rack Specifications

Number of PLCs per rack	2
Number of Slots per PLC	6 plus power supply slot
Dimensions:	Height: 11.15” / 283mm; Width: 19.00” / 483mm; Depth: 7.5” / 190mm
VME	System designed to support VME standard C.1

Using an Integrated Redundant Rack in a GMR System

The Integrated Rack was designed for use with half-slot modules. Although Series 90-70 Genius Bus Controllers are full-width modules, they can be used with this rack if the unoccupied slots are filled with VME interrupt jumpers (order item IC697ACC722 from GE Fanuc). One jumper is required for each Bus Controller in the Integrated r Rack.

As with other GMR systems, a system with Integrated Redundant Racks must be properly installed and configured. The power supply is placed in outside position in each half of the rack. On the left side of the rack, slots are numbered from left to right. On the right side of the rack, slots are numbered from right to left.

With the CPU at slot 1, an interrupt jumper must be placed at slot 2, before placing a Genius Bus Controller at slot 3. On the right side of the rack, it is not physically possible to place the Bus Controller at slot 2, and since the configuration of both sides must match, this physical setup must be applied to the left side as well. Another jumper must be placed at slot 4 on both sides, prior to placing the bus controller at slot 5.

When configuring the Integrated Redundant Rack with the GMR Configuration Software and when using the Logicmaster configuration software, the rack can be configured as either a 5-slot rack or a 9-slot rack. The Integrated Redundant Rack itself has 7 slots in each half. The configuration option selected only affects the way the rack is displayed during configuration. The 9-slot rack is the default selection. If the Integrated Redundant Rack is configured as a 9-slot rack, slots 8 and 9 are not accessible in each half.

Additional Items for GMR Systems

"SPECIAL SAFETY SYSTEM" red I/O block labels (package of 50 of the same type) are available: IC660SLA020, A021, A023, A024, A026, A100, A101, A103, A104, A106, D020, D021, D024, D025. These numbers correspond to the numbers of the blocks. For example, order label IC660SLA021 for block IC660BBA021.

Logicmaster 90-70 Software: release 6.01 or later is required for CPU 790. For CPU788 and CPU 789, Logicmaster release 4.02 provides generic GMR configurability. For applications using a Genius Bus Interface Unit where the CPU is required to explicitly check the ID of the Bus Interface Unit, Logicmaster release 6.02 or later is required.

Hand-held Monitor (optional): IC660HHM501H (version 4.5) or later.

SNP Programming Cable and RS 232/RS 485 adapter. (IC690ACC901)

Multidrop Cable (IC690CBL714) (Two required for connecting 3 CPUs.)

Termination Boards see chapter 12.

Incompatible Products

Graphics Display System (GDS): GMR is incompatible with Cimplicity 70 GDS.

Special Requirements for TÜV Systems

For a TÜV system, check the GE Fanuc website at
www.gefanuc.com/criticalcontrol
for the latest information about certified components.

Chapter 2

The Input Subsystem

This chapter describes the input subsystem of a GMR system.

- Types of GMR Input Groups
- Discrete input processing
- Discrete input autotest
- Line monitoring for 16-circuit DC blocks
- Manual discrete input controls
- GMR voted analog input groups
- Non-voted I/O in the input subsystem

Types of GMR Input Groups

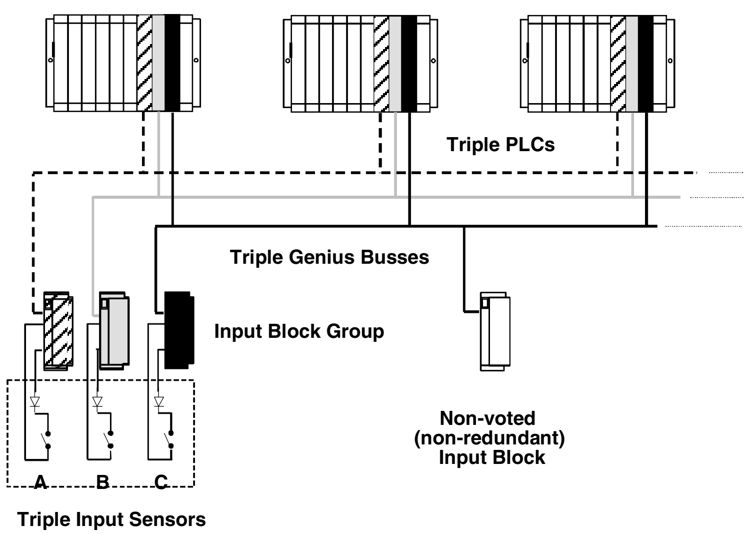
The input subsystem is the part of a GMR system that gathers input data and provides it to the PLCs.

The GMR input subsystem may include the following types of Input Groups:

- Voted: Genius discrete inputs
  Genius analog inputs
  VersaMax analog inputs
  Field Control analog inputs
- Non-voted: Genius discrete inputs
  Genius analog inputs
  VersaMax analog inputs
  Field Control analog inputs

Both Voted and Non-voted Groups are included in the GMR configuration. The system may also include inputs from individual blocks or modules that are not part of the GMR configuration.

The illustration below shows a triple PLC system. The input subsystem is represented by a triplex voted input group with individual sensors and a non-voted block. These and other types of GMR input groups are described on the following pages.

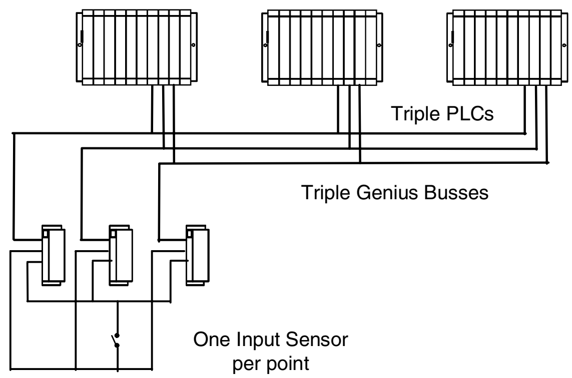


Sensors and Input Groups

The following combinations of sensors and inputs can be used with GMR:

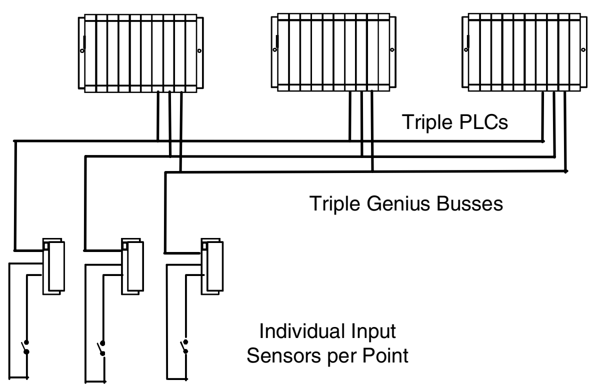
- **one sensor to three Genius inputs, three busses with one, two or three PLCs**
- **one sensor to two Genius inputs, two busses with one, two or three PLCs**

  This illustration shows a discrete input group where three discrete blocks share a single input device per point.



- **three sensors to three Genius inputs, three busses with one, two or three PLCs**
- **two sensors to two Genius inputs, two busses with one, two, or three PLCs**

  This illustration shows a discrete input group where three discrete blocks have individual sensors for each point.

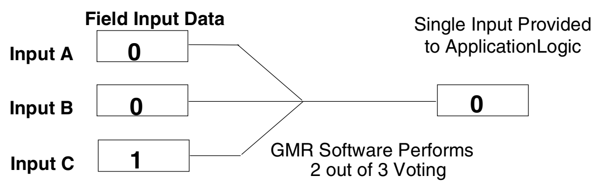


- **one sensor to one Genius input**

Configuring single discrete blocks as non-voted GMR blocks allows them to take advantage of the GMR system features.

Discrete Input Processing

Discrete input voting is handled in each PLC, by the GMR system software. Input processing by the PLC is explained in detail in chapter 4. Basically, the GMR system software compares input data from all corresponding inputs (3, 2, or 1) for each point, and provides a voted input result for use by the application program. If all the input data is not available, the GMR system software follows a configured voting adaptation scheme. The application program can also access the original, unvoted input data, along with any non-GMR inputs that have been included in the input subsystem.



For GMR inputs, if there is a discrepancy between the original input data for an input and the voted input state, the GMR software automatically places a message in the I/O Fault Table, where it is available to the Logicmaster 90 software and the application program logic. This is also described in more detail in the PLC chapter. Fault bits are also set for input discrepancies. These fault bits are available for use in the application program, for further annunciation or corrective action.

Discrepant signals are filtered for a configurable time period, to eliminate transient discrepancies caused by timing differences.

Discrete Input Autotest

Discrete Input Autotest is an optional GMR feature that can be configured for 16-circuit and 32-circuit DC blocks that have been set up as “DC GMR” blocks. The autotest exercises the system inputs to be sure they remain able to detect and respond to actual inputs. Input Autotest accommodates both normally-closed and normally-open devices with the devices in either state. The test detects input failures that would result in a failure to respond. Discrete Input Autotest does not cause spurious outputs.

Operation of the Input Autotest

Operation of the input autotest is internal to each Genius block. After initiation by the Autotest Master PLC, the autotest requires no additional interaction with the PLCs. While it is completing the autotest process, a block continues to supply its last valid set of inputs instead of the physical inputs to the PLCs.

The block performs the following actions during an Input Autotest:

- power feed outputs (point 16) are pulsed Off.
- selected input channels are pulsed On as shown in the table below.
- all associated inputs are checked for their ability to detect the On or Off state, as appropriate. A fault is reported if the correct state is not detected.

By allowing some inputs to be turned On, the Input Autotest checks for circuit-to-circuit shorts and also checks its own operation. The following table shows cycles in which blocks are autotested, and circuits that are turned On in the same cycle.

Block Type	1st A/T Cycle	2nd A/T Cycle	3rd A/T Cycle	4th A/T Cycle	Circuits Turned On at the Same Time	Circuit Fail Mask
16 Circuit DC	Block A	Block C	Block B	Block A	1,3,5,7,10,12,14	2A55
	Block B	Block A	Block C	Block B	2,4,6,8	00AA
	Block C	Block B	Block A	Block C	9,11,13,15	5500
32 Circuit DC	Block A		Block C	Block B	1,5,9,13,17,21,25,29	1111 1111
	Block B	Block A		Block C	2,6,10,14,18,22,26,30	2222 2222
	Block C	Block B	Block A		3,7,11,15,19,23,27,31	4444 4444
		Block C	Block B	Block A	4,8,12,20,24,28,32	8888 0888

Notes: Bit 16 corresponds to the power feed output. It is always 0.

For 16-Circuit blocks, each circuit is turned On each cycle when looked at across all 3 blocks, but the same circuit is never turned On at more than one block at a time.

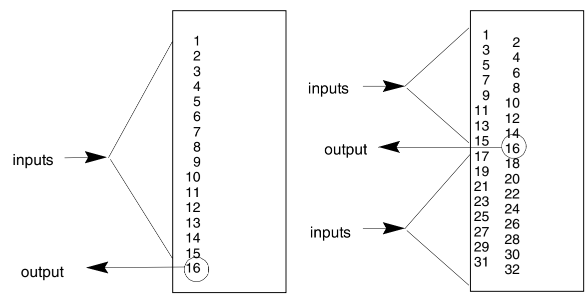
For 32-Circuit blocks, almost all circuits are turned On each cycle when looked at across all 3 blocks, but the same circuit is never turned On at more than one block at a time.

Configuration Required for Discrete Input Autotest

In addition to being configured as DC GMR blocks, blocks on which any inputs will be autotested must be configured as “combination” (input and output) blocks, with point 16 on each block set up as an output. Point 16 must be configured to be “Default On”. Autotesting is configurable on a point-by-point basis. In addition, blocks can be configured for either Synchronous or Asynchronous Autotest, as explained on the next page.

Setup Required for Discrete Input Autotest

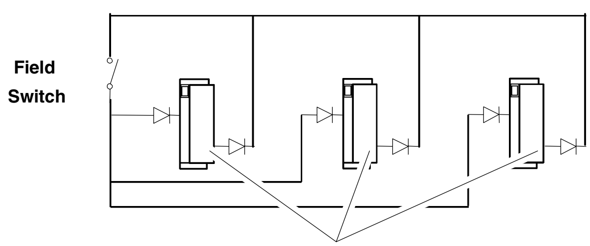
All inputs that will be autotested must have their power controlled by circuit 16, which functions as the “power feed output”. Each power feed output is capable of providing power to up to 31 input devices.



16-circuit block 32-circuit block

Setup to Detect Circuit Shorts

Autotesting can detect circuit-to-circuit shorts if isolation diodes are installed at the input point(s). If the block is part of an input group that has a single input sensor wired to more than one input block, isolation diodes must also be installed on the power feed outputs.

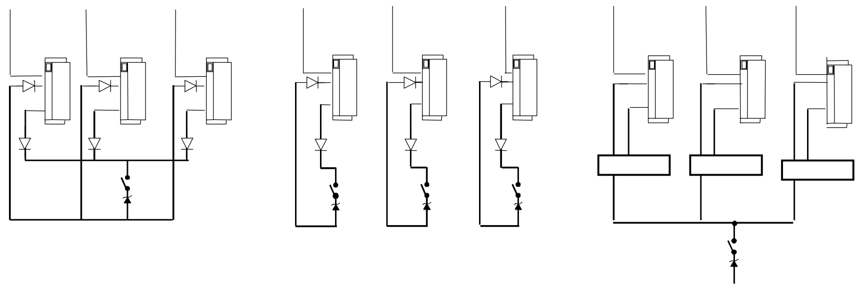


Power feed outputs require isolation diode when single input device is wired to more than one block.

Chapter 12 describes termination boards that can be used to simplify wiring for input autotest. These termination boards include the necessary isolation diodes.

Synchronous or Asynchronous Input Autotest and I/O Shutdown

In the GMR configuration discrete input groups can be configured for either Synchronous or Asynchronous Input Autotesting. Synchronous Autotesting must be selected if the blocks are used without isolation between them (example A below). Asynchronous Autotesting requires isolation either through the use of individual input devices (example B) or special termination boards (example C).



Example A: Blocks Wired Together (Use Synchronous Autotest)

Example B: Redundant Input Devices (Asynchronous Autotest OK)

Example C: Single Input Device Wired to Termination Boards (Asynchrounous Autotest OK)

Synchronous Input Autotest

If non-redundant simplex discrete input devices are used without isolation between blocks (I.E. the powerfeed outputs (point 16) of each block ARE wired together through diodes), Synchronous Input Autotesting must be used for the input group.

Two types of faults may prevent a synchronous autotest from completing for an input group, initiating an I/O shutdown for the inputs in the group:

- Loss of communications from block within the group.
- Autotest failure of the power feed output (point Q16) of any block in a group.

Asynchronous Input Autotest

Using Asynchronous Autotesting requires isolation of the blocks from each other. This may be accomplished with redundant discrete input devices (for example, sensors). See example B above. The redundant input devices allow individual blocks in a group to stay isolated from each other. In this case, the power feed outputs (point 16) of each block ARE NOT wired together.

Alternatively, Asynchronous Autotest can be used with only one input device if the input device is wired to special Terminal Boards. See example C above. Chapter 12 describes operation and installation of these Terminal Boards and associated Interface Modules.

With Asynchronous Autotesting, the input autotest can continue executing on other blocks in a group that are not affected by the fault. Because autotesting continues, an I/O shutdown is not necessary and WILL NOT occur.

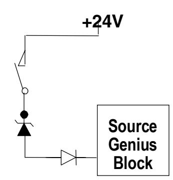
Line Monitoring for 16-Circuit DC Blocks

Input line fault detection is a feature of 16-circuit DC Genius blocks. These blocks (only) are capable of continually monitoring field circuits for either input short circuit or open circuit faults. The blocks detect On, Off, and eirher Short Circuit or Open Wire conditions. To report line faults, an input must be configured for tristate operation and installed as explained in chapter 11.

- For blocks in non-GMR mode, a line fault represents an open circuit fault in the field wiring. In this case, "non-GMR mode" means any block set up in its Genius block configuration for "Redundancy Mode" = None, Hot Standby, or Duplex. If a block is in "non-GMR" mode, a resistor must be installed in the circuit to provide Open Wire fault detection.
- For blocks in GMR mode, a line fault represents a short circuit fault on the field wiring. If the block is set up in its Genius configuration for "Redundancy Mode" = GMR, a zener diode is used instead of a resistor to detect short circuits. The diode is installed in series between the field switch and the tristate input blocks, physically at the field switch device. The Zener diode rating is 6.2V.

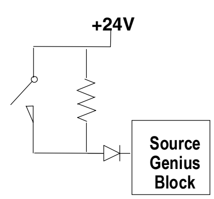
Normally-closed DC Inputs

For applications such as Emergency Shutdown (ESD), normally-closed inputs are generally monitored for short circuits across the lines, since that represents a fail to danger condition (that is: trip is not detected). In general, these inputs are powered from +24V, and a field short to ground is interpreted as a trip condition.



Normally-open DC Inputs

For applications such as Fire and Gas Detection, normally-open DC inputs are generally monitored for open circuits on the lines, since that represents a fail to danger condition (that is: trip is not detected). In general, these inputs are powered from +24V, and a field short to +24V is interpreted as a trip condition.



Calculating Voltage Drops on Tristate Inputs

It is important to consider the field wiring runs required for devices configured as tristate inputs. Devices powered by 24V DC will have a voltage-reducing component inserted at the field device to provide an input threshold range for three states. The table below shows appropriate ranges.

Wiring runs can reduce the voltage at the input block terminal further, to an inoperable level, depending on the length, conductor, and gauge. Isolation diodes placed before the terminal on the input will also drop the voltage.

Most applications <u>do not have</u> limitations created by these factors. However, to ensure that all input state operations are indicated correctly, calculations should include the field signal voltage, the wire resistance times the length and the voltage drop in any barriers or isolation devices, to determine the actual voltage present at the input terminal. Additional information about input blocks is located in the *Genius I/O Discrete and Analog Blocks User's Manual* (GEK-90486-2).

Ranges and Line Faults for DC Blocks

When a DC block is configured (with a Hand-held Monitor) as a GMR block, its input thresholds change to those listed below. In addition, when a block is in GMR mode, the status and on/off state of a tristate input have different specifications than they do in non-GMR mode.

			Non-GMR Mode		GMR Mode	
		Range	**Input Status**	**Input State**	**Input Status**	**Input State**
Source Blocks	**Tristate inputs**	<30% VDC	open circuit fault	0	off	0
		>50% VDC < VDC+-7V	off	0	on	1
		< VDC+-4V	on	1	short circuit fault	1
	Bi-state inputs	<30% VDC			off	0
		>50% VDC			on	1
Sink Blocks	**Tristate inputs**	<4V	on	1	short circuit fault	1
		>7V <50% VDC+	off	0	on	1
		>70% VDC+	open circuit fault	0	off	0
	Bi-state inputs	<50% VDC			on	1
		>70% VDC			off	0

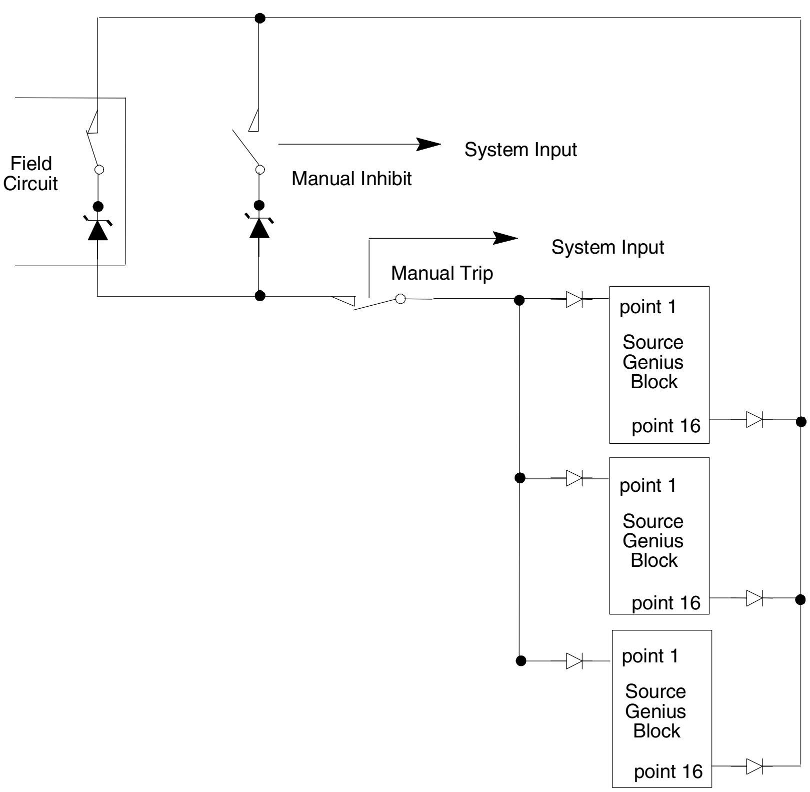
Manual Discrete Input Controls

Safety systems often use controls for manual trip and manual inhibit. The GMR autotest and fault processing features are not affected by such controls.

- A manual trip control causes the input to assume its alarm condition. For example, for a normally-energized input, the input would be tripped to open circuit.
- A manual inhibit control causes the input to remain in the normal condition. For example, for a normally-energized input, the input would be held high even if the input device was in its Off state.

These manual controls can be implemented either in hardware or in software.

Manual hardware controls usually consists of switch contacts applied to the input circuit, as shown below for a normally-energized input. Repeat contacts of the control switches are often input into the system for reporting purposes.



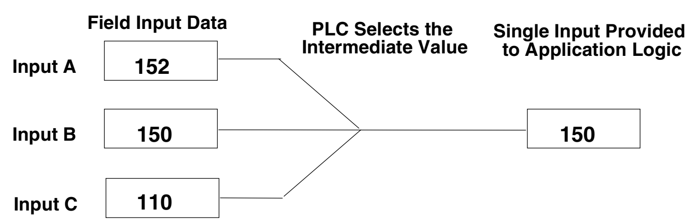
GMR Voted Analog Input Groups

The input subsystem can include groups of 1 to 3 analog input devices and non-voted analog inputs. Analog blocks in GMR input groups are *not* autotested by the GMR software.

Voted Analog Inputs

For voted analog inputs, analog blocks must be set up as 2-block or 3-block input groups. For each voted input channel in a 3-block group, either single or triple input sensors that are compatible with the input drive requirements of the Genius blocks can be used. The input values are in engineering units. Current-loop (4-20mA) devices must be converted to voltage when a single sensor is used.

For a 3-block group, the GMR software compares the three corresponding inputs for each channel and selects the intermediate value. This value is made available to the application program. The program can also access the original input values.



In the example shown above, inputs A, B, and C might represent the first channel on each block in a three-block group. The PLC would place the selected input value into the first voted input word for that group.

Analog Voting Adaptation

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.

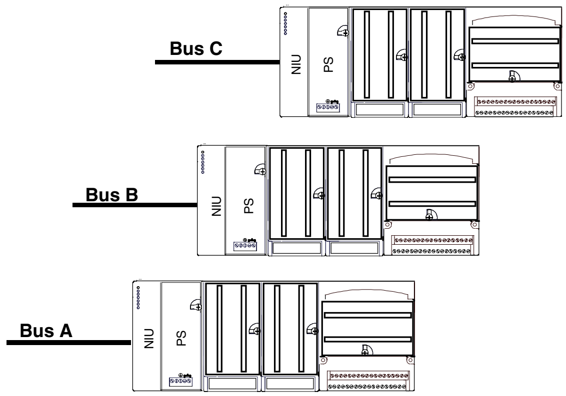
Analog Discrepancy Reporting

When the GMR software compares analog input data, it checks each channel against discrepancy limits provided as a part of the configuration for that input group. Any channel that varies by more than a configurable percentage from the intermediate value is reported.

Discrepancy signals are filtered for a configurable time period, to eliminate transient discrepancies caused by timing differences.

Voted VersaMax Analog Inputs

An input group can consist of 1 to 3 matching VersaMax I/O Stations with a Genius Network Interface Unit and up to 8 analog input modules. The Network Interface Unit and I/O modules mount on terminal blocks called Carriers, which provide electrical and field wiring connections.



The Genius Network Interface Unit functions as a single device on the bus, like an individual Genius block. It can exchange up to 128 bytes of input data and 128 bytes of output data each Genius bus scan.

Inputs from a VersaMax I/O Station

When the NIU takes its turn on the bus, it sends one input message containing the latest values of all configured discrete inputs followed by all configured analog inputs. The overall data length is equal to the lengths of %I data plus %AI data. In the input data message, analog inputs are received in the same sequence as their reference addresses. This matches the sequence of the modules in the I/O Station. For example:

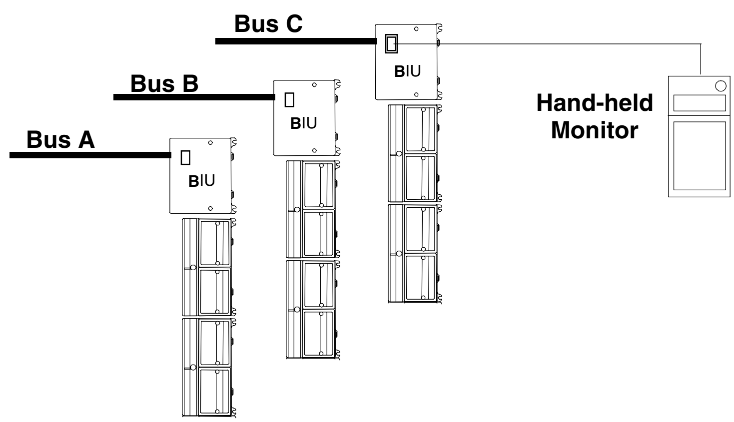
Total Input Data Message Length = 16 words		
Data from module 1: 4-Channel Analog Input Module ALG230 (4 words)	Data from module 2: 8-Channel Analog Input Module ALG260 (8 words)	Data from module 3: 4-Channel Analog RTD Input Module ALG620 (4 words)

The Genius Network Interface Unit performs diagnostic checks on itself and its I/O modules and relays diagnostic information to the GMR PLCs.

Voted Field Control Analog Inputs

A voted analog input group can consist of 1 to 3 matching Field Control I/O Stations with a Genius Bus Interface Unit and up to 8 analog input modules (depending on I/O count). The Bus Interface Unit and I/O modules mount on Terminal Blocks, which provide electrical and field wiring connections.

The Genius Bus Interface Unit functions as a single device on the bus, like an individual Genius block. It exchanges up to 128 bytes of input data and 128 bytes of output data each Genius bus scan. The intelligent processing capabilities of the Genius Bus Interface Unit allow the configuration of features such as fault reporting, selectable input and output defaults, analog scaling and analog range selection for the modules in the station. In addition, the Genius Bus Interface Unit performs diagnostic checks on itself and its I/O modules, and relays diagnostic information to the host (if configured for fault reporting) and to a Hand-held Monitor. A Hand-held Monitor is required for configuring the I/O Station. The following illustration represents an analog input group consisting of three Field Control I/O Stations each having four analog input modules. The Hand-held Monitor is used for configuration and monitoring. It connects directly to the Bus Interface Unit.



Non-Voted I/O in the Input Subsystem

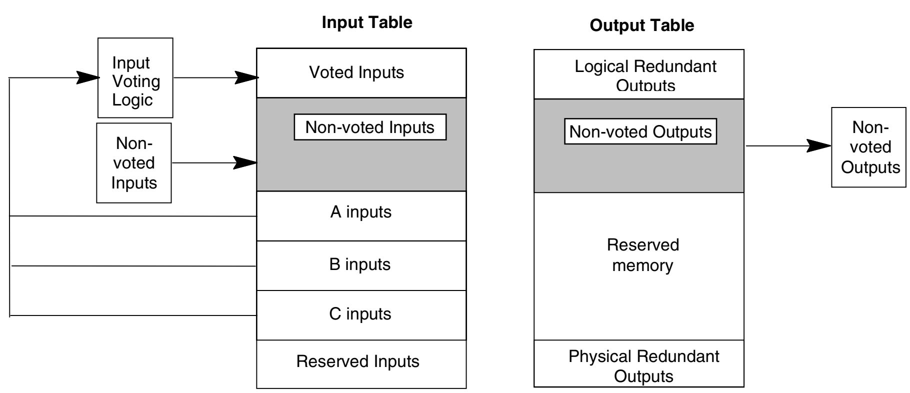
The GMR configuration software allows an individual input block or I/O Station to be configured in two different ways:

- As a Simplex Voted Input Group
- As a Non-voted I/O group

A Simplex Voted Input Group has only one block or I/O Station, so that although the PLC performs input voting, the result is the same as the actual input value. The input data for a Simplex Voted Input Group is placed into the area of the Input Table used for GMR inputs. As the diagram below shows, data for a Voted Input Group occupies 4 areas of the Input Table: as Voted Inputs (top), and also as Bus A inputs, Bus B inputs, and Bus C inputs. Corresponding references in these areas are reserved for a voted group regardless of whether it is a triplex, duplex, or simplex group.

In contrast, a Non-voted I/O Group does not required multiple areas of the Input Table. So each voted input group requires 4 times as much memory as a non-voted input group. Configuring a block as non-voted, therefore, is a way to conserve Input Table memory in the PLC.

Any outputs in a Non-voted I/O Group use the Non-voted area of the Output Table, as shown on the right side of the diagram.



The other basic difference between a Simplex Voted Input Group and a Non-voted Input Group is the ability of a Voted Input Group to select default states on a per-circuit basi. For a Non-voted Input Group, all input defaults on a block must be the same.

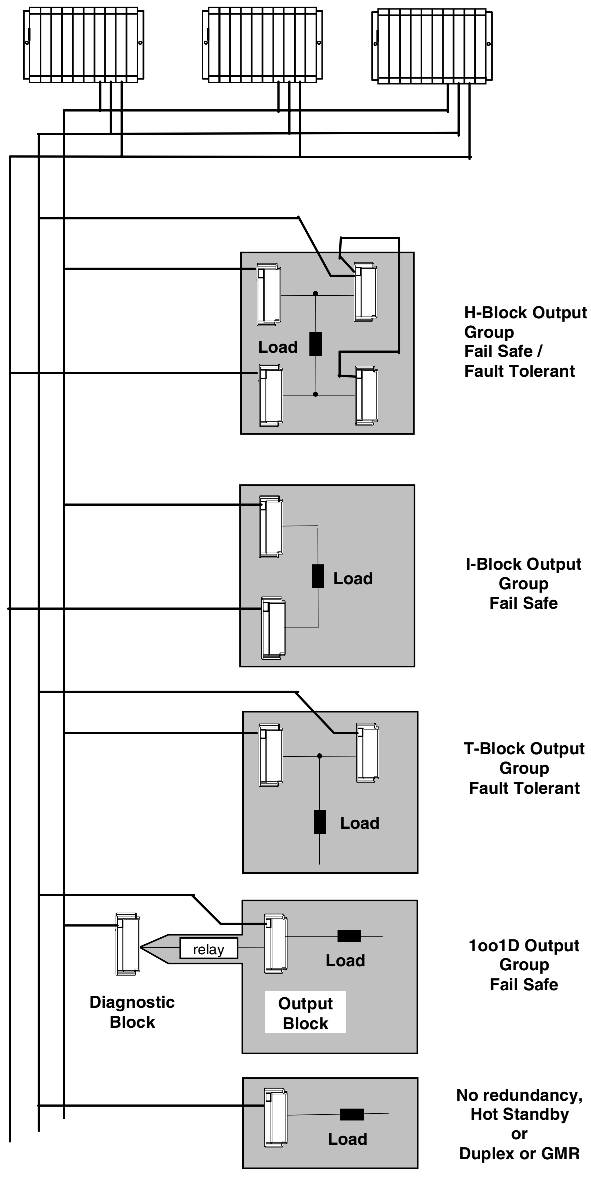
Chapter 3 The Output Subsystem

This chapter describes elements of a GMR output subsystem.

- Types of GMR outputs
- PLC Redundancy modes for output blocks
- GMR output voting
- Discrete Output Discrepancy Reporting
- Monitoring Manual Output Controls
- Discrete Output Autotest
- H-Block Output Group
- T-Block Output Group
- I-Block Output Group
- 1 out of 1 D Output Group
- Manual output controls
- Non-voted outputs
  - Duplex PLC Redundancy
  - Hot Standby Redundancy

Types of GMR Outputs

The output subsystem is the part of a GMR system that provides output data. The following illustration represents the basic types of output groups in a GMR system.



H-Block Output Group

In an H-Block Output Group, each field output is supported by two Genius source outputs connected in parallel on one side of the actuator and two Genius sink outputs connected in parallel on the other. Each block in the group receives outputs from each of up to three separate processors. Two or three Genius busses are used. The H-Block Output Group is suitable for applications requiring Fail-Safe and/or Fault Tolerant outputs. The blocks must be configured with an HHM to operate in GMR mode.

T-Block Output Group

In a T-Block Output Group, two 16-circuit or two 32-circuit source-type Genius blocks are connected in parallel on one side of the load. The other side of the load is connected to zero VDC. Two Genius busses are used. The T-block group is suitable for high-availability applications. The blocks must be configured with an HHM to operate in GMR mode.

I-Block Output Group

In an I-Block Output Group, one 16-circuit or 32-circuit source-type Genius block is connected to one side of the load and one 16-circuit or 32-circuit sink-type Genius block is connected to the other side of the load. Two Genius busses are used. The I-Block group is suitable for shutdown applications. The blocks must be configured with an HHM to operate in GMR mode.

1out of 1 Diagnostic Block Output Group

Unlike the other output groups described above, a 1oo1D Output Group consists of just one block. That block, referred to as the Output Block, has its power feed controlled by a single point on a separate block. The second block, which is referred to as a Diagnostic Block, may actually control power feed relays to as many as 32 1oo1D Output Group blocks. The Output Block must be on a different bus than the Diagnostic Block. The 1oo1D Output Group is suitable for shutdown applications. The blocks must be configured with an HHM to operate in GMR mode.

Individual Genius Blocks

Individual Genius blocks can also be connected to the system. These blocks may be configured with an HHM for Hot standby, Duplex, or Triplex CPU redundancy if desired.

PLC Redundancy Modes for Output Blocks

The redundancy mode of output blocks is set up using a Hand-held Monitor during block configuration, as described in chapter 8.

Configuration for Blocks in an Output Group

Blocks in a redundant output group must be configured for GMR mode.

This changes some diagnostic characteristics of the block:

- Blocks automatically report faults to bus controllers at serial bus addresses 29, 30, and 31.
- To prevent false Failed Switch diagnostics during switching transitions, detection of Failed Switches is delayed for one second.
- For the 16-circuit DC block, detection of No-load faults is delayed for one second. This prevents Failed Switch faults being falsely reported during switching transitions.
- For 16-circuit DC blocks, individual outputs can be configured to enable or disable reporting No-Load faults The minimum load current required to assure proper no-load reporting is 100mA (not 50mA as it would be for a block not used in a GMR group).
- For the 16-circuit DC block, the Unit OK LED does *not* indicate No-load faults in GMR mode. This is necessary, since blocks may share output loads.

Configuration for Individual Output Blocks (Not in an Output Group)

Individual output blocks can be configured for GMR mode or one of these other redundancy modes, according to block type:

- No PLC Redundancy
- Hot Standby PLC Redundancy
- Duplex PLC Redundancy

When configured for GMR mode, their characteristics change as described above for blocks in an output group.

When configured for Hot Standby or Duplex operation, they operate as described later in this section (see Non-voted Outputs).

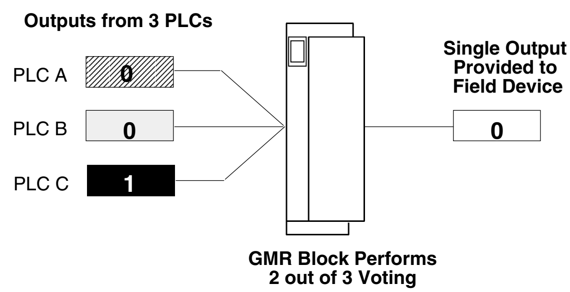
GMR Output Voting

Unlike GMR input voting, which is done by the GMR software in the PLCs, output voting is performed *at the output block groups*. The voted state of the output is available to the GMR system to determine output discrepancies. However, the voted output state is not available to the application program.

To perform output voting, the blocks must be one of the listed types below and they must be configured (with a Hand-held Monitor) in GMR mode.

24/48 VDC 16-Circuit Source block:	IC660BBD020
24/48 VDC 16-Circuit Sink block:	IC660BBD021
12/24 VDC 32-Circuit Source block.	IC660BBD024
5/12/24 VDC 32-Circuit Sink block:	IC660BBD025
24/48 VDC 16-Circuit Source block	IC660BRD020

A GMR output block group performs output voting by comparing the corresponding output data for each point as received from each of the three PLCs. If all three PLCs are online, the data from at least two must match. The block group sets each output load to match the state commanded by at least two of the PLCs.



If only two of the three PLCs are communicating on the bus and they send matching output data for a point, the block group sets the output to that state.

If only two PLCs are communicating, the block group performs 2 out of 3 voting using the data from the two online PLCs and the block's configured duplex default state in place of the offline PLC data.

If only one of the three controllers is present on the bus, the block group sets output states to match the output data sent by that PLC.

If the Simplex Shutdown feature is enabled, a PLC will shut down if it determines that it is the only PLC still operating. The timeout period before it shuts down is configurable. When the PLC shuts down and a block group is no longer receiving output data, outputs go to their default state or last state, as configured.

If all PLCs are offline, the block group forces its outputs to the block's configured default state.

Duplex Default for Voted Outputs

If a Block determines that only two PLCs are online, it uses the configured duplex default state in place of the third output in voting. This, in turn, determines whether the effect of voting will be 1 out of 2 or 2 out of 2 when only two PLCs are providing outputs. How this works is shown in the following three tables, which compare voting results for a block group receiving outputs from all three PLCs with voting results when one PLC is offline.

Results of Block Group Voting with Three PLCs Online

The first table shows how a block group votes on outputs received from three PLCs when all three are online. The block group doesn't use the Duplex Default, so it is shown as an X (don't care).

PLC A Output State	PLC B Output State	PLC C Output State	Duplex Default Setting in Block	Output State
0	0	0	X	0
0	0	1	X	0
0	1	0	X	0
0	1	1	X	1
1	0	0	X	0
1	0	1	X	1
1	1	0	X	1
1	1	1	X	1

Results of Block Group Voting with Two PLCs Online, Duplex Default Set to 1

If one PLC is offline, the outputs from both online PLCs must be 0 for the voted output state to be 0. The voted output is 1 if either of the online PLCs outputs a 1.

PLC A Output State	PLC B Output State	PLC C Output State	Duplex Default Setting in Block	Output State
0	0		1	0
0	1		1	1
1	0		1	1
1	1		1	1

Results of Block Group Voting with Two PLCs Online, Duplex Default Set to 0

If one PLC is offline, the inputs from both online PLCS must be 1 for the voted output to be 1. The voted output is 0 if either of the online PLCs outputs a 0.

PLC A Output State	PLC B Output State	PLC C Output State	Duplex Default Setting in Block	Output State
0	0		0	0
0	1		0	0
1	0		0	0
1	1		0	1

Results of Block Group Voting with One PLC Online

If two PLCs are offline, the “voted” outputs are the same as the outputs from the PLC which is still online (x = don't care).

PLC A Output State	PLC B Output State	PLC C Output State	Duplex Default Setting in Block	Output State
0			x	0
1			x	1

PLC Logon Control

To prevent untripping of tripped block outputs, blocks do not use output data from a PLC that has previously been offline until one of the following occurs:

A. all of the output data received from the newly-online PLC agrees with the voted output data of the block.

B. the user forces the PLC to log onto the output block(s) by turning on the GMR control bit FORCLOG (Force Logon).

For more information about PLC Logon control, please see chapter 4.

Discrete Output Discrepancy Reporting

Output discrepancy monitoring is the process of monitoring the block's output voting to detect discrepant output data from the PLC processors.

How Output Discrepancy Checking is Done

All PLCs periodically monitor all blocks' discrepancy status. On interrogation by any PLC, the block responds with a discrepancy report message indicating any discrepant output and disagreeing PLC. If a PLC is sending discrepant output data to a block, the GMR system logs an output discrepancy fault in the I/O fault table and sets the appropriate fault contacts.

The GMR system performs output discrepancy checking whenever it is not performing input or output autotesting (between autotests during the autotest interval). It checks all output blocks in redundant output groups and any non-redundant output blocks marked for discrepancy checking in the GMR configuration.

Discrete Output Discrepancy Reporting with Dynamic Outputs

If the GMR system determines that an output changed state during a discrepancy check, it attempts up to three times to properly complete the discrepancy check on an output block. This prevents logging false discrepancy faults that might be caused by the application program changing the state of an output while a discrepancy check is being performed

Output discrepancy checking works with outputs that change state less frequently than approximately once per 10 PLC scans. If an output changes state more rapidly than approximately once per 10 PLC scans, the results of output discrepancy checking for that output could be ignored. Nuisance discrepancy faults caused by transitioning outputs should NOT ever be logged.

As explained in chapter 9, a specific %M command bit (%M12266) can be used to enable/disable fault report information about rapidly-transitioning output discrepancies.

In a safety system, outputs are normally static. Outputs that are not static, that is, outputs that normally change state, may not be autotested as frequently as expected.

Discrete Output Autotest

Discrete output autotest checks the ability of outputs to respond to the commanded output state. It detects short circuit, open circuit, failed switch and other types of faults.

Output Faults that Cause I/O Shutdown

For discrete output groups, two types of faults may prevent the output autotest from completing for that output group and thus cause an I/O shut down for the outputs in the group. The faults are:

1. Loss of a block within the group (any failure that causes the block to no longer communicate on the Genius bus such as loss of power.)
2. Output autotest failure of a type that could potentially prevent a normally energized output from being tripped off. An example is the short of a source block output to +24 Vdc.

Operation of the Output Autotest

Output Autotest uses the standard Genius block Pulse Test feature. During testing, the system is online and available.

For the test to be performed:

- All blocks in the group must be online.
- There may be no I/O override applied to any block in the group.
- For each block output in the group:
  - there may be no I/O force applied.
  - there may be no hardware fault (such as a failed switch).
  - for all outputs, the corresponding circuit of each block in the group must be in the same logical state.

The devices connected to the output circuits to be autotested must be able to withstand the On and Off pulse times discussed in this section. Note that actual times in an application depend on the presence of other scheduled tasks and on the configuration of the points.

Pulse testing occurs whether the output is in the On state or the Off state by executing one of two tests. These are the pulse ON-OFF-ON test and the pulse OFF-ON-OFF test. The following Pulse Test descriptions refer to Pulse Test operation of a block configured in the GMR mode only.

Note: Use of the Genius output Pulse Test feature from the application program or Hand-held Monitor is NOT recommended for GMR applications, since it will produce erroneous results.

GMR Pulse Test Operation for 32-Circuit Blocks

For 32-circuit blocks, outputs to be Pulse-Tested must be able to withstand On and Off pulse times of approximately 1 millisecond.

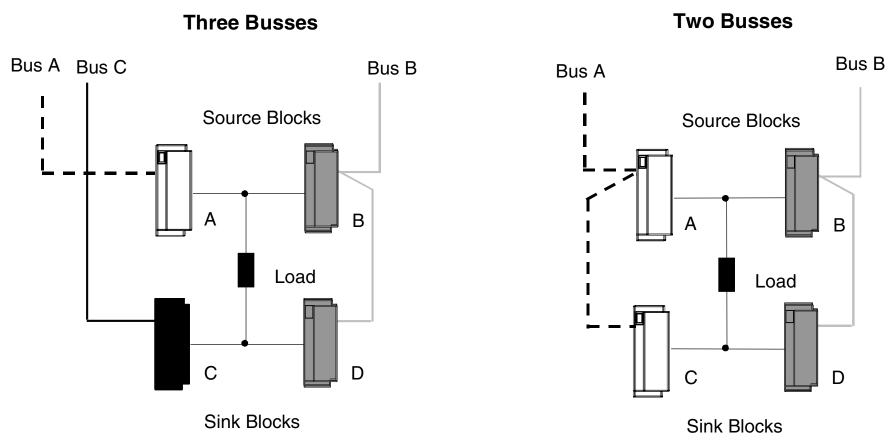
GMR Pulse Test Operation for 16-Circuit Blocks

OFF-ON-OFF Test: The first ON pulse is for about 1.7mS. During this time, if the No Load diagnostic is enabled, the current data is checked and recorded. After this time, the test turns the point Off and the diagnostic, volts, and current data (if No Load is enabled) are checked. If the correct voltage and/or current data is NOT reported, the time constant is increased and the process repeats. If the correct voltage and/or current data is reported after any of the pulses, the test is passed and no further pulsing of the point occurs. The maximum number of pulses that can occur is 7, with a minimum duration of 1.7mS and a maximum duration of 20mS. Also, there is a delay of approximately 5 to 15mS until the same point is pulsed again. These times depend greatly on the configurations of the other points.

ON-OFF-ON Test: Similar activity occurs for this test. The initial time a point is Off is about 5mS. The only fault checked for in this case, however, is that the volts feedback agrees with the commanded state. If it does not, the point is pulsed Off again for about 7.5mS. A maximum of two pulses of approximately 5mS and 7.5mS duration can occur. The 7.5mS pulse occurs only if the volts feedback for the first pulse is incorrect.

The H-Block Output Group

All four blocks in an H-Block Output Group must be either 16-circuit or 32-circuit blocks. In this type of group, two source-type Genius blocks are connected in parallel on one side of each load and two sink-type Genius blocks are connected in parallel on the other side. An H-Block Output Group requires either two or three Genius busses.



If the blocks are on three busses, one source and one sink block in the group must be on the same bus. The two blocks on the same bus must have different serial bus addresses. If the blocks are on two busses, one source and one sink block are on one bus and the other source and sink block are on the other bus. Any blocks that share a bus must have different serial bus addresses.

Redundant Busses in an H-Block Output Group

By connecting the H-Block Output Group to either two or three busses, as long as there is one bus remaining, I/O data is communicated to at least one sink output and one source output to control the load. When a block loses communication with all the PLCs, its outputs go to a default state. If the default state is Off, the system is fault-tolerant as shown in this chart.

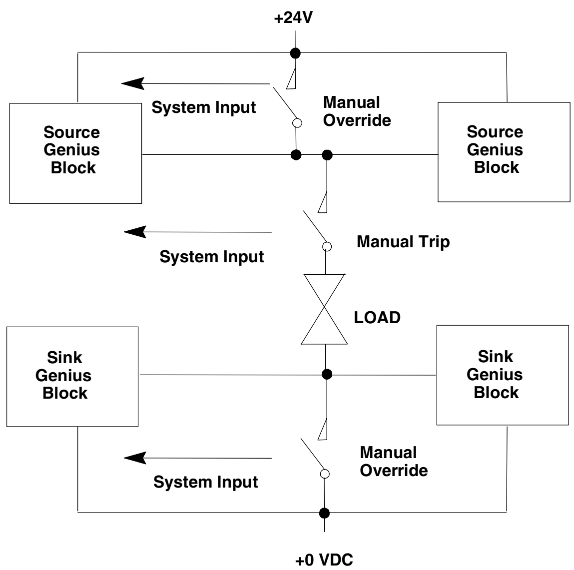
Fault	To Turn the Load Off or On
bus A fails	busses B and C still provide I/O communications to blocks B, C, and D; turning outputs at those blocks On or Off turns the load On or Off.
bus B fails	busses A and C still provide I/O communications to blocks A and C; if the Block B and D outputs are configured to default Off, turning output at blocks A and C On or Off turns the load On or Off.
bus C fails	busses A and B still provide I/O communications to blocks A, B, and D; turning outputs at those blocks On or Off turns the load On or Off.

Manual Output Controls for an H-Block Output Group

Optional manual trip and override controls can be implemented in hardware or in software. If the software method is used, the GMR autotest and fault processing operations are not affected. If manual trip and manual override controls are implemented in hardware, they can be set up as shown below.

A ***manual trip*** causes an output to assume its alarm condition. For example, a normally-energized output is de-energized.

A ***manual override*** causes an output to remain in its normal condition. For example, a normally-energized output is held energized.



The operation of manual output devices can be monitored and reported by connecting them as inputs to non-voted Genius blocks in the system.

These inputs use a special set of Reserved Inputs at the end of the Input Table. See chapter 5 for more information.

Output Load Sharing in an H-Block Output Group

In an H-Block Output Group, current to output loads is shared. Therefore, it is not possible to be sure exactly how much power is being provided by each block. If 16-circuit blocks in an H-Block Output Group are configured for No Load fault reporting, the minimum connected load that can be used is 100mA.

If outputs are off, a No-load fault is reported in the normal manner if any block in the group has a no-load condition. However, if outputs are on and a No-load fault occurs on just one block of a pair, the No-load fault does not appear in the fault table because the other block of the pair is still supporting the load. Therefore, an output No-load fault is reported only if both sink blocks or both source blocks in the group report a No-load fault. The fault location listed in the I/O Fault Table is that of the <u>second</u> block reporting the fault. For example:

0.3.1.1 1 %Q 00019 CIRCUIT FAULT DISCRETE FAULT 03-08 11:23:16

In this example, the location of the output block reporting the fault is rack 0, slot 3, bus 1, serial bus address 1. However, both of the (source or sink) blocks in that pair actually have No-load faults for output %Q00019.

Operation of an H-Block Output Group

An H-block Output Group is fault-tolerant because no single point of failure will cause the system to lose control of a critical load. This is achieved by:

- output voting
- redundant busses
- the electrical characteristics of sink and source blocks

If a load is wired between a sink and source block, both the sink output and the source output must be active to control the load. If either the sink output or the source output fails On, turning the other Off turns the load Off.

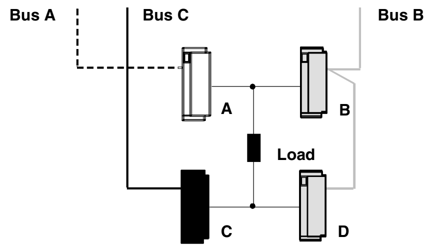
The blocks are configured for GMR mode using the Genius Hand-held Monitor.

Output circuits that are to be autotested must be able to withstand the On and Off pulse times used by the test. Check each output device's characteristics against the specifications listed in chapter 11 (for 32-point blocks) to verify that it can be autotested and/or used in a 4-block output group.

The following chart shows how an H-Block Output Group maintains control of critical loads following certain types of failures. All operating blocks receive the same I/O data, because within a fault-tolerant H-block group, all four blocks are configured at the same output address. The chart indicates which blocks actually affect the state of the load under different fault scenarios. All operating blocks act on the I/O data received.

Fault	Other Blocks Used To Turn the Load Off	Other Blocks Used To Turn the Load On
output at Block A fails On	turn outputs at Block C and D Off	turn output at Block C or D On
output at Block A fails Off	turn output at Block B off	turn output at Block B and either C or D On
output at Block B fails On	turn outputs at Block C and D Off	turn output at Block C or D On
output at Block B fails Off	turn output at Block A off	turn output at Block A and either C or D On
output at Block C fails On	turn outputs at Block A and B Off	turn output at Block A or B On
output at Block C fails Off	turn output at Block D off	turn output at Block D and either A or B On
output at Block D fails On	turn outputs at Block A and B Off	turn output at Block A or B On
output at Block D fails Off	turn output at Block C off	turn output at Block C and either A or B On

Discrete Output Autotest for an H-Block Output Group



With an H-Block Output Group, the discrete output autotest will work on outputs that are either on or off, with or without load monitoring.

- for normally deenergized outputs that are off when tested, the test detects:

  Open Circuit load (if No-load Diagnostic is enabled)
  Block A/B short to 0V
  Block C/D short to 24V
  Any single block open circuit (if No-load Diagnostic is enabled)
  Any single block Switch Failed off

- for normally deenergized outputs that are on when tested, the test detects:

  Open Circuit load (if No-load Diagnostic is enabled)
  Any single block open circuit (more precise if No-load Diagnostic is enabled)
  Any single block Switch Failed off

- for normally energized outputs that are off when tested, the test detects:

  Block A/B short to 0V
  Block C/D short to 24V
  Any single block Switch Failed off

- for normally energized outputs that are on when tested, the test detects:

  Open Circuit load (if No-load Diagnostic monitoring is enabled)
  Any single block open circuit (more precise if No-load Diagnostic is enabled)
  Block A/B short to 24
  Block C/D short to 0V
  Any single block Switch Failed off
  Any single block Switch Failed on

- detect any output failure that would result in a failure to respond.

Although no test results are generated if outputs change state during the test, it does not cause spurious faults to be logged.

During output autotest, the Genius block group still controls the physical outputs, so output devices are not affected by the test.

Operation of the Discrete Output Autotest: H-Block Output Group

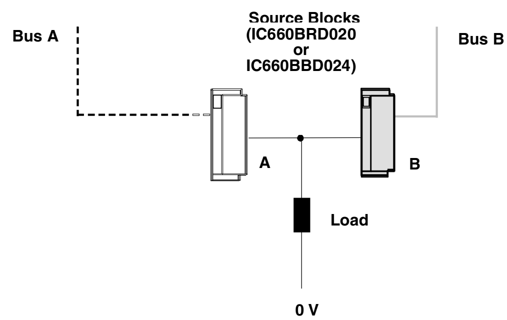
The PLC that is presently the Autotest Master informs the other PLCs (if any) which autotest group it is about to test. All PLCs read the diagnostic status of all blocks in the group to be tested, and will ignore any subsequent faults that may occur in that group.

The Autotest Master PLC reads the current output state and force state for each circuit in the output group. Then, the Autotest Master pulse-tests the blocks in the output group. The test sequence for an H-Block Output Group is described below.

1. The Autotest Master overrides the normally deenergized outputs on Block C to ON.
2. The Autotest Master pulse-tests Block B. Any faults on Block B are noted.
3. If any outputs on Block B configured as normally-energized logged a Failed Switch when pulsed, the master overrides them to OFF.
4. The Autotest Master pulse tests Block A. Any faults on Block A are noted.
5. The master resets all four blocks in the output group.
6. Overrides on Block C are cancelled.
7. The master cancels overrides on Block B *except for any outputs that have tripped erroneously.*
8. The Autotest Master repeats the above process for blocks D/A/B, then A/D/C, then B/C/D.
9. The Autotest Master reports faults to the other PLCs (if any). All the PLCs log any faults that occur into their Fault Tables.
10. The Autotest Master continues testing with the next group.

The T-Block Output Group

A T-Block Output Group consists of two Genius 16-circuit or two 32-circuit source-type Genius blocks connected in parallel on one side of a load. The other side of the load is tied to ground. Although the illustration shows 16 loads, and a pair of 32-circuit blocks can control up to 32 loads.



Outputs of a T-Block Output Group are “normally-energized”. 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. Both blocks must be either 16-circuit or 32-circuit blocks. The two blocks must be connected to two different busses. The blocks must be configured for GMR mode using the Genius Hand-held Monitor.

For a 16-circuit T-Block Output Group, Source Block IC660BRD020 should be used. This block has been designed for use in T-Block Output Groups. It has diodes integrated into the terminal assembly to prevent current feedback from keeping the block powered up, via output connections, when it has otherwise lost power.

Output circuits that are to be autotested must be able to withstand the On and Off pulse times used by the test. Check each output device's characteristics against the specifications listed in chapter 11 to verify that it can be autotested and/or used in a T-Block Output Group.

Bus Redundancy in a T-Block Output Group

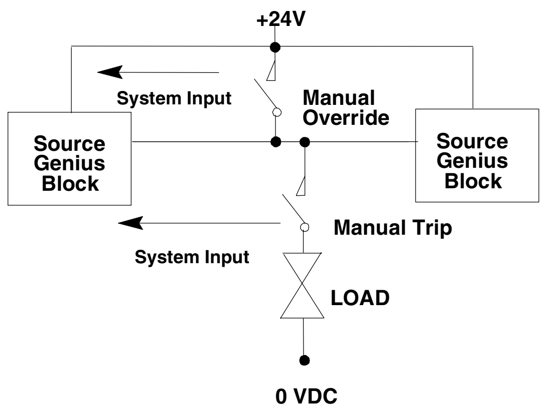
If either of the two busses serving a T-Block Output Group is damaged or cut, there is still I/O data communicated the other output block to control the load. When a block loses communication with all PLCs, its outputs go to a default state.

Manual Output Controls for a T-Block Output Group

Optional manual trip and override controls can be implemented in hardware or in software. If the software method is used, the GMR autotest and fault processing operations are not affected. If manual trip and manual override controls are implemented in hardware, they can be set up as shown below.

A ***manual trip*** causes an output to assume its alarm condition. For example, a normally-energized output is de-energized.

A ***manual override*** causes an output to remain in its normal condition. For example, a normally-energized output is held energized.



The operation of manual output devices can be monitored and reported by connecting them as inputs to non-voted Genius blocks in the system.

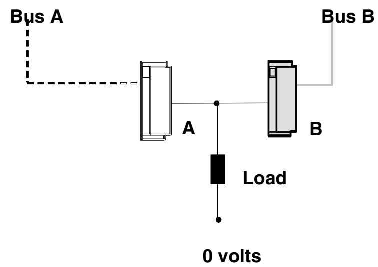
These inputs use a special set of Reserved Inputs at the end of the Input Table. See chapter 5 for more information.

Output Load Sharing in a T-Block Output Group

In a T-Block Output Group, current to output loads is shared. Therefore, it is not possible to be sure exactly how much power is provided by each block. If 16-circuit blocks in a T-Block Output Group are configured for No Load fault reporting, the minimum connected load that can be used is 100mA. A system output No Load fault will only be reported if both of the blocks report No Load faults.

Discrete Output Autotest for a T-Block Output Group

In this example, the two blocks are shown connected to busses A and B, and are referred to as Block A and Block B. In an actual GMR system, the two blocks can be assigned to any two of the three GMR busses.



With a T-Block Output Group, the discrete output autotest will work on outputs that are either on or off, with or without load monitoring.

- for normally deenergized outputs that are off when tested, the test detects:
  - Open Circuit load (if No-load Diagnostic is enabled)
  - Block A/B short to 0V
  - Any single block open circuit (if No-load Diagnostic is enabled)
  - Any single block Switch Failed off
- for normally deenergized outputs that are on when tested, the test detects:
  - Open Circuit load (if No-load Diagnostic is enabled)
  - Any single block open circuit (more precise if No-load Diagnostic is enabled)
  - Any single block Switch Failed off
- for normally energized outputs that are off when tested, the test detects:
  - Block A/B short to 0V
  - Any single block Switch Failed off
- for normally energized outputs that are on when tested, the test detects:
  - Open Circuit load (if No-load Diagnostic monitoring is enabled)
  - Any single block open circuit (more precise if No-load Diagnostic is enabled)
  - Block A/B short to 24
  - Any single block Switch Failed off
  - Any single block Switch Failed on
- The test will detect any output failure that would result in a failure to respond.

Although no test results are generated if outputs change state during the test, it does not cause spurious faults to be logged.

During output autotest, the Genius block group still controls the physical outputs, so output devices are not affected by the test.

Operation of the Discrete Output Autotest for a T-Block Output Group

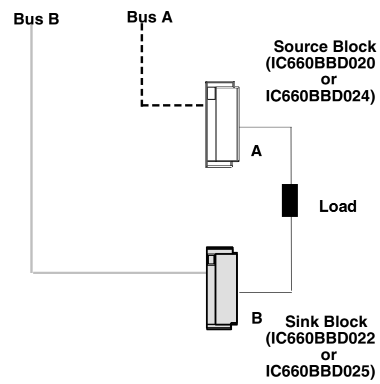
The PLC that is presently the Autotest Master informs the other PLCs (if any) which autotest group it is about to test. All PLCs read the diagnostic status of all blocks in the group to be tested, and will ignore any subsequent faults that may occur in that group.

The Autotest Master PLC reads the current output state and force state for each circuit in the output group. Then, the Autotest Master pulse-tests the blocks in the output group. The test sequence for a T-Block Output Group is described below.

1. The Autotest Master pulse-tests Block B. Any faults on Block B are noted.
2. If any outputs on Block B configured as normally-energized logged a Failed Switch when pulsed, the master overrides them to OFF.
3. The Autotest Master pulse tests Block A. Any faults on Block A are noted.
4. The master cancels overrides on Block B *except for any outputs that have tripped erroneously.*
5. The master resets both blocks.
6. The Autotest Master pulse tests Block A. Any faults on Block A are noted.
7. If any outputs on Block A that are configured as normally-energized have logged a Failed Switch when pulsed, the master overrides them to OFF.
8. The Autotest Master pulse-tests Block B. Any faults on Block B are noted.
9. The master cancels overrides on Block A *except for any outputs that have tripped erroneously.*
10. The Autotest Master reports faults to the other PLCs (if any). All the PLCs log any faults that occur into their Fault Tables.
11. The Autotest Master continues testing with the next group.

The I-Block Output Group

An I-Block Output Group consists 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. Both blocks in an I-Block Output Group must be either 16-circuit or 32-circuit blocks. The two blocks must be connected to two different busses. Although the illustration below shows just one load for a group of two blocks, a pair of 16-circuit blocks can control up to 16 loads, and a pair of 32-circuit blocks can control up to 32 loads.



An I-Block Output Group might be used in fail-safe applications where it is necessary to be able to turn OFF a critical load. If either block fails, the other can still turn the load OFF.

The blocks must be configured for GMR mode using the Genius Hand-held Monitor. Output circuits that are to be autotested must be able to withstand the On and Off pulse times used by the test. Check each output device's characteristics against the specifications listed in chapter 11 to verify that it can be autotested and/or used in an I-Block Output Group.

Operation of an I-Block Output Group

If a load is wired between a sink and source block, both the sink output and the source output must be active to control the load. If either the sink output or the source output fails On, turning the other Off turns the load Off.

Bus Redundancy in an I-Block Output Group

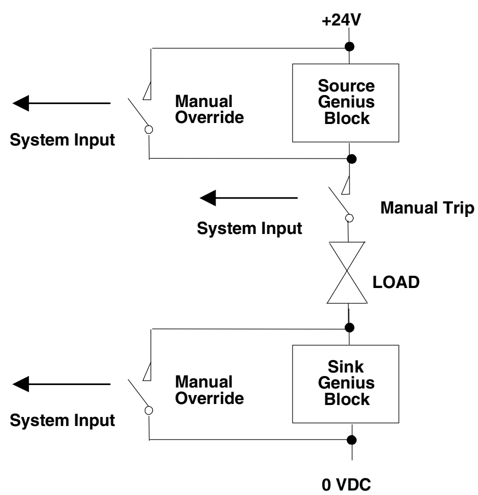
If either of the two busses serving an I-Block Output Group is damaged or cut, outputs for the block wired to that bus are set to their configured default states. The remaining block on the functioning bus will still allow the load to be turned off.

Manual Output Controls for an I-Block Output Group

Optional manual trip and override controls can be implemented in hardware or in software. If the software method is used, the GMR autotest and fault processing operations are not affected. If manual trip and manual override controls are implemented in hardware, they can be set up as shown below.

A ***manual trip*** causes an output to assume its alarm condition. For example, a normally-energized output is de-energized.

A ***manual override*** causes an output to remain in its normal condition. For example, a normally-energized output is held energized.

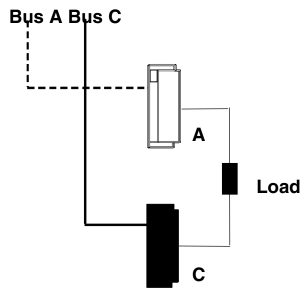


The operation of manual output devices can be monitored and reported by connecting them as inputs to non-voted Genius blocks in the system.

These inputs use a special set of Reserved Inputs at the end of the Input Table. See chapter 5 for more information.

Discrete Output Autotest for an I-Block Output Group

In this example, the two blocks are shown connected to busses A and C, and are referred to as Block A and Block C. In an actual GMR system, the two blocks can be assigned to any two of the three GMR busses.



With an I-Block Output Group, the discrete output autotest will work on outputs that are either on or off, with or without load monitoring.

- for normally deenergized outputs that are off when tested, the test detects:

  Open Circuit load (if No-load Diagnostic is enabled)
  Any single block open circuit (if No-load Diagnostic is enabled)
  Any single block Switch Failed off

- for normally deenergized outputs that are on when tested, the test detects:

  Open Circuit load (if No-load Diagnostic is enabled)
  Any single block open circuit (more precise if No-load Diagnostic is enabled)
  Any single block Switch Failed off

- for normally energized outputs that are off when tested, the test detects:

  Any single block Switch Failed off

- for normally energized outputs that are on when tested, the test detects:

  Open Circuit load (if No-load Diagnostic monitoring is enabled)
  Any single block open circuit (more precise if No-load Diagnostic is enabled)
  Any single block Switch Failed off
  Any single block Switch Failed on

The test will detect any output failure that would result in a failure to respond. Although no test results are generated if outputs change state during the test, it does not cause spurious faults to be logged.

During output autotest, the Genius block group still controls the physical outputs, so output devices are not affected by the test.

Operation of the Discrete Output Autotest for an I-Block Output Group

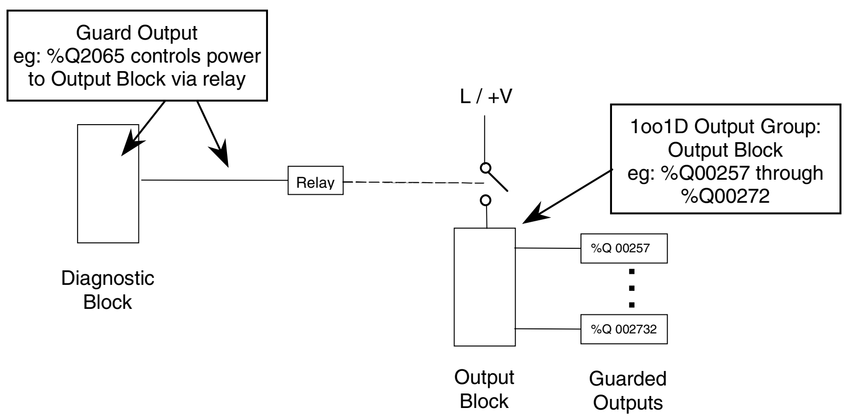
The PLC that is presently the Autotest Master informs the other PLCs (if any) which autotest group it is about to test. All PLCs read the diagnostic status of all blocks in the group to be tested, and will ignore any subsequent faults that may occur in that group.

The Autotest Master PLC reads the current output state and force state for each circuit in the output group. Then, the Autotest Master pulse-tests the blocks in the output group. The test sequence is described below.

1. For the I-Block Output Group, the Autotest Master overrides the normally deenergized outputs on Block C to ON.
2. The Autotest Master pulse tests Block A. Any faults on Block A are noted.
3. Overrides on Block C are cancelled.
4. The master resets both blocks.
5. The Autotest Master overrides the normally deenergized outputs on Block A to ON.
6. The Autotest Master pulse tests Block C. Any faults on Block C are noted.
7. Overrides on Block A are cancelled.
8. The Autotest Master reports faults to the other PLCs (if any). All the PLCs log any faults that occur into their Fault Tables.
9. The Autotest Master continues testing with the next group.

The 1oo1D Output Group

A 1oo1D Output Group consists of one discrete Output Block driving up to 32 normally-energized loads. This type of group can be used as an alternative to an I-block Output Group. It provides a fail-safe solution with a smaller number of Genius blocks. A separate discrete block (either AC or DC), which is not part of the 1oo1D group, controls power feed into the Output Block via a relay. Controlling output block power with this block, which is referred to as the Diagnostic Block, makes it possible to bring an output load to its safe state even though the output point on the block may have a “stuck-at-1” fault.



Operation of a 1oo1D Output Group

During system operation, the GMR software compares the logic demand state (%Q) of each “Guarded” output on the Output Block with its corresponding point input feedback (%I). If, when the output is tripped (0), the feedback indicates the output point is stuck on (1), the Diagnostic Block removes power to the Output Block. This forces outputs on the Output Block to a de-energized safe state, unless they have been physically bypassed (as explained in this section). All points on a 1oo1D Output Block are pulse-tested if the block is configured for pulse-testing. Faults generated by the pulse test are logged in the I/O Fault Table. They do not cause the Diagnostic Block to shut down the Output Block where the pulse test fault occurred.

Restoring Power to a Tripped Output Block

When an Output Block has been tripped by the Diagnostic block, the fault must be cleared or the physical outputs must be isolated before attempting to restore power to the Output Block. This prevents restoring power to a faulted output. Outputs can be isolated by providing bypass circuitry as described in this section. Tripped outputs can be reset by using the DIAGRES %M control bit (%M12267), as described in the Programming chapter.

Depending on the application and on the individual Output Group, it may be preferable to temporarily disconnect the physical output before re-powering the Output Block. The block should be pulse-tested to confirm that the fault is cleared and all logic states agree, before re-connecting the physical output and removing any bypasses. Note that if the block is configured for Pulse Testing, the pulse test will be initiated and executed during the standard autotest cycle at its configured interval.

Configuration and Diagnostics for 1oo1D Output Groups

The table below summarizes the diagnostics and GMR Block Mode configuration for 1oo1D Output Blocks. An Output Block should not be configured for Redundancy Mode: Hot Standby.

Power Source	Genius Block	Supported Diagnostics	Block Redundancy Mode Configuration	Default State	Duplex Default
115V AC / 125V DC	IC660BBS103 (8 Channel) *	Overtemperature Short Circuit Overload Shutdown	No Controller Redundancy or Duplex	0	0
24 / 48V DC	IC660BBD020 (16 channel Source)	Overtemperature Short Circuit Failed Switch Overload Shutdown	No Controller Redundancy or GMR	0	0
24 / 48V DC	IC660BBD024 (32 channel Source)	Short Circuit Failed Switch Overtemperature Overload Shutdown	No Controller Redundancy or GMR	0	0

* IC660BBS103 does not support GMR block mode. It can only be controlled by one or two (not three) CPUs.

An Output Block should be configured as a "combination" input/output block with its individual circuits configured as outputs with input feedback. The Output Block should also have No Load Reporting disabled, and optionally Pulse Test enabled.

The Diagnostic Block and Relay

The Diagnostic Block is a separate discrete block that controls power feed into the Output Block via a relay. The Diagnostic Block must be on a separate bus from the Output Block. The bus must be the same one specified in the GMR configuration.

For fail-safe operation, a normally-energized relay with a current rating of at least 16A is required in the output circuit from the Diagnostic Block. See the example that follows. This relay must conform to IEC 60255-1-00 (Electrical Relays – Part 1, All or Nothing Electrical Relays) and EN 50156-1 (Electrical Equipment for Furnaces and Ancillary Equipment Part1, Requirements for Application, Design and Installation). Periodic proof testing must be performed to be sure the relay can be driven to its safe state.

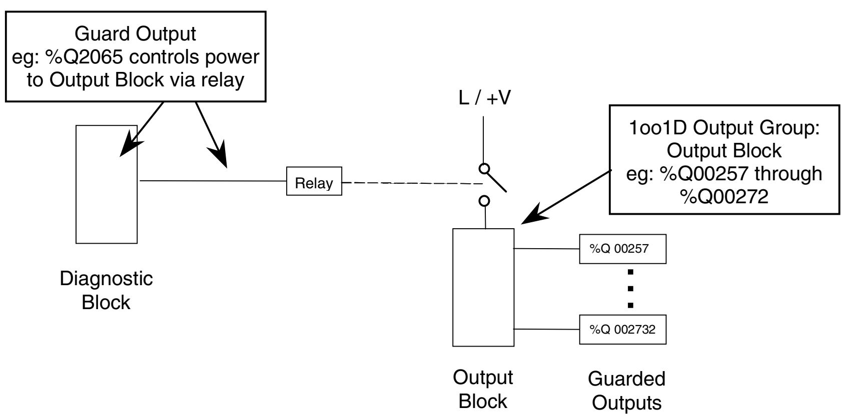
The Diagnostic Block can be any supported Non-Voted Discrete I/O block. If the system requires TUV approval, the Diagnostic Block must be a TUV-approved Non-Voted Discrete DC block. Each output point on a Diagnostic Block that controls a relay to a 1oo1D Output Group must be configured with a Default State of 0 and a Duplex Default of 0.

I/O References for a 1oo1D Output Group

The output points controlled by the 1oo1D group use output (%Q) references assigned to the Output Block during GMR configuration. The corresponding input (%I) references, used for feedback of the output states, are automatically assigned by the configuration software.

The GMR System Software automatically monitors these %I and %Q references during system operation. If the actual state of any “guarded” point on the Output Block does not match the output state commanded by the application program, the GMR System automatically sets to 0 the %Q point on the Diagnostic Block that controls power to the Output Block. At the same time, a “10608 - Diagnostic ShutDown” fault is placed in the PLC Fault Table

In the simplified representation below, the system monitors feedback from point %Q00257 by comparing it with the corresponding input reference %I00257. If %I00257 not match %Q00257, the GMR system automatically sets point %Q02056 on the Diagnostic Block to 0. That turns off power to the Output Block. As a result, all points from %Q00257 through %Q00272 are set to their non-energized safe state.



I/O references for the Diagnostic Block and the Output Block are assigned when configuring the 1oo1D Output Group. Details are given in the GMR Configuration chapter. The I/O references for both the Diagnostic Block and the Output Block must be located in the non-voted area of the I/O tables.

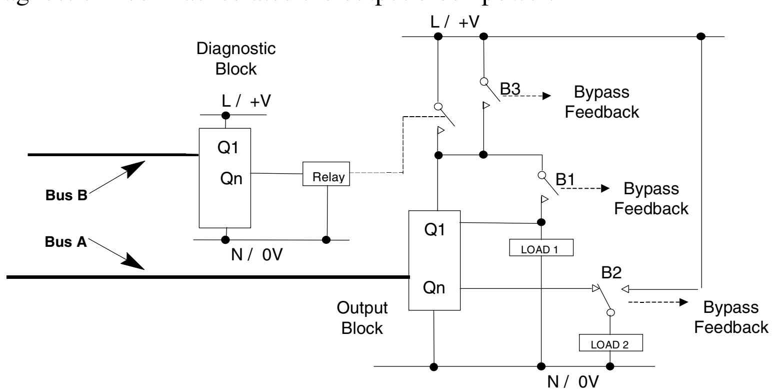
Manual Output Controls for a 1oo1D Output Group

Optional manual trip and override controls can be implemented in hardware or in software. If the software method is used, the GMR autotest and fault processing operations are not affected. If manual trip and manual override controls are implemented in hardware, they can be set up as shown below.

A *manual trip* causes an output to assume its alarm condition. For example, a normally-energized output is de-energized. A *manual override* causes an output to remain in its normal condition. For example, a normally-energized output is held energized. The operation of manual output devices can be monitored and reported by connecting them as inputs to non-voted Genius blocks in the system. These inputs use a special set of Reserved Inputs at the end of the Input Table. See chapter 5 for more information.

Example 1oo1D Output Group with Bypassed Outputs

In the example below, the Output Block (right) is shown with 2 loads. The circuit for Load 1 shows an optional direct output bypass (*B1*). B1 is driven from the isolated power rail, so B1 is deactivated when the Diagnostic Block has isolated the power. The circuit for Load 2 shows an example of an optional changeover output bypass with a Make-Before-Break (MBB) switch being driven from the non-isolated power rail (*B2*). This bypass can be used to keep the load energized when the Diagnostic Block has isolated the output block power.



- With the block powered, switch B1 prevents tripping Load 1 if the logic output is deactivated while the physical output is bypassed. This switch must be fed from block power, otherwise power can be backfed into the Output Block via the bypassed outputs. This switch can optionally provide feedback for an individual point or for a group of points, depending on the needs of the application. The GMR system can monitor feedback using %I references identified during GMR configuration of the 1oo1D Output Group. These references must be located in the Non-voted area of the %I Input Table.

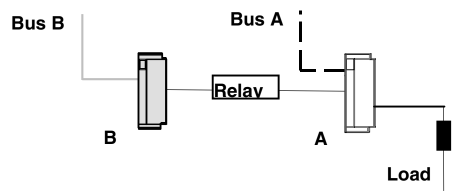
- Switch B2 in the example is similar to B1, EXCEPT that while B1 overrides the output when the block is powered, B2 holds the output in a bypassed condition regardless of the block state. B2 must be a Make-Before-Break switch. The optional feedback can be monitored for annunciation purposes by any inputs in the system.
- Switch B3 is also optional. It can be used to manually test the output relay driven *from the Diagnostic Block* without affecting the Output Block. It can also be used to bypass the relay to restore a tripped Output Block if a “stuck-at-1” fault is present with the output off, causing GMR to re-trip the block. The optional feedback from this type of switch can be monitored by any inputs in the system.

Discrete Output Autotest for a 1oo1D Output Group

As described previously, a 1oo1D Output Group consists of one Output Block that has its power controlled by a Non-Voted Discrete I/O block (the Diagnostic Block) that has been configured separately. The same Diagnostic Block may control output power for several Output Blocks. Each of the Output Blocks is considered a separate 1oo1D Output Group. These Output Blocks are autotested independently.

As part of the configuration, No Load Reporting should be disabled for the 1oo1D Output Block points that have their power controlled by the Diagnostic Block. Some outputs on the Output Block can be set up as “bypassed” outputs, and installed so that they receive power from an independent source. The Discrete Output Autotest will not check the operation of the bypassed outputs.

In this simplified example, the Diagnostic Block is connected to bus B and the 1oo1D Output Block is connected to bus A. In an actual GMR system, the two blocks can be assigned to any two of the three GMR busses.



For a 1oo1D Output Group, the Discrete Output Autotest tests the operation of the Output Block only, it does not test the Diagnostic Block. However, the Diagnostic Block, as a Non-voted Discrete I/O Block, can also be set up to be Pulse Tested.

With a 1oo1D Output Group, the discrete output autotest will:

- work on outputs that are either on or off, with or without load monitoring.
- for outputs that are off when tested, the test detects:

  Switch Failed off
- for outputs that are on when tested, the test detects:

  Switch Failed off
  Switch Failed on

During output autotest, the Output Block still controls the physical outputs, so output devices are not affected by the test.

Operation of the Discrete Output Pulse Test for a 1oo1D Output Group

The PLC that is presently the Autotest Master informs the other PLCs (if any) which autotest group it is about to test. For a 1oo1D group, all PLCs read the diagnostic status of the Output Block in the group to be tested and ignore any subsequent faults that may occur on that block.

The Autotest Master pulse-tests the Output Block.

1. The Autotest Master reports faults to the other PLCs (if any). All the PLCs log any faults that occur into their Fault Tables.
2. The Autotest Master continues testing with the next group.

Pulse Testing the Diagnostic Block

As mentioned, the 1oo1D autotest does not test the Diagnostic Block that has been selected to control power to the output block. The Diagnostic Block may be pulse-tested using a Hand-held Monitor. Be sure that the pulse test will not cause the relay that controls power to the output block to operate. That would momentarily interrupt the power supply to the Output Block.

Checking the Watchdog Relay

When using a 1oo1D Output Group, it is important to periodically, manually check the operation of the relay that controls the power supply for the output block.

Redundancy Modes for Non-voted Outputs

During Genius block configuration, non-voted output and non-voted mixed I/O blocks can be configured for GMR mode or for:

A. Hot Standby PLC Redundancy

B. Duplex PLC Redundancy

C. No PLC Redundancy

Selecting No PLC Redundancy causes the block to operate as it normally would in a non-redundant system. Operation in Hot Standby mode and Duplex mode are described below.

Duplex PLC Redundancy for Non-voted Outputs

Duplex PLC Redundancy is not the same as Duplex GMR Redundancy. Duplex GMR Redundancy is used by voted output groups. Duplex PLC Redundancy can be used by non-voted discrete I/O in a two-PLC system as a means of selecting which PLC will normally control the outputs.

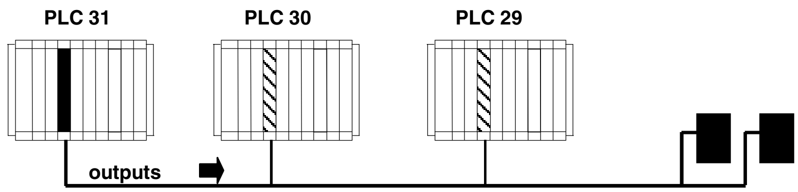
When a non-voted discrete group is configured with the Hand-held Monitor for PLC Redundancy: Duplex, it operates in the same way that a block in a two-PLC, non-GMR system would. In Duplex mode, the block receives outputs from PLCs 30 and 31 and compares them. If PLCs 30 and 31 agree on the output state, the output goes to that state. If 30 and 31 send different states for an output, the block defaults the output to its configured Duplex Default State.

Commanded State from Serial Bus Address 31	Commanded State from Serial Bus Address 30	Duplex Default State in the Block	Actual Output State
On	On	Don't Care	On
Off	On	Off	Off
Off	Off	Don't Care	Off
On	Off	On	On

If either PLC 31 or 30 stops sending outputs to the block, outputs are controlled directly by the remaining device.

Hot Standby Redundancy, GMR System with Three PLCs

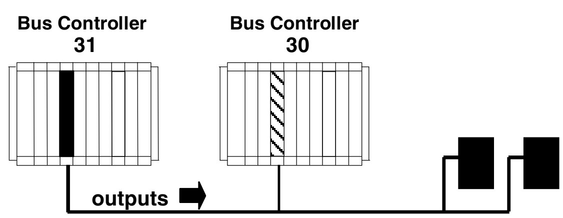
For individual outputs in a GMR system with three PLCs to operate in Hot Standby Mode, it is necessary to configure the blocks for Hot Standby YES in the GMR configuration (Non-Voted Discrete I/O, General tab), and set PLC Redundancy to Hot Standby when configuring the blocks themselves with the HHM.



This “triple” Hot Standby redundancy is available with the 16 and 32-circuit DC Blocks: IC660BBD020, BBD021, BBD024, and BBD025, and IC660BRD020. In this mode, the block receives outputs from PLCs at serial bus addresses 31, 30, and 29. The block uses outputs from PLC 31 if they are available. If not, it uses outputs from PLC 30. If outputs from both PLC 31 and PLC 30 are not available, the block uses outputs from PLC 29. If output data is not available from any of the three PLCs, outputs go to their configured default or hold their last state. The PLC at bus address 31 always has priority, so that when 31 is online, it always has control of the outputs.

Hot Standby Redundancy, System with Two PLCs

For individual outputs in a GMR system with two PLCs to operate in Hot Standby Mode, configure the blocks for Hot Standby NO in the GMR configuration (Non-Voted Discrete I/O, General tab), and set PLC Redundancy to Hot Standby when configuring the blocks with the HHM.



In this mode, the block receives outputs from two PLCs, at serial bus addresses 31 and 30. The block uses outputs from PLC 31 if they are available. If no output data is available from bus address 31 for a period of three bus scans, the outputs are immediately controlled by the PLC at bus address 30. If output data is not available from either 30 or 31, outputs go to their configured default or hold their last state. The PLC at bus address 31 always has priority, so that when 31 is online, it always has control of the outputs.

Chapter 4 The PLC Subsystem

In a GMR system, the basic operation of the Series 90-70 PLC is enhanced by the features provided by the GMR System Software.

This chapter describes:

- GMR System Operation
- The CPU Sweep in a GMR PLC
- GMR System Startup
- Communications between GMR PLCs
- Discrete Input Data Processing
- Analog Input Data Processing
- Output Processing
- GMR Autotest
- The PLC and I/O Fault Tables in a GMR System
- Setting Up Multiple Fault Reports

GMR System Operation

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 VersaMax 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 input device transmits 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.

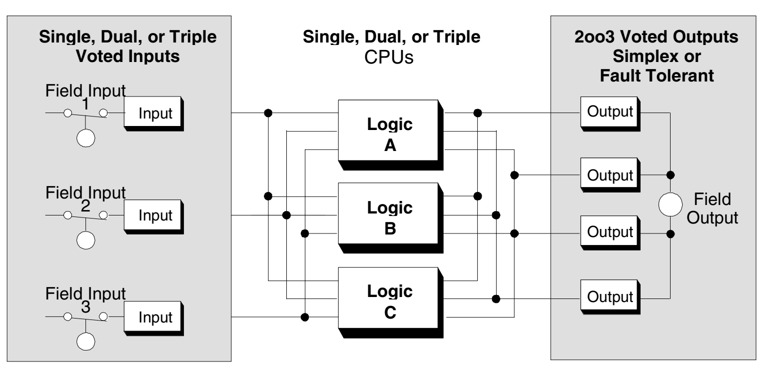
Depending on the redundancy needs of the application, there may be one, two, or three PLCs in the GMR system. Each PLC CPU votes on the input data it has received before each execution of the application program.

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.

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.

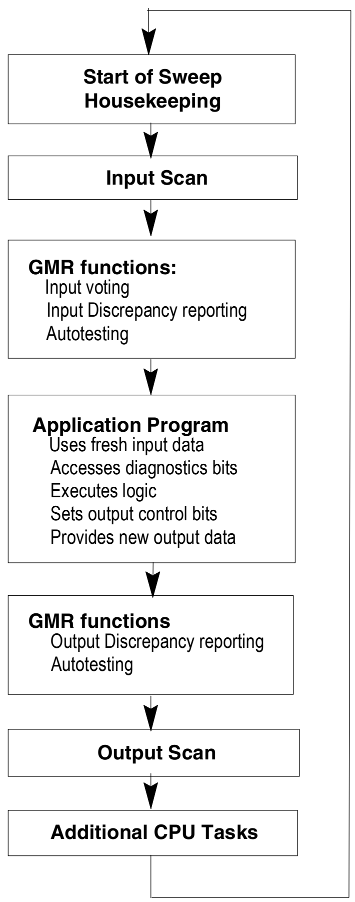
The intelligent Genius output block groups perform output voting. The manner of voting is configurable for the application. Because output voting is performed by the block groups at the point of control, output data discrepancies are caught by the voting process.

Overview of GMR System Operation



The CPU Sweep in a GMR PLC

When the GMR System Software is present in the folder, its functions are incorporated into the basic PLC sweep as shown below.



Each PLC in the GMR system receives the input state from each connected block on each PLC sweep.

After the Input Scan, the GMR System Software performs voting on the inputs configured for GMR redundancy, and places the results into the specially-mapped areas of the discrete and analog input tables. From there, they are available to the application program. The GMR System Software notes any data discrepancies and provides fault bits and fault messages that can also be accessed by application program. Chapter 9 provides information about programming.

The application program determines the required state of the outputs as a function of the inputs received. The application program only needs to set a single output bit for each device to be controlled, even for a voted output group. The appropriate number of redundant Genius blocks are configured to use identical output references.

After the Output Scan, the CPUs monitor the voted output state from each Genius output block group. They do that by checking output feedback received from the blocks in special reserved references in the input table. The GMR System Software provides diagnostic information about any output discrepancy and identifies the discrepant PLC.

The executive path in each processor (field input to field output) is independent of any inter-processor data exchange, with the exception of initialization data at powerup.

Estimating CPU Sweep Time in a GMR System

The GMR system software produces a "base" CPU sweep time that is part of the overall sweep time of the CPU with a ladder logic application program. This base sweep time must be considered during application program design and development. Base sweep time depends on GMR configuration parameters such as Input and Output table sizes. Typical base sweep times for a system with six Bus Controllers are shown below for different I/O Table sizes.

with table sizes of	with table sizes of
Voted %I = 64 Voted %AI = 64 Logical %Q = 64	Voted %I = 256 Voted %AI = 256 Logical %Q = 256
Base Sweep time, 790 CPU= 30mS Base Sweep time, 788/789 CPU= 107mS	Base Sweep time, 790 CPU = 31ms Base Sweep time, 788/789 CPU =116mS

The base sweep time for your system could be less or more depending on the table sizes you configure. For a 790 CPU, base sweep time varies by +/-3-4mS during single sweeps when the GMR software performs diagnostics on the CPU subsystem and I/O subsystems. For a 788 or 789 CPU, base sweep time varies by +/-10mS.

Sweep Time Contribution of Genius I/O and GBCs

The contribution of Genius I/O, Field Control and VersaMax I/O, and Genius Bus Controllers to the sweep time of the PLC is similar to that of Series 90-70 I/O. There is an overhead for the I/O scan, a per Bus Controller sweep time impact, a per scan segment impact; and a transfer time (per word) impact for all I/O data. The potential Bus Controller impact on the CPU has three parts:

1. Time to open the system communications window, added once when the first intelligent option module (such as a Bus Controller) is placed in the system.
2. Time to poll each Bus Controller for background messages (datagrams). This must be added for every Bus Controller in the system.
3. Time needed for the CPU to scan the Bus Controller.

For detailed information about estimating CPU sweep time, refer to the *Series 90-70 PLC Reference Manual* (GFK-0265).

> ***Important Note*** In the section on Sweep Time Impact, the *Series 90-70 PLC Reference Manual* describes the technique of eliminating the first and second parts of the Bus Controller's sweep time contribution by closing the system communications window (setting its time to 0). This should NOT be done in a GMR system.

GMR System Startup

This section describes in detail how the GMR PLCs operate and interact when the system is started up. For suggestions on application programming related to startup, turn to chapter 9, Programming.

The following actions occur during orderly startup of the GMR system:

1. While a PLC is initializing, the GMR software automatically prevents its application program from executing until initialization is complete. It also disables the PLC's outputs to Genius blocks. If the Outputs Disable function does not complete successfully, the GMR software sets the flag “GMR System Initialization Fault” and the GMR software puts the PLC in Halt mode.
2. Each PLC determines its PLC identity: PLC A, PLC B, or PLC C.

   For each PLC, all Bus Controllers that are included in the GMR software configuration must have been assigned the same serial bus address: 29, 30, or 31. Each PLC checks its GMR configuration to be sure this has been done. If it has, the PLC determines its identity as follows:

   PLC A all GMR Bus Controllers at serial bus address 31.
   PLC B all GMR Bus Controllers at serial bus address 30.
   PLC C all GMR Bus Controllers at serial bus address 29.

   If a PLC determines that its GMR Bus Controllers have been configured with incorrect serial bus addresses, it logs an “Invalid Bus Address” fault into its PLC Fault Table and stops the PLC.
3. During initialization, a PLC communicates with the GMR I/O blocks and with Bus Controllers in other PLCs. If any of these communications fails, the GMR software automatically sets status bit %M12234 on (1). This bit indicates System Failure at Powerup.
4. As each PLC starts up, it checks to see whether another PLC is already online and sending outputs. “Online” means the other PLC is running its application program, and its outputs are enabled. If one other PLC is already online (running the application program and transmitting output data), the initializing PLC reads that PLC's initialization data (%M and %R). It places this data into a configurable area of %R memory.

   It may take several CPU sweeps to read all the data from both PLCs. Data is read in quantities of up to 64 words at a time. The data transfer is divided across the busses to minimize the total time required. Therefore the overall time depends on the data lengths and the number of busses available.

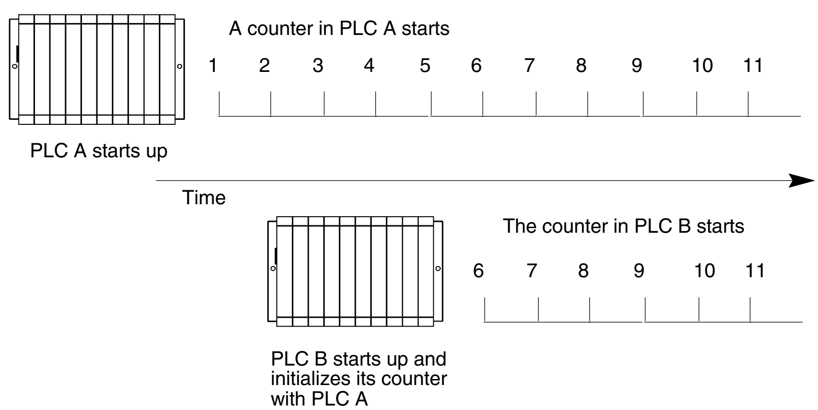
5. Each PLC compares its initial GMR configuration checksum with those of the other PLCs. If they do not match, the PLC stops.

   After successful initialization, when the application program is running, the PLC will continuously compare its program checksum against the initial program checksum, and if they do not match, the PLC will (as configured) either stop or keep running.

   Note that if an initializing PLC detects that an online PLC has gone offline, it attempts to restart data initialization with the other PLC. If the other PLC is not online, the synchronizing PLC will flag that initialization is not possible, and halt.

6. PLC C (which uses serial bus address 29) sends an “Assign Controller” datagram to all blocks and also sends an “Assign Monitor” datagram to the blocks configured for Hot Standby mode to ensure correct operation with three PLCs. If this function does not complete successfully, the GMR software places a “GMR System Initialization” fault into the PLC Fault Table. This fault can be configured to stop initialization and halt the PLC or allow it to continue.

7. If either or both of the other PLCs is already online (running the application program and transmitting output data), the initializing PLC synchronizes its %M and %R data with that of the other PLC(s). This is shown by the following simplified example:



   If both of the other PLCs are already online, the initializing PLC reads the %R (only) initialization data from the other PLC with the higher serial bus address. It then sets its own data to match as shown above.

Each PLC reads data only once. If data in the online PLC changes after the initializing PLC reads it, the change is not noticed. To minimize data differences on continually changing data such as timer and counter accumulators, they should be located at the end (top) of the configured %R memory space. That part of the %R initialization data is copied last. Locating changeable data at the top of the %R data assures that the most recent values are included when the data is copied.

The third initializing PLC reads any %M (bit) initialization data from *both* of the online PLCs , and compares the two sets of data. If the data does not match, it tries again. After a total of three retries, if the data still doesn't match, the initializing PLC may either:

- Halt the PLC (if this fault is configured as fatal)
- Allow the PLC to continue operating (if it is configured as diagnostic) and set the %M12232 (Init Miscompare at Startup) status flag.

The action taken is determined by the GMR configuration (see page 6-20).

If the initializing PLC is unable to successfully read all the data from the other PLC(s), it sets a flag for the application program. The entire initialization sequence then begins again, excluding the Genius bus with which communications failed.

8. When the PLC completes its data initialization, the GMR software clears the Inhibit status flag (%M12231). The PLC starts executing the application program.
9. When the Continue control flag is set by the user's application program, the PLC begins sending outputs from the application program to Genius blocks.
10. If these outputs match the current output states of the blocks, they are accepted by the blocks. If a block detects that outputs from a PLC do not match the current output states of the blocks, the block does not use those outputs in its output voting. The block(s) continue to ignore outputs from the PLC until they match those of the block's voted outputs or until commanded to do so by setting the FORCLOG command bit (%M12263). This is described on the next page.

Startup requires multiple PLC sweeps to complete. Execution of the application program should not be started until initialization has been completed successfully.

Enabling Outputs At Startup

As mentioned above, each PLC starts sending outputs when bit %M12257 is set to 1 in its application program. When the first PLC starts sending outputs, its outputs are compared to the configured default states for each output. When each subsequent PLC starts sending outputs, its outputs are compared to the voted output states at each output block group.

If the states do not agree for any output block, status bit %M12240 (LOGONFT) is set to 1.

The block ignores the new output data until either:

- voted output states match for the complete output block or
- the application program sets the Force PLC Logon bit. For more information, see chapter 9.

Force Logon for 1oo1D Output Groups

At system start-up the GMR System Software automatically turns on (sets to 1) the %Q reference of all guarded outputs on 1oo1D Output Blocks.

If the 1oo1D Diagnostic Block is in GMR mode when the first CPU comes on-line, the commanded output states may not be the same as the Default states programmed in the blocks. Therefore, a Force Logon is needed to enable the I/O, forcing the Guard Relay output on (1). That provides initial power to the output block if there had been no active 'Diagnostic defeat' bypass.

A Force Logon may be required by other CPUs when they come online.

Performing I/O Fault Reset

If I/O faults occur while a GMR PLC is initializing, the faults are reported to that CPU. An I/O Fault Reset should be performed when any of the GMR CPUs are initialized. That will cause any current I/O fault information to be re-reported, and it will be seen by the other PLCs.

If manual output controls are used in a GMR system and the appropriate GMR Autotest inhibit inputs are used to block faults created by the manual controls, any standard Genius type fault (open, overload, short, etc.) is also blocked during the time the inhibit input is on. It is therefore recommended that after the inhibit input is turned off, an I/O fault reset be performed, which will cause any current I/O fault information to be re-reported.

Communications Between GMR PLCs

The regular and automatic broadcasting of Global Data on the Genius bus allows the PLCs in a GMR system to exchange information in a reliable, structured way. The GMR system software uses Global Data to exchange interface information among the PLCs. The application program can also use Global Data as a way of easily transmitting data from one GMR PLC to the others.

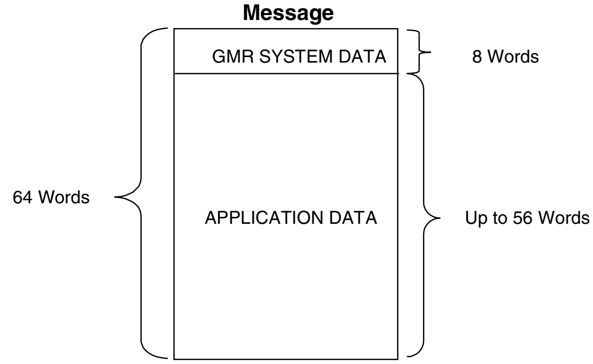
Format of a Global Data Message

In a Series 90-70 PLC/Genius system, Global Data is data that is automatically broadcast by a PLC Bus Controller, each bus scan.

In a duplex or triplex PLC GMR system, each GMR PLC sends one Global Data message each bus scan.

The message begins with 8 words of %R GMR system data. Because Global Data messages can be up to 64 words in length, 56 additional words of the message are available for use by the application program. This structure is represented below. The first 8 words are the GMR system data.

A Global Data Message



The rest of the message can be any data one GMR PLC wants to share with the others. For example, one PLC might send the others information from non-GMR devices, or its current timer and counter states.

Sending this additional application data does not impact the bus scan timing. The Global Data exchange takes the same amount of time whether or not the message includes any application data.

Sending and Receiving Application Global Data

The GMR PLC uses its Global Data memories (%G, %GA, %GB, and %GC) for application Global Data. To send data to the other PLCs, the application program in each PLC must place the data in references %G0001 through %G0896. It is not necessary to use all of the references. The program logic should refresh the data in %G memory as often as necessary.

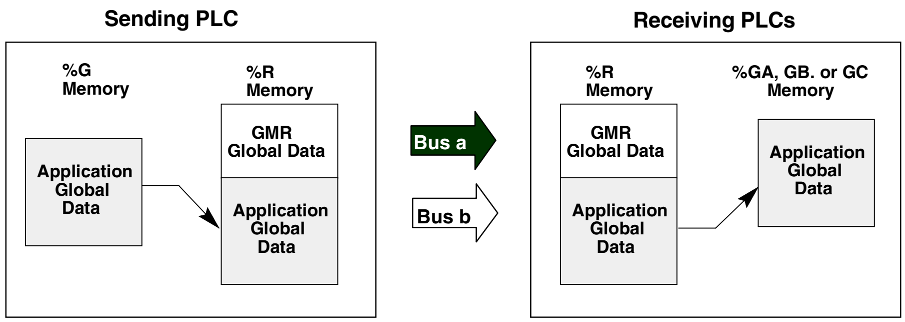
To use the Global Data received from other GMR PLCs, the application program reads the data from %GA, %GB, and %GC memory. In addition, each PLC can also read a copy of its own Global Data.

In the GMR system, these memory areas are assigned differently in the two or three GMR PLCs, as shown in the table below. The application program in each PLC must know the locations assigned to the other PLCs to interpret the incoming Global Data correctly.

All PLCs	%G0001 -%G0896	Application Global Data to be transmitted.
PLC A	%GA0001-%GA0896	Copy of transmitted Global Data (SBA 31)
(SBA 31)	%GB0001-%GB0896	Data received from PLC B (SBA 30)
	%GC0001-%GC0896	Data received from PLC C (SBA 29)
PLC B	%GA0001-%GA0896	Data received from PLC A (SBA 31)
(SBA 30)	%GB0001-%GB0896	Copy of transmitted Global Data (SBA 30)
	%GC0001-%GC0896	Data received from PLC C (SBA 29)
PLC C	%GA0001-%GA0896	Data received from PLC A (SBA 31)
(SBA 29)	%GB0001-%GB0896	Data received from PLC B (SBA 30)
	%GC0001-%GC0896	Copy of transmitted Global Data (SBA 29)

Automatic Global Data Mapping

Each GMR PLC automatically reads the application program Global Data you want to transmit from its %G memory and copies it into its %R memory. Then, each scan of the Genius bus, the PLC broadcasts the combined system Global Data plus application Global Data message on two busses, bus a and bus b.



When another GMR PLC receives the Global Data from either bus a or bus b (if bus a is not available), it copies the portion of the data intended for application program use into %GA, %GB, or %GC memory as shown on the right above.

During the same Genius bus scan, when the other PLCs have their turn on the bus, they send Global Data in the same way.

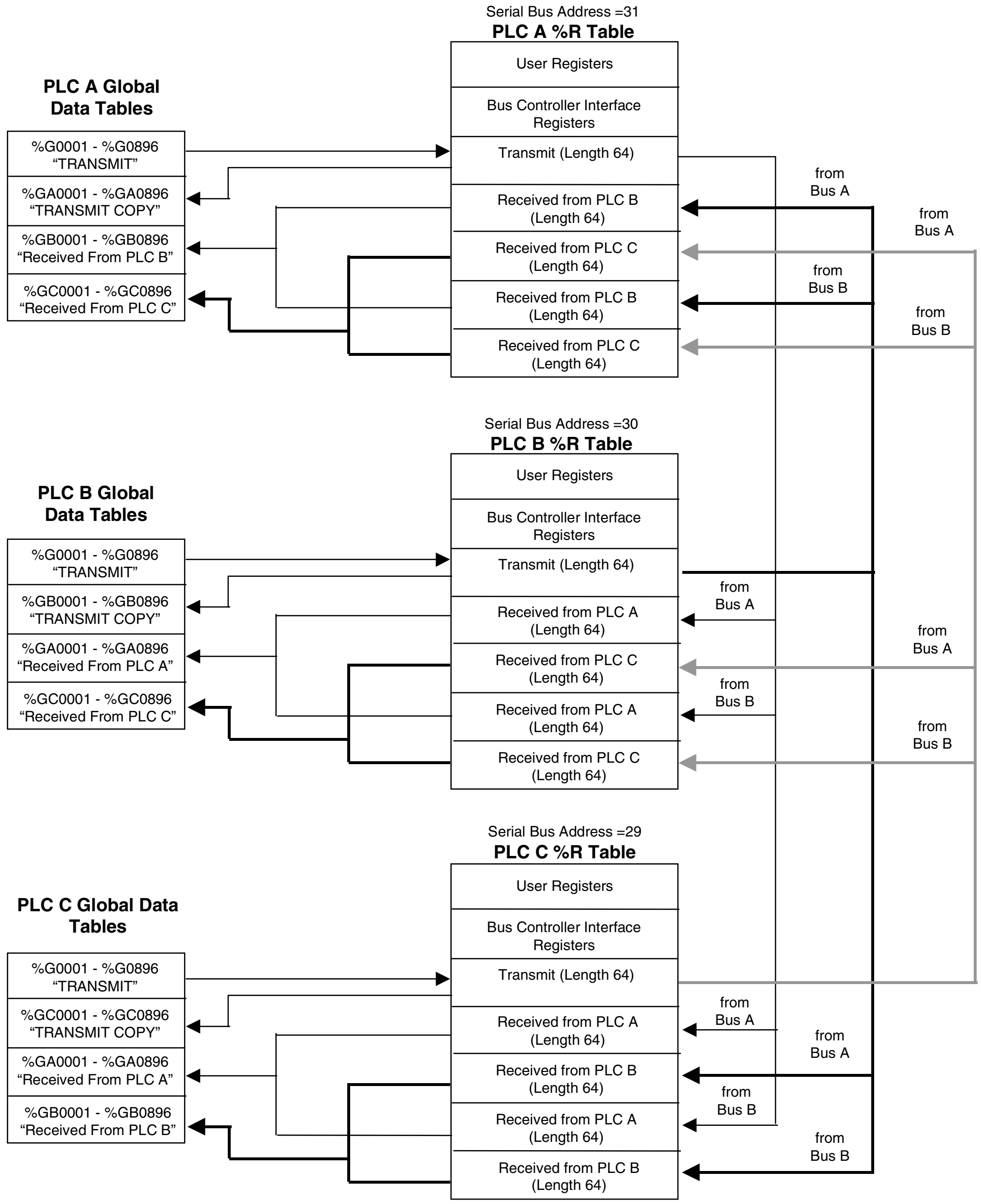
The diagram on the next page shows this Global Data exchange and mapping for all three GMR PLCs.

Global Data Redundancy

As mentioned above, two busses are used to transmit Global Data, bus a and bus b. Therefore, each GMR PLC receives two sets of Global Data from each of the other PLCs. It gives preference to Global Data from the bus designated bus a. If that data isn't available, each PLC uses Global Data received from the bus designated bus b. Under ordinary circumstances, these two sets of data match. The incoming Global Data that can be read in %GA, %GB, or %GC memory, therefore, is the Global Data received on bus a if that data is available. Otherwise, it is the Global Data received on bus b.

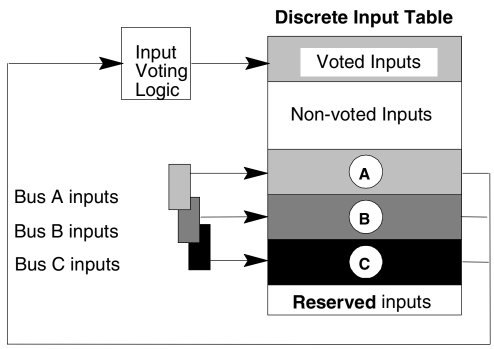
The use of two busses provides redundant operation in case a bus or Bus Controller is not available. If a PLC loses communications with another PLC on both busses, the Global Data from that device is held at its last state. The GMR software places a fault in the PLC fault table when communications are lost.

In addition, the GMR software maintains status flags that can be monitored by the application program to check the state of communications between PLCs. These are described in chapter 9, Programming.



Discrete Input Data Processing

During the Input Scan, data from discrete input blocks is placed in the Input Table as shown below. Inputs from blocks that have been included in the GMR configuration is placed in the areas labeled A, B, and C. Data from any additional discrete input blocks (non-voted GMR blocks or blocks on other busses) is placed in a separate area as shown.

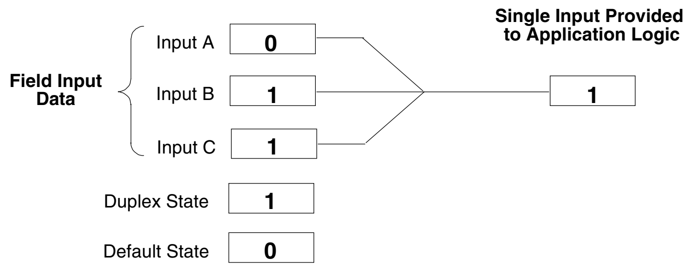


The GMR software creates and maintains the separate areas of the discrete Input Table. In addition to the four areas used for the inputs received from Genius blocks, there are two additional areas. The first, at the beginning of the Input Table, is for voted inputs. The other, at the end of the table, is for “reserved” inputs, which are used to inhibit diagnostics for outputs that are being controlled manually.

Discrete Input Voting

Immediately after the input scan, before the application program execution begins, the GMR software performs input voting. It automatically reads and votes on the three (or two) sets of data in areas A, B, and C of the discrete Input Table.

If a failure (discrepancy fault, Autotest fault, or Genius fault) occurs, the GMR software adapts to reject the faulty data. 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.

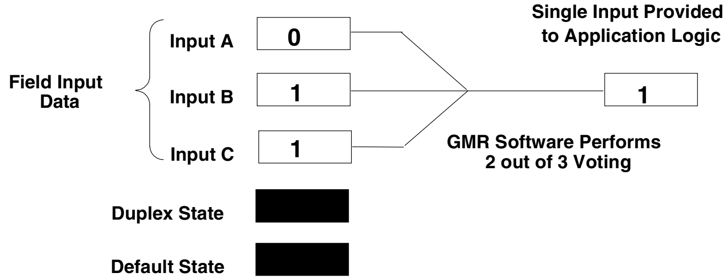


In addition to field input data, the GMR software may also make use of the input group's configured Duplex State and Default State in determining the final input value to provide to the PLC.

Duplex State	The Duplex State is a “tiebreaker" value used when there are two field inputs operating.
Default State	The Default State is the value that will be provided directly to the PLC instead of a voted input value if the following inputs fail: The single input in a one-block group. The remaining input in a two- or three-block group configured for 3-2-1-0 Voting Adaptation. Either of the two inputs to a two-block group configured for 3-2-0 Voting Adaptation. Either of the two remaining inputs to a three-block group configured for 3-2-0 Voting Adaptation.

Voting for a Triplex Discrete Input Group with Three Inputs Present

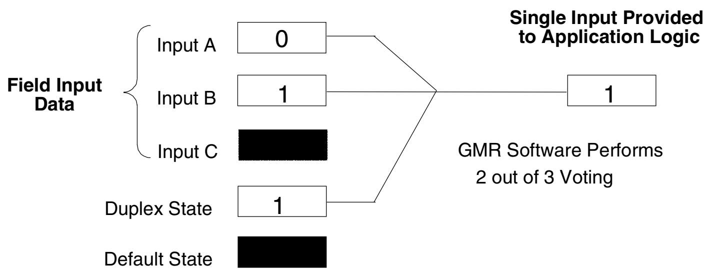
For a three-block input group with three inputs present, the GMR software performs 2 out of 3 voting.



The Duplex State and Default State are not used when three field inputs are available. In the illustration above, inputs A, B, and C might represent the first input point on each block in a three-block group. The PLC would place the voted input value into the first voted input word for that group.

Voting for a Triplex Discrete Input Group if One Input Fails

If one of the three inputs fails, the GMR software uses the group's configured Duplex State for voting, in place of a third actual input.



Discrete Input Voting with Two Inputs Present and Duplex State Set to 1

If the Duplex State is set to 1 and two inputs are available, both of the "actual" inputs must be 0 for the voted input state to be 0. The voted input is 1 if either of the actual inputs is 1. For example:

Input A State	Input B State	Input C (Duplex State)	Voted Input State
0	0	1	0
0	1	1	1
1	0	1	1
1	1	1	1

Discrete Input Voting with Two Inputs Present and Duplex State Set to 0

If the Duplex Default state is set to 0 and two inputs are available, both of the "actual" inputs must be 1 for the voted input to be 1. The voted input is 0 if either of the remaining inputs is 0. For example:

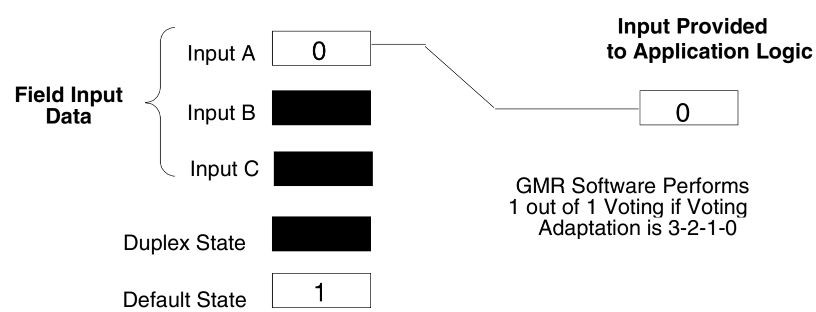
Input A State	Input B State	Input C (Duplex State)	Voted Input State
0	0	0	0
0	1	0	0
1	0	0	0
1	1	0	1

Voting for a Triplex Discrete Input Group if Two Inputs Fail

If only one input is available in a three-block group, voting is not performed. Either the actual input or the default state is used, depending on the Voting Adaptation mode that has been configured for the input group.

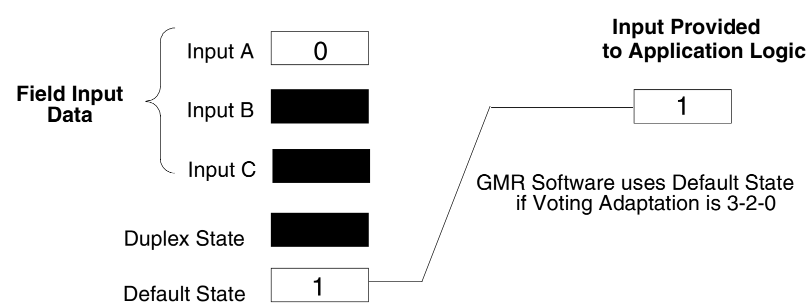
Discrete Input Voting with One Input Present: Voting Adaptation Set to 3-2-1-0

If there is just one actual input present on a group configured for 3-2-1-0 Voting Adaptation, the voted input is the same as the actual input.



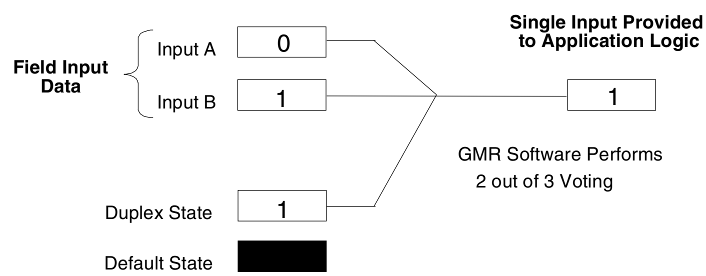
Discrete Input Voting with One Input Present: Voting Adaptation Set to 3-2-0

Configuring 3-2-0 Voting Adaptation prevents the data from just one input being used as the only input data for that group. If an input group configured for 3-2-0 Voting Adaptation has just one input present, the configured input Default State is used instead of the remaining actual input.



Voting for a Duplex Discrete Input Group

In a two-block input group, the GMR software uses the group's configured Duplex State for voting in place of a third actual input.



Discrete Input Voting with Two Inputs Present and Duplex State Set to 1

If the Duplex State is set to 1, both of the “actual” inputs must be 0 for the voted input state to be 0. The voted input is 1 if either of the actual inputs is 1.

Input A State	Input B State	Input C (Duplex State)	Voted Input State
0	0	1	0
0	1	1	1
1	0	1	1
1	1	1	1

Discrete Input Voting with Two Inputs Present and Duplex State Set to 0

If the Duplex Default state is set to 0, both of the “actual” inputs must be 1 for the voted input to be 1. The voted input is 0 if either of the remaining inputs is 0.

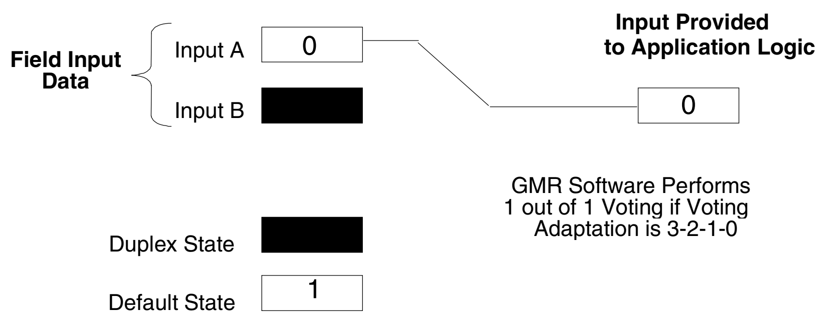
Input A State	Input B State	Input C (Duplex State)	Voted Input State
0	0	0	0
0	1	0	0
1	0	0	0
1	1	0	1

Voting for a Duplex Discrete Input Group if One Input Fails

If only one input is available in a two-block group, voting is not performed. Either the actual input or the default state is used, depending on the Voting Adaptation mode that has been configured for the input group.

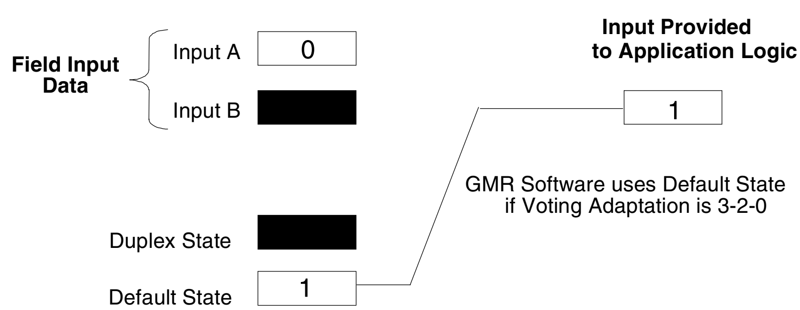
Discrete Input Voting with One Input Present: Voting Adaptation Set to 3-2-1-0

If there is just one actual input present on a group configured for 3-2-1-0 Voting Adaptation, the voted input is the same as the actual input.



Discrete Input Voting with One Input Present: Voting Adaptation Set to 3-2-0

Configuring 3-2-0 Voting Adaptation prevents the data from just one input being used as the only input data for that group. If an input group configured for 3-2-0 Voting Adaptation has just one input present, the configured input Default State is used instead of the remaining actual input.

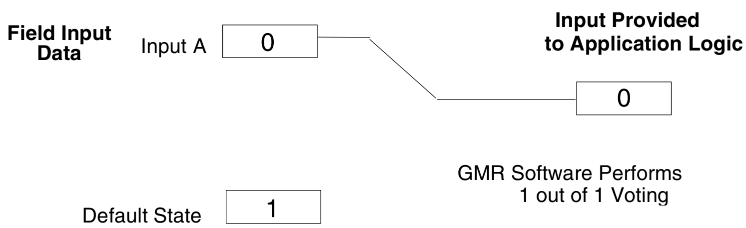


Inputs for a Simplex Discrete Input Group

In a non-voted input group, the actual input is always provided to the application logic. For a one-block input group, Voting Adaptation should always be set to 3-2-1-0.

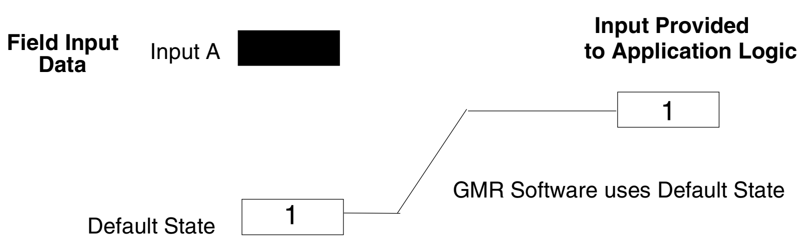
Discrete Input for a Simplex Group with One Input Present

During normal operation, the voted input is the same as the actual input.



Discrete Input for a Simplex Group if the Input Fails

If that input in a simplex group is lost, the configured input Default State is used instead.



Discrete Input Discrepancy Reporting

When a GMR PLC performs input voting, the PLC checks for any discrepancy between an original input data value for an input and its voted input state.

The following table shows possible discrepancies between the input data and voted input data.

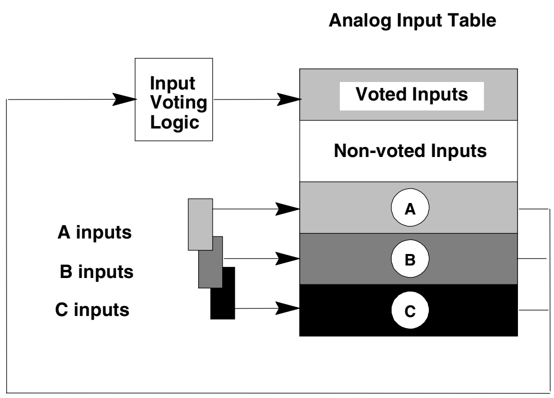
Input Data			Voted	Discrepancy		
A	B	C	Inputs	A	B	C
0	0	0	0	0	0	0
0	0	1	0	0	0	1
0	1	0	0	0	1	0
0	1	1	1	1	0	0
1	0	0	0	1	0	0
1	0	1	1	0	1	0
1	1	0	1	0	0	1
1	1	1	1	0	0	0

If a discrepancy occurs, the PLC automatically places a message in the I/O Fault Table. This discrepancy message is available to the Logicmaster 90 software and the application program logic. Discrepancy faults are latched. When a discrepancy occurs, the PLC also sets the fault contact for that voted input.

Discrepancy signals are filtered for the configured input discrepancy filter time to eliminate transient discrepancies caused by timing differences.

Analog Input Data Processing

GMR analog input processing is similar to discrete input processing. During the Input Scan, data from analog input blocks is placed in the Analog Input Table as shown below. Inputs from blocks that have been included in the GMR configuration are placed in the areas labeled A, B, and C. Data from any additional analog input blocks (non-voted blocks or blocks on other busses) is placed in a separate area as shown.

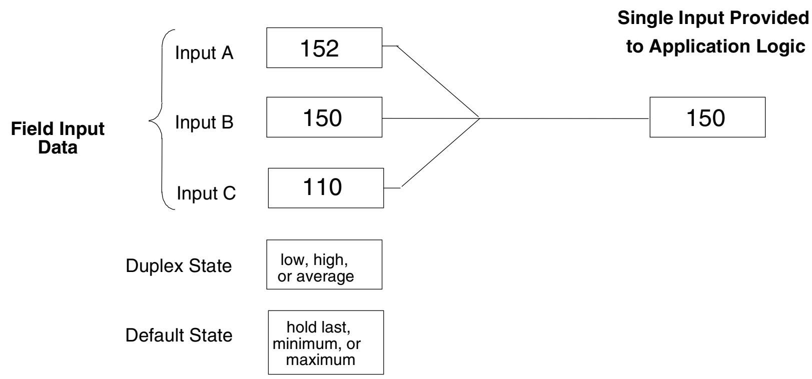


The GMR software creates and maintains the separate areas of the analog Input Table. In addition to the four areas used for the inputs received from Genius blocks and VersaMax / Field Control modules, there is an additional area at the beginning of the analog Input Table for voted inputs.

Analog Input Voting

Immediately after the input scan, before the application program execution begins, the GMR software performs input voting. It automatically reads and votes on the three sets of data in areas A, B, and C of the analog Input Table. How it does the voting is described below. It places the resulting voted input value into the voted inputs area of the Input Table.

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.

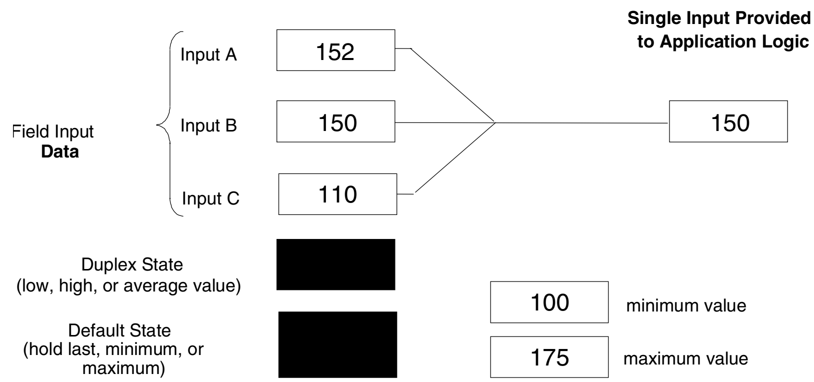


In addition to field input data, the GMR software may also make use of the input group's configured Duplex State and Default State in determining the final input value to provide to the PLC.

Duplex State	The Duplex State is used when there are two field inputs present. The Duplex State may be configured as the higher actual input value, the lower value, or an average of the two.
Default State	The Default State is the value that will be provided directly to the PLC instead of a voted input value if the following inputs fail: The single input in a Simplex group. The remaining input in a two- or three-block input group configured for 3-2-1-0 Voting Adaptation. Either of the two inputs to a two-block input group configured for 3-2-0 Voting Adaptation. Either of the two remaining inputs to a three-block input group configured for 3-2-0 Voting Adaptation. The Default State can be configured as the last input state, or a specified maximum or minimum value.

Voting for a Triplex Analog Input Group with Three Inputs Present

For a three-block input group with three inputs present, the GMR software compares three corresponding analog input values. It selects the intermediate value and places it into the voted inputs portion of the Analog Input Table.



Duplex State and Default State are not used when three field inputs are available.

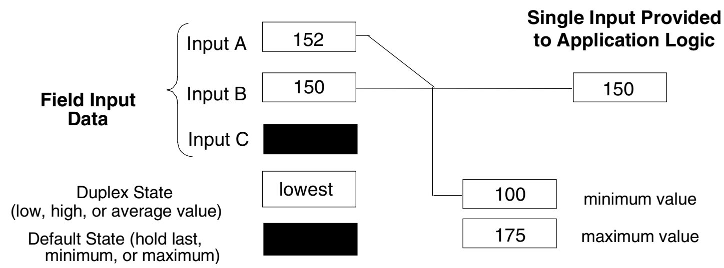
In the illustration above, inputs A, B, and C might represent the first input channel on each block in a three-block group. The PLC would place the selected input value into the first voted input word for that group.

Voting for a Triplex Analog Input Group if One Input Fails

If one of the three inputs fails, the GMR software uses the group's configured Duplex State for voting, in place of a third actual input.

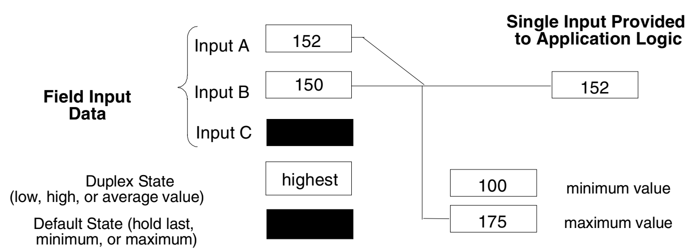
Analog Input Voting with Two Inputs Present and Duplex State Set to Lowest

If the duplex state is *lowest*, the GMR software uses the configured minimum value in place of the missing input. It selects the intermediate value as the voted analog input value.



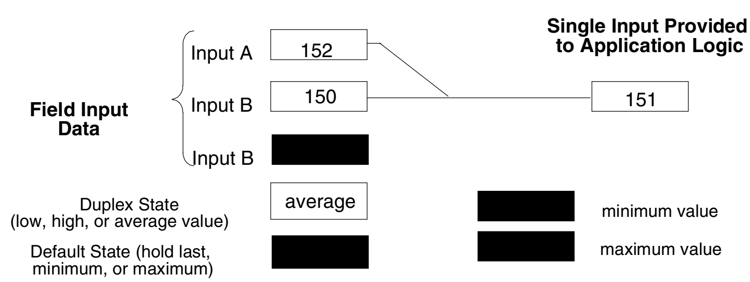
Analog Input Voting with Two Inputs Present and Duplex State Set to Highest

If the duplex state is *highest*, the GMR software uses the configured maximum value in place of the missing input. It selects the intermediate value as the voted analog input value.



Analog Input Voting with Two Inputs Present and Duplex State Set to Average

If the duplex state is *average*, the GMR software averages the two remaining input values and supplies the result to the PLC Input Table.

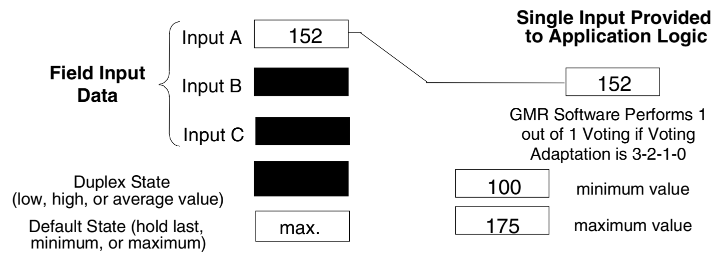


Voting for a Triplex Analog Input Group if Two Inputs Fail

If only one input is available in a three-block group, voting is not performed. Either the actual input or the default state is used, depending on the Voting Adaptation mode that has been configured for the input group.

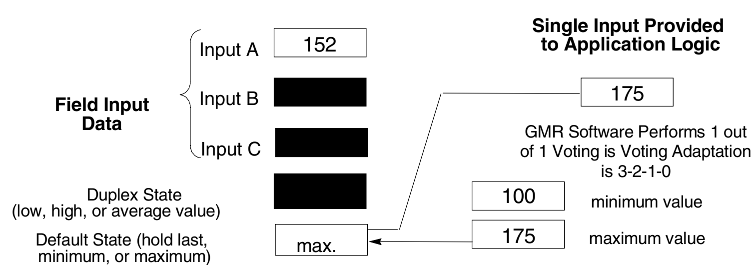
Analog Input Voting with One Input Present: Voting Adaptation Set to 3-2-1-0

If there is just one actual input present in an input group configured for 3-2-1-0 Voting Adaptation, the voted input is the same as the actual input.



Analog Input Voting with One Input Present: Voting Adaptation Set to 3-2-0

Configuring 3-2-0 Voting Adaptation prevents the data from just one input being used as the only input data for that group. If an input group configured for 3-2-0 Voting Adaptation has just one input present, the configured input Default State is used instead of the remaining actual input.

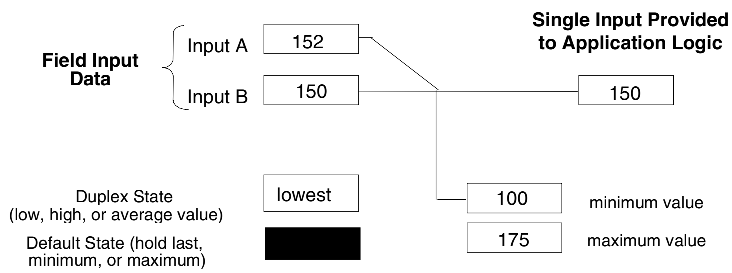


Voting for a Duplex Analog Input Group

In a two-block input group, the GMR software uses the group's configured Duplex State for voting in place of a third actual input.

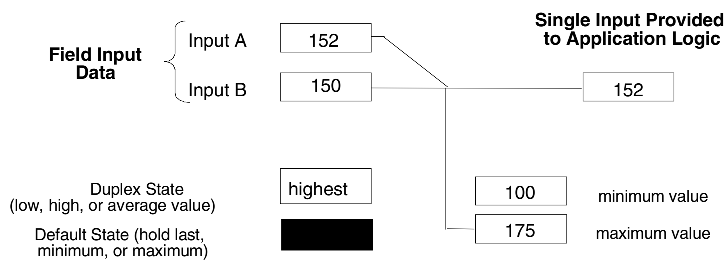
Analog Input Voting with Two Inputs Present and Duplex State Set to Lowest

If the duplex state is *lowest*, the GMR software selects the intermediate value with the unused (third) channel being assigned its minimum configured value.



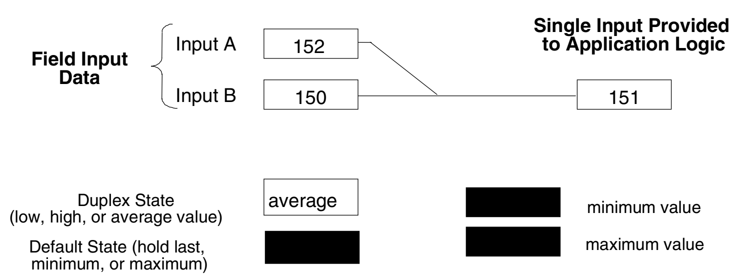
Analog Input Voting with Two Inputs Present and Duplex State Set to Highest

If the duplex state is *highest*, the GMR software selects the intermediate value, with the unused channel being assigned its maximum configured value.



Analog Input Voting with Two Inputs Present and Duplex State Set to Average

If the duplex state is *average,* the GMR software averages the two remaining input values and supplies the result to the PLC Input Table.

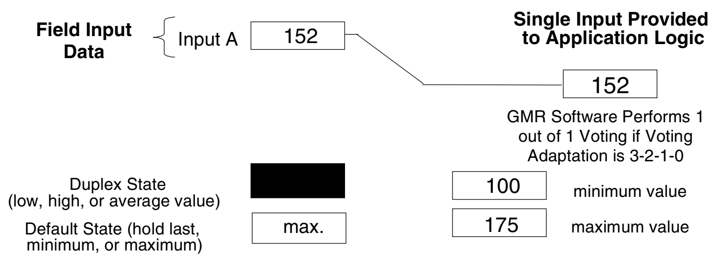


Voting for a Duplex Analog Input Group if One Input Fails

If only one input is available in a two-block group, voting is not performed. Either the actual input or the default state is used, depending on the Voting Adaptation mode that has been configured for the input group.

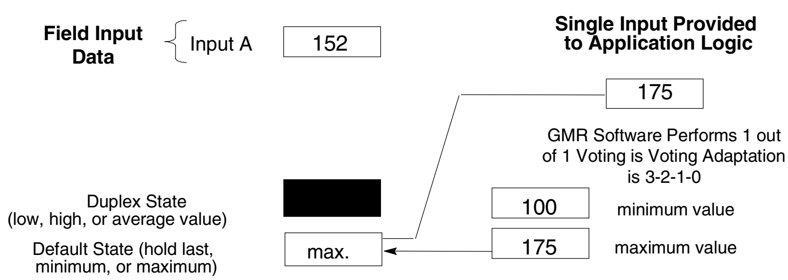
Analog Input Voting with One Input Present: Voting Adaptation Set to 3-2-1-0

If there is just one actual input present in an input group configured for 3-2-1-0 Voting Adaptation, the voted input is the same as the actual input.



Analog Input Voting with One Input Present: Voting Adaptation Set to 3-2-0

Configuring 3-2-0 Voting Adaptation prevents the data from just one input being used as the only input data for that group. If an input group configured for 3-2-0 Voting Adaptation has just one input present, the configured input Default State is used instead of the remaining actual input.

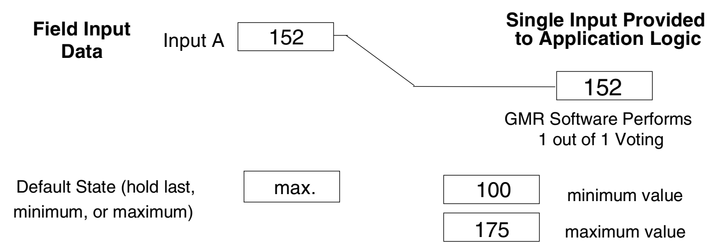


Inputs for a Simplex Analog Input Group

In a non-voted input group, the actual input is always provided to the application logic.

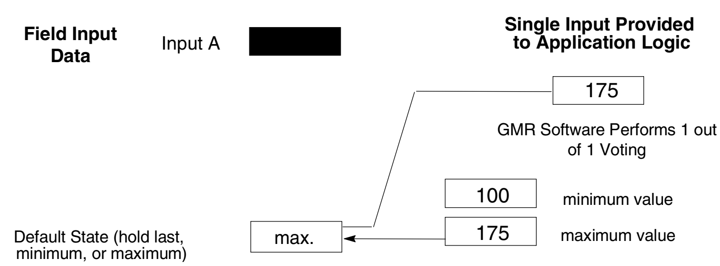
Analog Input for a Simplex Group with One Input Present

During normal operation, the voted input is the same as the actual input.



Analog Input for a Simplex Group if the Input Fails

If that input in a simplex group is lost, the configured input Default State is used instead.

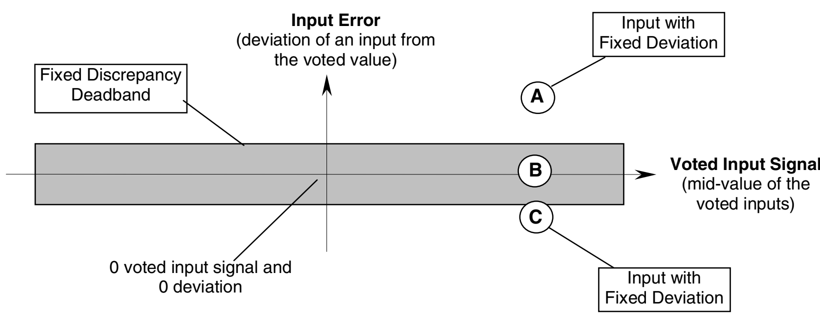


Analog Input Deviation Reporting

The GMR software automatically performs analog deviation reporting as set up in the GMR configuration. Deviation reporting checks whether an analog input varies too greatly from the present voted input value. Deviation deadband signals are filtered for the configured input filter time to eliminate transient deviations caused by timing differences.

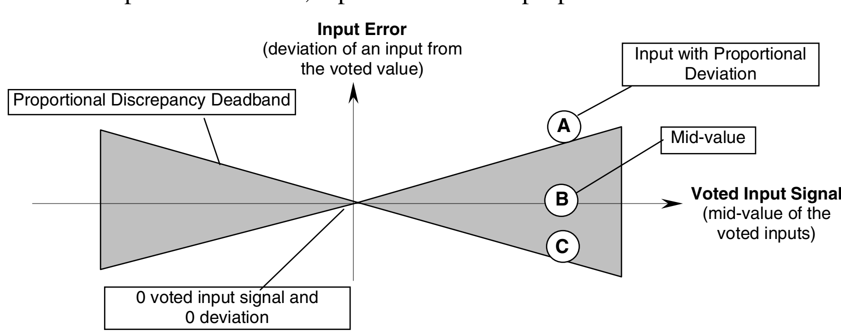
Fixed Deviation

A fixed deviation occurs if an individual analog input lies outside its fixed discrepancy deadband. This deadband is a percentage of the range determined by its configured maximum and minimum values. The fixed deviation deadband is constant over the range of the input value. This is shown as the shaded rectangle in the illustration below. In this example, input B is the voted mid-value. Inputs A and C both have a fixed deviation.



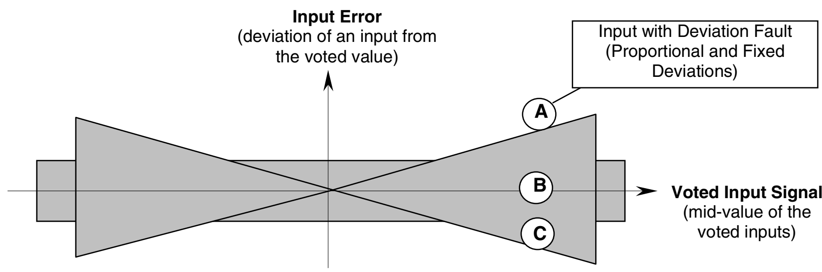
Proportional Deviation

A proportional deviation occurs if an individual analog input lies outside its proportional deadband. This deadband is a percentage of the present voted value of the input. The proportional deviation deadband increases as the voted value increases. This is shown by the shaded triangles in the illustration below. In the same example shown above, input A also has a proportional deviation.



Deviation Faults

Both a Fixed and Proportional Deviation must be present for an input before an Analog Input Deviation is logged in the fault table. In the example, input A is outside both the fixed and proportional deadbands, and would cause a fault:



Deviation is calculated for engineering unit values. Up to two of the three analog inputs may be deviant at any given time.

Deviation faults are latched, but can be cleared by performing an I/O Fault Reset (see chapter 9, Programming). When a deviation occurs, the PLC sets the fault contact for that voted input and adapts according to its configuration.

Output Processing

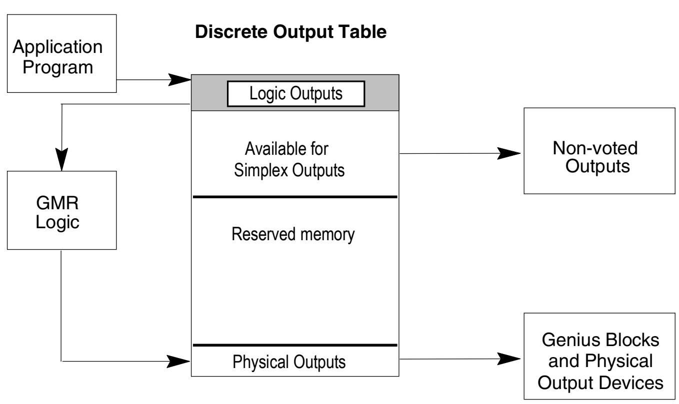
For discrete outputs, the GMR System Software does not perform “redundancy” voting. Instead, voting is done by the specified types of discrete output block groups. Analog blocks do not provide redundancy voting or autotest features. Both discrete and analog Genius blocks can be used in the output subsystem as non-GMR blocks. VersaMax and Field Control devices cannot.

Memory Allocation

As it does for inputs, the GMR software uses separate areas of the Output Table for non-voted outputs, GMR outputs and copies of the GMR outputs.

After the application program executes, the GMR software processes discrete output data as described below.

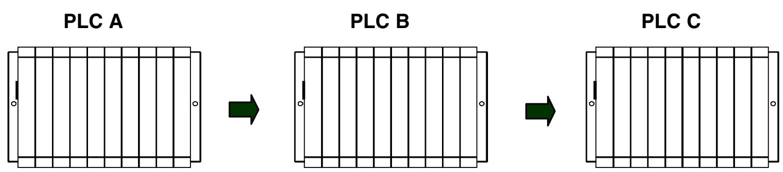
- The application program places outputs into the discrete Output Table. Data for blocks that are included in the GMR configuration is placed at the start of the output table. In the illustration below, the application program outputs for redundant blocks are labeled “logic outputs”. This data is followed by outputs for non-voted blocks.
- The GMR software copies these logic output into the bottom portion of the Output Table. This data, shown as Physical Outputs in the illustration below, 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.
- During the output scan portion of the CPU sweep, the CPU sends the non-voted outputs plus the copied GMR outputs to the Genius blocks.



GMR Autotest

GMR Autotest regularly checks the operation of the discrete inputs and discrete outputs in the system. The GMR System Software controls execution of GMR Autotest feature.

Autotesting occurs at a configured interval during system operation. Each PLC in turn controls the sequence. If one or two of the PLCs are not available, autotesting continues with the remaining PLC(s).



During its turn as the Autotest Master, a PLC tests all input and output groups that are set up for autotesting.

Discrete Input Autotest exercises the selected system inputs to be sure they remain able to detect and respond to actual inputs. Input Autotest accommodates both normally-closed and normally-open devices with the devices in either state. For a detailed description of discrete input autotest, please refer to chapter 2.

Discrete Output Autotest checks the ability of outputs to respond to the commanded output state. It detects short circuit, open circuit, disconnect, failed switch and other types of faults. Output Autotest uses the standard Genius block Pulse Test feature. For a detailed description of discrete output autotest, please refer to chapter 3.

I/O Shutdown

When discrete I/O faults occur during Autotest, the system logs the appropriate faults in its fault tables and set the associated fault contacts. For some types of discrete I/O faults, if the problem is not rectified within a configurable period of time, an I/O Shutdown of the affected block(s) occurs. (See chapter 8 for more information about programming to detect or prevent I/O Shutdown condition.)

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 that has been configured for the input group.

The current Autotest Master PLC controls I/O shutdown in all PLC(s). After the Autotest Master completes an Autotest on an I/O group, it notifies the other GMR PLC(s) if an error occurred during Autotest.

Each PLC will then run an I/O shutdown timer for the I/O group, initiating a shutdown on timeout. The I/O shutdown timer is configured using the GMR configuration utility. The maximum timer interval is 10 days or 14,400 minutes. During that time, the fault can be repaired and the block(s) can be put back into operation.

The Autotest Master does NOT initiate an I/O Shutdown if:

- One or more blocks in the current input/output group were offline during an autotest.
- All blocks were on-line but one or more of them were unable to communicate with the Autotest Master.

I/O shutdown is cancelled if:

- The fault has been cleared. Both the Autotest Master and non-master PLC(s) determine that a fault has been cleared by successful Autotest results. Successful Autotest clears the associated I/O shutdown timer, and logs a message in the PLC fault table.
- The Cancel I/O Shutdown bit) (%M12265, SDCAN) is set. This can be done from any PLC, it does not have to be the Autotest Master.

Total Time until I/O Shutdown

The amount of time between the actual occurrence of a fault and the time when the affected I/O are physically shut down depends on:

- The delay in detecting the fault because of the configured Autotest interval.
- The delay selected as the configured shutdown period.

The Autotest Interval

The time required to detect a fault during Autotest depends on the Autotest interval that has been configured for the system. That interval can be up to 1092 hours.

The Shutdown Period

The shutdown period is a configurable delay of up to 10 days or 14,400 minutes hours from the time the fault is detected to the time the block(s) I/O is shut down.

Recovery from an I/O Shutdown

To recover from an I/O shutdown:

1. Repair the fault that caused the I/O shutdown to initiate. This may require simply replacing a blown fuse that had supplied power to a block, or replacing a damaged or failed block or repairing field wiring.
2. If the next scheduled or commanded autotest on the PLC(s) that started its shutdown timer then completes without faults on the affected block(s), the block(s) is repaired and again functioning properly.
3. If a block was powered off or replaced, a shutdown of outputs on the block(s) may require a force logon to get them to accept output data from the PLCs.
4. Clear any standing faults at the block(s) and in the I/O fault table of the PLCs.

The PLC and I/O Fault Tables in a GMR System

The PLC and I/O Fault Tables in a GMR system operate in the same way as in a non-GMR system.

In addition, a GMR system provides the following types of messages:

- Special PLC Fault Table messages for GMR (PLC Fault Table)
- Autotest fault messages (I/O Fault Table)
- Discrepancy fault messages (I/O Fault Table)

Faults can be displayed with the programmer in either On-Line or Monitor mode. Additional information about specific faults can be displayed by pressing CTRL/F, as described in this section.

Clearing the Fault Tables in a GMR System

Although the Fault Tables seem to operate as they would in a non-GMR system, they are actually controlled by the GMR software, *not* the PLC firmware.

In a GMR application, the fault tables must be monitored and cleared from the application program logic.

Caution

Use these %M references to clear the PLC Fault Tables.

- To clear the PLC Fault Table in a single PLC, set reference %M12259 to 1 for at least one PLC sweep in that PLC.
- To clear the PLC Fault Table in all PLCs, set reference %M12264 to 1 for at least one PLC sweep in any PLC.
- To clear the I/O Fault Table and corresponding fault contacts in all PLCs, set reference %M12258 to 1 for at least one PLC sweep in any PLC.

PLC Fault Table Messages for GMR

In addition to the basic Series 90-70 PLC Fault Table messages, a GMR system provides a broad range of additional diagnostic messages related to GMR operations. These are listed and explained in appendix D. If you need additional help, call GE Fanuc Technical Service at 1-800-828-5747.

I/O Fault Table Messages for GMR

Faults and alarms from I/O devices, Bus Controller faults, and bus faults are automatically logged into the Series 90-70 PLC's I/O Fault Table.

In addition to the standard PLC and I/O fault messages, in a GMR system, the I/O Fault Table displays:

- Autotest fault messages
- Discrepancy fault messages

These faults have the following fields on the Logicmaster Fault Table display:

Fault Location*:	Rack
	Slot
	Bus: always 1
	Block serial bus address
Circuit Number:	Block circuit number
Reference Address:	Physical I/O reference
Fault Category:	Circuit Fault
Fault Type:	Discrete Fault

* For autotest faults (only) the fault location given is for block A of the group if the fault affects all blocks in the group; otherwise, the location is that of the affected block.

Displaying Additional Fault Information About I/O Faults (with CTRL/F)

Pressing the programmer CTRL/F keys provides more information about a fault. Entries that apply to the GMR system are described below.

Fault Description:

Code (Hex)	Meaning
00	Loss of Device
F0	Digital Input Autotest Fault
F1	Digital Input Discrepancy Fault
F2	Digital Output Autotest Fault
F3	Digital Output Discrepancy Fault
F4	Analog Input Discrepancy Fault
FF	GMR I/O Fault

Fault Specific Data:

Loss of Device	Byte 1	= 84 (Hex)	
	Bytes 2 - 5	= Always 0	
Digital Input Discrepancy	Byte 1 - 5	= Always 0	
Input Autotest	Byte 1	= Master PLC (AA, BB, or CC (Hex)	
	Bytes 2 and 3	= Always 0	
	Byte 4	= Fail State :	(01 = input stuck at 0)
			(02 = input stuck at 1)
	Byte 5	= Always 0	
Analog Input Discrepancy	Byte 1 - 5	= Always 0	
Output Autotest	Byte 1	= Master PLC (AA, BB, or CC (Hex)	
	Bytes 2 and 3	= Always 0	
	Byte 4	= Fault type (see below)	
	Byte 5	= Always 0	
Output Discrepancy	Byte 1	= Master PLC (AA, BB, or CC (Hex)	
	Bytes 2 and 3	= Always 0	
	Byte 4	= discrepant PLC (AA, BB, or CC (Hex)	
	Byte 5	= Always 0	
Analog Input Discrepancy	Byte 1 - 5	= Always 0	
GMR I/O Fault	Byte 1	= Master PLC (AA, BB, or CC (Hex)	
	Bytes 2 and 3	= Always 0	
	Byte 4	= 1 (Logon fault)	
	Byte 5	= discrepant PLC (AA, BB, or CC (Hex)	

Fault Type for Output Autotest

For Output Autotest, the Fault Type byte may have the following content (hex values):

Error Codes for 4-Block H-Pattern Output Group			
11	Block A & B short circuit to 0V	22	Block B switch failed off
12	Block C & D short circuit to +24V	23	Block C switch failed off
13	Block A cannot turn on	24	Block D switch failed off
14	Block B cannot turn on	25	Block A not connected to Block B
15	Block C cannot turn on	26	Block C not connected to Block D
16	Block D cannot turn on	27	Block A cannot turn off
17	Load disconnection	28	Block B cannot turn off
18	No Load connection on Block A	29	Block A & B cannot turn off
19	No Load connection on Block B	2A	Block C cannot turn off
1A	No Load connection on Block C	2B	Block D cannot turn off
1B	No Load connection on Block D	2C	Block C & D cannot turn off
1C	Inconsistent No Load reporting	30	Force override (spurious trip)
21	Block A switch failed off		
Error Codes for 2-Block T-Pattern Output Group			
11	Short circuit load	1C	Open circuit load
18	Open circuit block A	25	Blocks A and B disconnected
19	Open circuit block B		
Error Codes for 2-Block I-Pattern Output Group			
11	Short circuit load	19	Open circuit block C
12	Short circuit block C to +24V	23	Short circuit block A to 0v
18	Open circuit block A	25	Blocks A and B disconnected

Setting Up Multiple Fault Reports

Ordinarily, Genius devices send only one copy of a Fault Report. However, in a GMR system, devices can be set up to send additional Fault Reports. The setup needed depends on two things: what type of device it is, and how many PLCs should receive its Fault Reports.

DC Blocks

A 16 or 32 Circuit DC Sink/Source block (only) will send three Fault Reports, one each to serial bus addresses 29, 30, and 31, if the Genius block configuration is set up in either of the following ways:

- For blocks in a GMR group, block configuration is CPU Redundancy = GMR
- For non-GMR group blocks, block configuration is CPU Redundancy=Hot Standby. Hot Standby is selected with the GMR configuration software.

Other Devices

- Inputs-only devices automatically send two Fault Reports to serial busses 30 and 31 with no additional configuration.
- Output and mixed I/O blocks configured for CPU Redundancy = Hot Standby will send two Fault Reports to serial bus addresses 30 and 31.
- If the device is configured in the GMR configuration, the GMR software issues an "Assign Monitor" datagram to cause a device to send the third fault report.

The following table summarizes how many Fault Report messages are sent by devices configured for different types of CPU Redundancy, with or without the Assign Monitor datagram. X means the feature is not configurable for that device.

Device Type	CPU Redundancy Mode Configuration				
	GMR	none		Hot Standby	
		no Assign Monitor datagram	yes Assign Monitor datagram	no Assign Monitor datagram	yes Assign Monitor datagram
16 or 32 Ckt DC Sink/Src	3	1	2	2	3
8 Ckt AC Grouped I/O	X	1	2	2	3
Relay Outputs NO/ NC	X	1	2	2	3
16 Ckt AC Inputs	X	2	3	X	X
4 In, 2 Out Analog	X	1	2	2	3
Crnt source Analog In	X	2	3	X	X
Crnt source Analog Out	X	1	2	2	3
Thermocouple or RTD	X	2	3	X	X
High-speed Counter	X	1	2	2	3
PowerTRAC Block	X	1	2	2	3
VersaMax NIU	X	1	2	2	3
Field Control BIU	X	1	2	2	3

Chapter 5

Reference Assignments for a GMR System

This chapter is a reference to the special memory assignments used in a GMR system.

It includes:

- Summary of GMR Reserved References
- Memory Write Access in a GMR System
- %I and %Q References for GMR
- Reference Addresses for Manual Output Controls
- %AI and %AQ References for GMR
- %R (Register) References for GMR
- %G References for GMR
- %M Status References for GMR
- %M Control References for GMR

Summary of GMR Reserved References

In a GMR system, the following references are reserved or assigned special functions:

References	Reserved For:
%I00001 to %I12288 (790/789 CPU) %I0001 to %I1024 (788 CPU)	Input Table. Some references are automatically assigned by the GMR Configuration Software. Others are available for application use, as explained in this chapter.
%Q00001 to %Q12288 (790/789 CPU) %Q0001 to %Q1024 (788 CPU)	Output Table. Some references are automatically assigned by the GMR Configuration Software. Others are available for application use.
%AI0001 to %AI_{max}	The length of %AI data (shown at left as $_{max}$) is configurable. Some references are automatically assigned by the GMR software. Others are available for application use.
%$R_{max-320+(66xN)}$ to %R_{mx}	The length of %R data is configurable. At left, the letter N represents the number of GMR bus controllers in the system. The GMR software requires the use of several areas of %R memory, as detailed in this chapter.
%G0001 to %G0896 %GA0001 to %GA0896 %GB0001 to %GB0896 %GC0001 to %GC0896	The GMR software provides these memory areas for application global data transfer. The correct method of programming global data in a GMR system is described in chapter 9.
%M12225 to %M12256	System status bits
%M12257 to %M12288	System control bits
%R0001 to %R0256 (defaults: starting reference and length are configurable)	%R startup initialization data from another online PLC. References shown at left are the defaults; refer to your GMR configuration printout for the actual references used.
%R0257 to %R0272 (defaults: starting reference is configurable)	%M startup initialization data from another PLC. References shown at left are the defaults; refer to your GMR configuration printout for the actual references used. %M defaults to 16 words long.

Memory Write Access in a GMR System

Caution

The reserved memory areas listed on the previous page are used by the GMR System Software, and must not be written to. Writing data into these reserved areas could cause unpredictable system operation.

The following memory areas can be written to if Write Access is enabled during GMR configuration:

%I	Discrete Input Table
%Q	Discrete Output Table
%AI	Analog Input Table
%AQ	Analog Output Table
%R	Registers
%T	Temporary internal reference bits that are not saved through power loss
%M	Internal reference bits that are saved through power loss
%G	Global Data memory
%GD	Global Data memory
%GE	Global Data memory

For discrete (bit) memories: %I, %Q, %T, and %M, the starting reference must be on a byte boundary 1, 9, 17, etc).

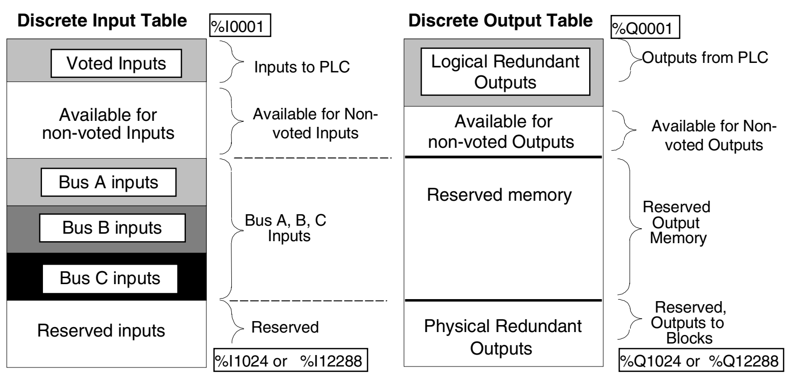
Global Data **%GA**, **%GB**, and **%GC** memories are not available. Those memory areas are used by the GMR system to exchange data (see previous page), and cannot be accessed directly.

Limited Write Access when the CPU is Halted

Write Access is only possible when the CPU is running.

%I and %Q References for GMR

I/O addressing for GMR is unlike I/O addressing for a conventional Series 90-70 application. In a GMR application, the GMR software automatically divides the Discrete Input (%I) and Discrete Output (%Q) Tables and the Analog Input (%AI) Table into special-purpose areas, as diagrammed below.



- The total amount of I/O data available depends on the CPU type.
- Voted inputs and logical redundant outputs are at the beginning of the discrete I/O tables. Normally, the application program uses this I/O data. However, the program can also access the rest of the I/O tables.
- Non-voted inputs and outputs occupy the next areas of the %I and %Q Tables. For example, if there were 48 voted inputs and 64 redundant outputs, non-voted I/O data would begin at addresses %I0049 and %Q0065. These areas are available for non-voted blocks on GMR busses and blocks on other busses in the PLCs. The amount of non-voted I/O available depends on CPU type and on the amount of voted I/O data required.
- In the Output Table, the area of memory corresponding to the Bus A, B, and C Inputs is reserved. Blocks in voted input groups are configured as combination input/output blocks, so the corresponding output references should not be used for other purposes.
- The last part of the Output Table is used for the copied physical redundant output data. This is the data sent to the Genius blocks included in the GMR configuration. The same amount of memory is reserved in the corresponding area of the Input Table. It is used to allow GMR fault processing to be inhibited on a circuit-by-circuit basis for the corresponding physical redundant outputs when they are externally overridden or bypassed.

Discrete I/O Tables: Example

The simple example below illustrates I/O allocation. In this example, there are:

- a model 788 CPU (with 352 physical I/O).
- One output group of four discrete 16-circuit blocks. The application program uses logical outputs at addresses %Q0001 to %Q0016. This requires just 16 output references, because the references used by all four blocks in the group are the same. The references that these blocks will be configured to respond to are assigned to the 16 bits at the end of the output table. Since the example CPU is a model 788, the 16 references at the end are:

  %Q1009 to %Q1024

  The corresponding 16 bits in the Input Table are also reserved for GMR fault detection disabling. The reserved input references are:

  %I1009 to %I1024

- One input group of three discrete 32-circuit blocks. The application program will use voted inputs at addresses %I0001 to %I0032.

  The beginning Input Table reference for the data is equal to:

  I/O Table length - reserved inputs - (3 X input data length for one group) +1

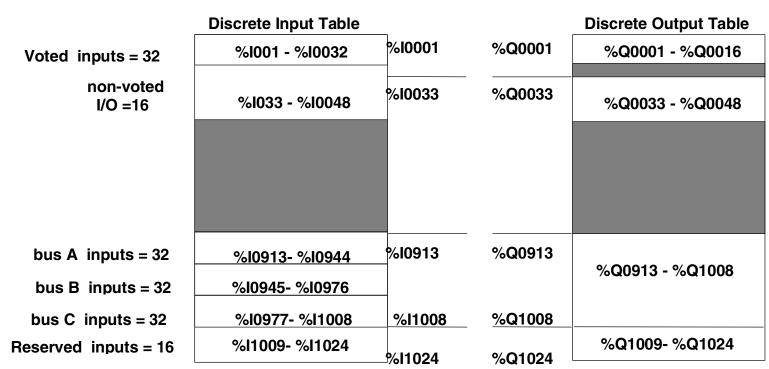
  For the example, this is:

  1024 - 16 - (3 x 32) +1 = 913 = %I0913

  In the output table, the corresponding area (%Q0913 to %Q1008) is reserved.

- One non-voted discrete 16-circuit block. If configured as a combination block, it occupies references %I0033 to %I0048 in the Input Table and %Q0033 to %Q0048 in the Output Table. Notice, as shown in the illustration, that these references begin after the last voted input reference and that output references %Q0017 to %Q0032 are not used.

The illustration shows where these example inputs and outputs would be located in the I/O tables. Shaded areas would be available for non-voted I/O.



Total Discrete I/O in a GMR System

The I/O capacity of the system depends on whether the CPU is a model 790, model 789 or model 788.

- For a model 790 or 789 CPU, there can be a total of 12288 I/O addresses (or a maximum of 4096 redundant I/O points).
- For a model 788 CPU, there can be a total of 352 physical inputs and outputs or approximately 100 redundant I/O points.

CPU Model	Total Discrete Physical I/O	Maximum Voted Inputs	Maximum Voted Outputs
789, 790	12288	2048	2048
788	352	112	80

For most applications, these limits will not be reached. If you need help estimating I/O sizes for a large application, contact GE Fanuc at 1-800-828-5747.

I/O Table Usage

For most applications, it is not necessary to calculate either the amounts of memory available I/O, or the reference addresses. Address assignment can be done automatically by the system configuration tools. However, for a system where memory allocation is critical, the numbers of non-voted discrete inputs and outputs that can be included in the system can be either approximated or specifically calculated using the information in this section.

Address Space Available for Non-Voted I/O

The tables below show how much memory is available for non-voted discrete I/O in a 790 or 789 CPU system with different combinations of triplicated voted GMR inputs and redundant GMR outputs.

Number of References Available for Non-Voted Inputs (CPU 790/789)

If you need to calculate the specific number of non-voted inputs available, use this formula:

%I Map = 12288 – (4 x (number of voted redundant %I)
– (number of voted redundant %Q))

Triplicated Voted GMR Inputs	Redundant GMR Outputs (H-Block Groups)								
	0	**256**	**512**	**768**	**1024**	**1280**	**1536**	**1792**	**2048**
0	12288	11776	11264	10752	10240	9728	9216	8704	8192
256	11264	11008	10752	10496	10290	9984	9782	9472	9216
512	10240	9984	9728	9472	9216	8960	8704	8448	8192
768	9216	8960	8704	8448	8192	7936	7680	7424	7168
1024	8192	7936	7680	7424	7168	6912	6656	6400	6144
1280	7168	6912	6656	6400	6144	5888	5632	5376	5120
1536	6144	5888	5632	5376	5120	4864	4608	4352	4196
1792	5120	4864	4608	4352	4096	3840	3584	3328	3072
2048	4096	3840	3584	3328	3072	2816	2560	2304	2048

Number of References Available for Non-Voted Outputs (CPU 790/789)

If you need to calculate the specific number of non-voted outputs available, use this formula:

%Q Map = 12288 – (3 x (number of voted redundant %I))
– (2 x (number of voted redundant %Q))

Triplicated Voted GMR Inputs	Redundant GMR Outputs (H-Block Groups)								
	0	**256**	**512**	**768**	**1024**	**1280**	**1536**	**1792**	**2048**
0	12288	11776	11264	10752	10240	9728	9216	8704	8192
256	11520	11008	11520	9984	9472	8960	8448	7936	7424
512	10752	10240	9728	9216	8704	8192	7680	7168	6656
768	9982	9470	8958	8446	7934	7422	6910	6400	5886
1024	11264	10752	10240	9728	9216	8704	8190	7680	7168
1280	8448	7936	7424	6912	6400	5888	5376	4864	4352
1536	7680	7168	6656	6144	5632	5120	4608	4096	3584
1792	6912	6400	5888	5376	4864	4352	3840	3382	2816
2048	6144	5632	5120	4608	4096	3584	3072	2560	2048

Number of Non-Voted I/O Available for a 788 CPU

The table below shows how much memory is available for non-voted I/O in a 788 CPU system with different combinations of triplicated voted GMR inputs and redundant GMR outputs.

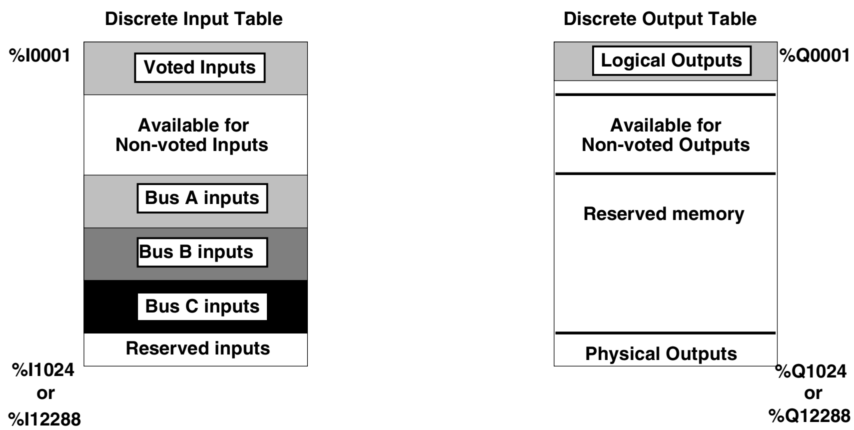
These are physical limitations imposed by the Logicmaster programming software for the model 788 CPU only. They cannot be exceeded.

Number of Triplicated Voted GMR Inputs	Number of Redundant GMR Outputs for H-Block Groups					
	0	**16**	**32**	**48**	**64**	**80**
0	352	288	224	160	96	32
16	304	240	176	112	48	
32	256	192	128	64	0	
48	208	144	80	16		
64	160	96	32			
80	112	48				
96	64	0				
112	16					

Reference Addresses for Manual Output Controls

Safety systems often include manual trip and override controls. These controls can be implemented in software, or in hardware as shown in chapter 3.

The operation of manual trip and output override devices can be monitored and reported by connecting them as inputs to non-voted Genius blocks in the system. These inputs should be configured to use references in the area at the end of the Discrete Input Table shown as “reserved inputs” below.



There is a one-to-one correspondence between Reserved Input and physical output reference addresses.

The GMR software in each PLC automatically monitors the Reserved Inputs. On detection of either manual control, it disables the appropriate Genius diagnostics and the output autotest for the corresponding output circuit(s), since a manual trip or override could cause false autotest or diagnostic results

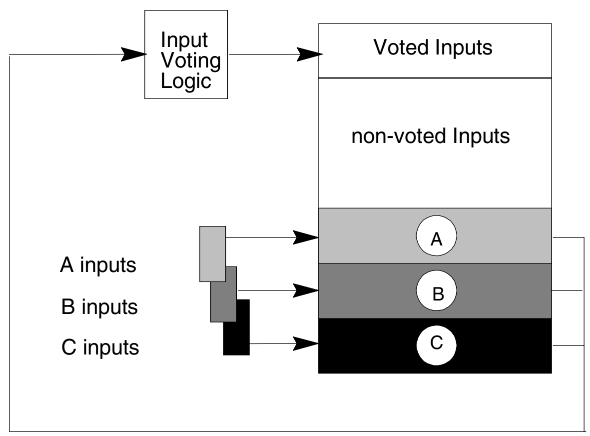
%AI and %AQ References for GMR

%AI references for GMR are described below. Analog blocks with outputs can be used in a GMR system, but they do not operate in GMR mode, and do not use special %AQ table references.

%AI References for GMR

The size of the Analog Input Table is defined during PLC configuration. The maximum size is 8192 analog channels (words). Like the discrete Input and Output Tables, the Analog Input Table is divided into sections.

Analog Input Table



The voted analog references are assigned starting at %AI0001. The size of the voted analog input area is determined by the number of voted analog inputs, including spares.

Physical input data from analog block groups is located at the end of the Analog Input Table, in the areas labeled A, B, and C above. *Each* of these areas is equal in length to the number of voted inputs at the beginning of the table.

The unused portion of the table can be used for non-voted analog inputs.

Example:

An application has sixteen analog input groups (each of which is a 6-input group), including spares. The total number of analog inputs from these blocks would be:

16 x 6 = 96 words required.

If the Analog Input Table had a configured length of 1024, these inputs would be located in the table as shown below.

Analog Input Table

References	Use
%AI0001 – %AI0096	Voted Analog Inputs = 96
%AI0097 – %AI0736	Available for single Genius analog inputs or other use
%AI0737 – %AI0832	Bus "A" inputs = 96
%AI0833 – %AI0928	Bus "B" inputs = 96
%AI0929 – %AI1024	Bus "C" inputs = 96

As with discrete inputs, all of the analog inputs are available to the PLC application program.

%R (Register) References for GMR

The GMR software uses several areas of %R memory for specific functions. Address assignments should be obtained by printing out the GMR configuration *before configuring the GMR Bus Controllers with Logicmaster*. The application program should use only the area labeled “Application Registers”. Within that area, a portion is reserved for initialization data.

Application Registers	%R1	%R and %M Initialization Data Defaults	%Rmax-320+66xN
Bus Controller 1 Interface		66 words	
⋮		⋮	%Rmax-452
Bus Controller N-1 Interface	%Rmax-451	66 words	%Rmax-386
Bus Controller N Interface	%Rmax-385	66 words	%Rmax-320
Global Data to be Sent	%Rmax-319	64 words	%Rmax-256
Global Data Received from PLC on Bus a or b* with highest serial bus address	%Rmax-255	64 words	%Rmax-192
Global Data Received from PLC on Bus a or b* with lower serial bus address	%Rmax-191	64 words	%Rmax-128
Global Data Received from PLC on Bus b or c* with highest serial bus address	%Rmax-127	64 words	%Rmax-64
Global Data Received from PLC on Bus b or c* with lower serial bus address	%Rmax-63	64 words	%Rmax

%R References Used for Startup Initialization Data

The GMR software stores %R and %M data received at startup in %R memory. The default reference for the beginning of the initialization data is %R0001. The default reference for the beginning of the %M initialization data is %R0257.

%R References Used for the Bus Controller Interface

The GMR software uses the area directly after the application area of %R memory for functions such as autotesting and communicating with other bus controllers. The overall length of this area depends on the number of other bus controllers.

%R References Used for Global Data

The GMR software uses the references directly after the bus controller data to store a copy of that PLC’s outgoing Global Data. The GMR software automatically moves the data to this %R location from the %G locations described on the next page. Finally, the areas after the outgoing Global Data are used for the two sets of incoming Global Data received from the other PLC(s).

%G References for GMR

The GMR PLC uses its Global Data memories (%G, %GA, %GB, and %GC) for application Global Data.

The PLCs in a GMR system use the same %G references for Global Data they transmit. However, the individual PLCs in the system use %GA, %GB. and %GC memory uniquely, depending on their serial bus address (SBA).

To send data to the other PLCs, the application program in each PLC must place the data in references %G0001 through %G0896.

Global Data received from other GMR PLCs and a copy of the Global Data sent by the same PLC can be read from the assigned areas of %GA, %GB, and %GC memory.

All PLCs	%G0001 -%G0896	Application Global Data to be transmitted.

PLC A	%GA0001-%GA0896	Copy of transmitted Global Data (SBA 31)
(SBA 31)	%GB0001-%GB0896	Data received from PLC B (SBA 30)
	%GC0001-%GC0896	Data received from PLC C (SBA 29)

PLC B	%GA0001-%GA0896	Data received from PLC A (SBA 31)
(SBA 30)	%GB0001-%GB0896	Copy of transmitted Global Data (SBA 30)
	%GC0001-%GC0896	Data received from PLC C (SBA 29)

PLC C	%GA0001-%GA0896	Data received from PLC A (SBA 31)
(SBA 29)	%GB0001-%GB0896	Data received from PLC B (SBA 30)
	%GC0001-%GC0896	Copy of transmitted Global Data (SBA 29)

%M Status References for GMR

%M memory is used for status and control bits. %M status references are bits that are automatically set by the GMR System software. They can be used as appropriate in the application program as explained chapter 9.

Reference	Nickname	Name	Meaning		
%M12225	PLCA	PLC Ident is A	Identifies PLC A (all its GMR bus controllers use SBA 31). For references %M12225, 26, and 27, only one will be set in each PLC.		
%M12226	PLCB	PLC Ident is B	Identifies PLC B (all its GMR bus controllers use SBA 30).		
%M12227	PLCC	PLC Ident is C	Identifies PLC C (all its GMR bus controllers use SBA 29).		
%M12228	PLCAOK	PLC A is online	In PLC A: PLC A outputs enabled	In PLC B: PLC A communications with PLC B healthy and PLC A outputs enabled	In PLC C: PLC A communications with PLC C healthy and PLC A outputs enabled
%M12229	PLCBOK	PLC B is online	In PLC A: PLC B communications with PLC A healthy and PLC B outputs are enabled	In PLC B: PLC B outputs are enabled	In PLC C: PLC B communications with PLC C healthy and PLC B outputs are enabled
%M12230	PLCCOK	PLC C is online	In PLC A: PLC C communications with PLC A healthy and PLC C outputs are enabled.	In PLC B: PLC C communications with PLC B healthy and PLC C outputs are enabled.	In PLC C: PLC C outputs are enabled.
%M12231	INHIBIT	Inhibit user application	Set to 1 at startup to prevent execution of the application program until data initialization is complete.		
%M12232	MISCMP#*	Init. miscompare at startup	Set to 1 by an initializing PLC if it detects a miscompare between %M (bit) init. data from two online PLCs. Automatically cleared (0) at startup. Can also be cleared by the application program		
%M12234	SYSFLT#*	System fault at startup	If this bit is et to 1 at startup, it indicates a communications failure with a GMR bus controller.		
%M12235	SYSFLT	System fault	Set to 1 if a PLC CPU is unable to communicate with its GMR bus controller. Automatically cleared when PLC Fault Reset is issued (%M12259 is set).		
%M12236	OPDISC	O/P discrepancy	Set to 1 if there is an output discrepancy. Automatically cleared (0) when PLC Fault Reset is issued (%M12259 is set)		
%M12237	COLDST*	Cold start performed	Set to 1 at startup if an initializing PLC detects no other PLCs online. When the application program detects this flag has been set, it can initialize any %M and %R initialization data. Automatically cleared (0) at startup. Can also be cleared by the application program		
%M12238	IORESIP	I/O reset in progress	An I/O fault reset is in progress: the bit is set to 1 for one scan when the internal GMR fault tables are cleared.		
%M12239	ATINPRG	Autotest in progress	This bit is 1 if an input or output autotest is in progress (not necessarily initiated by this PLC). The state of this bit is the same in all running PLCs.		
%M12240	LOGONFT	Block logon fault	This bit is set to 1 if any output blocks are receiving discrepant outputs from an initializing PLC. This bit remains set until the I/O Fault Table is cleared. See page 9-7 for information about logon faults.		

* Only set at startup if condition occurs. These bits remain set until the system is restarted. They can also be reset by the application program. To reset a status flag, enter 0 in its %M reference.

%M Status References *(continued)*

Reference	Nickname	Name	Meaning		
%M12241	SIMPLEX •	Simplex mode	One PLC controls the system.		
%M12242	DUPLEX •	Duplex mode	Two PLCs control the system.		
%M12243	TRIPLEX •	Triplex mode	Three PLCs control the system.		
%M12244	IO_SD	Any I/O Shutdown Timer activated	Set to 1 if least one of the GMR PLCs has begun timing an I/O Shutdown. See chapter 4 for information about I/O Shutdown.		
%M12245	A1_FAIL	Comms Bus Alpha PLC 1 Status	When viewed in PLC A: No comms with PLCB on Alpha bus 1	When viewed in PLC B: No comms with PLCA on Alpha bus 1	When viewed in PLC C: No comms with PLCA on Alpha bus 1
%M12246	B1_FAIL	Comms Bus Beta PLC 1 Status	When viewed in PLC A: No comms with PLCB on Beta bus 1	When viewed in PLC B: No comms with PLCA on Beta bus 1	When viewed in PLC C: No comms with PLCA on Beta bus 1
%M12247	A2_FAIL	Comms Bus Alpha PLC 2 Status	When viewed in PLC A: No comms with PLCC on Alpha bus 2	When viewed in PLC B: No comms with PLCC on Alpha bus 2	When viewed in PLC C: No comms with PLCB on Alpha bus 2
		Comms Bus Beta PLC 2 Status	When viewed in PLC A: No comms with PLCC on Beta bus 2	When viewed in PLC B: No comms with PLCC on Beta bus 2	When viewed in PLC C: No comms with PLCB on Beta bus 2
		Any Communication s Fault Detected	A latching fault bit that is set to 1 if there has been an inter-PLC communications failure on any alpha or beta bus. It is cleared by a user-initiated PLC reset.		
%M12250	A_MSTR	PLC A is autotest master			
%M12251	B_MSTR	PLC B is autotest master			
%M12252	C_MSTR	PLC C is autotest master			
%M12253	A_OPBYP	Any Output Bypass detected by PLC A			
%M12254	B_OPBYP	Any Output Bypass detected by PLC B			
%M12255	C_OPBYP	Any Output Bypass detected by PLC C			

- Only one of these three will be set at a time.

%M Control References for GMR

The %M control references can be set by the application program to provide information to the GMR software. See chapter 9 for information about using these references in an application program.

Reference	Nickname	Description	Meaning
%M12257	CONTINU	Continue with initialization & enable outputs	When the application program has computed valid outputs that can be sent to output blocks, the application program must set this bit to 1 to enable the outputs to the blocks.
%M12258	IORES	Perform I/O Fault Table clear.	Setting this bit to 1 clears the I/O Fault Table and corresponding fault contacts in all PLCs.
%M12259	PLCRES	Perform PLC Fault Table clear.	Clears the PLC Fault Table in one PLC when set to 1 for at least one sweep.
%M12260	ATMANIN	Autotest Manual Initiate	Initiates a single autotest (both input and output) any time it is set to 1, even if the Autotest Inhibit bit is on (1).
%M12261	ATINHIB	Autotest inhibit	Prevents the "automatic" autotest (both input and output) from occurring at the Autotest Interval specified in the GMR Configuration for as long as this bit is set to 1. Note: this does not prevent an Autotest Manual Initiate.
%M12262	REPORT	Report GMR version / status	When set to 1 by a GMR PLC, this bit causes the GMR software to report information about the versions of GMR software files to that PLC's PLC Fault Table.
%M12263	FORCLOG	Force block(s) to log on	This bit can be set to 1 to force all output block groups to begin voting on output data supplied by the GMR PLCs after a PLC logs on, even though the output states being received from the PLCs may not presently match. See page 4-8 for information about Force Logon.
%M12264	PLCRESG	Clear PLC Fault Tables in all PLCs.	Setting this bit to 1 clears the PLC Fault Tables in all PLCs.
%M12265	SDCAN	Cancel I/O Shutdown	If an I/O Shutdown was initiated by any PLC, setting this bit to1 cancels the shutdown and prevents it from occurring. If this bit is set to 1 continuously, no I/O Shutdown will be initiated. See chapter 4 for information about I/O Shutdown.
%M12266	ENTRAN	Enable transition	If this bit is 1, a message will be placed in the I/O Fault Table if discrepant outputs transition too quickly to be read.
%M12267	DIAGRES	Diagnostic Reset	Setting this bit to 1 resets the Diagnostic Block for a 1oo1D Output Group.
%M12268 to %M12288	Reserved for future GMR use.		

Chapter 6 Creating a GMR Configuration

This chapter explains how to use the GMR Configuration Software to define the GMR system.

Additional System Configuration Steps

In addition to the GMR configuration, the system also requires a PLC configuration, which is created separately using the Logicmaster Configuration software. Another separate step is the Genius device configuration, which sets up the operating characteristics of the Genius blocks, VersaMax NIUs, and Field Control BIUs on the bus. PLC configuration is described in chapter 7. Genius device configuration is described in chapter 8.

Getting Started

Equipment Needed to use the GMR Configuration Software

The GMR Configuration Software requires a Windows® 95, Windows® 98, or Windows NT® 4.0 with Service Pack 4 operating system. Note that this version of the GMR software is not compatible with Windows® 2000 or subsequent versions of the Windows® software. Other minimum system requirements are a display adapter capable of 800x600x256 colors, 32MB RAM, HDD with 20MB free space and a CD-ROM drive.

Installing the Configuration Software

Install the GMR Configuration Software on your hard drive. Installation is fully-prompted.

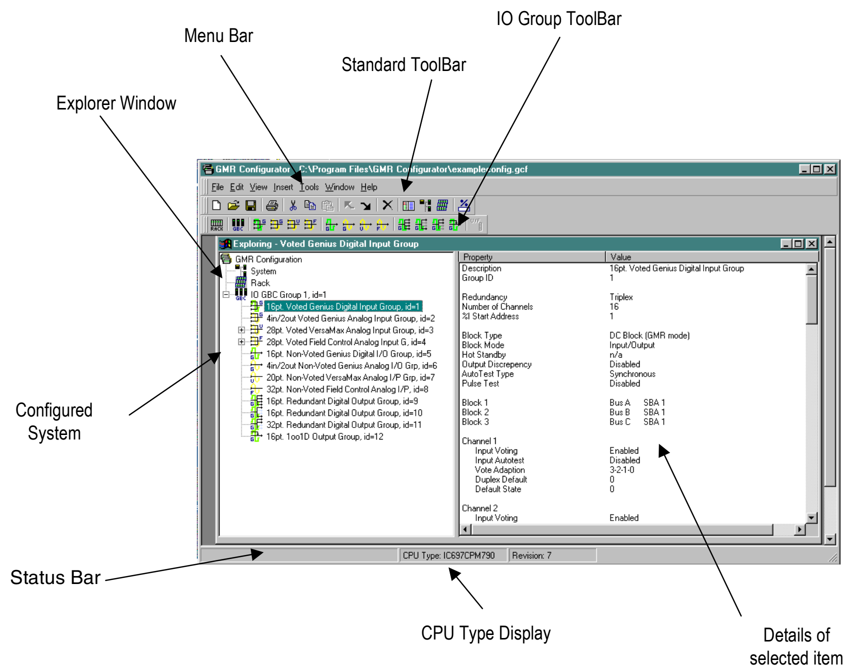
Information You'll Need to Complete the Configuration

The completed configuration must include information about the PLCs, about the number and locations of bus controllers in the PLC racks, about the I/O drops, about memory usage, and about redundancy operation.

The GMR Configuration Software automatically supplies default values for some of these items. The defaults are generally appropriate for a Emergency Shutdown System. Check the defaults shown in this book and on your screen. You will only need to change any defaults that are not suitable for your application.

Using the GMR Configuration Software Features

The GMR Configuration Software uses many standard MS Windows features, plus a few that are unique.



The Explorer window shows the current configuration, with details of the selected item shown in the right pane.

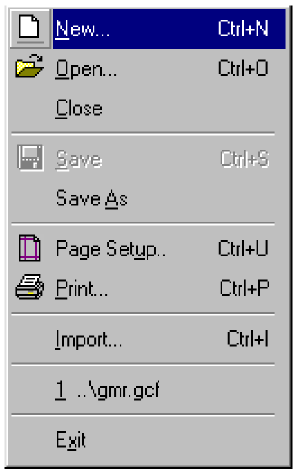
The Menu Bar provides a custom set of pulldown menus. Toolbars for frequently-used functions make it easy to add new items to the configuration.

Menus

The Menu bar provides standard both Windows selections and GMR features.

The File Menu

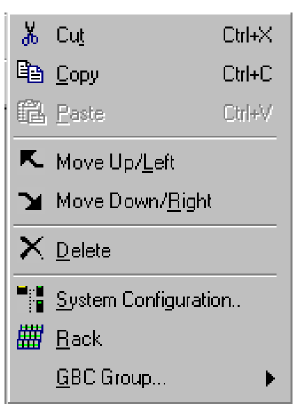
The File Menu is where you open, save, print, and import configuration files.



Create a new configuration
Open a saved configuration
Close the current configuration
Save the current configuration
Save the configuration to a specified file name
Format the printout
Print the configuration or save it as HTML file (in DHTML format)
Import an existing configuration from GMR Configuration Software version 7.01
List of configuration files last opened
Exit and close the GMR Configuration Software

The Edit Menu

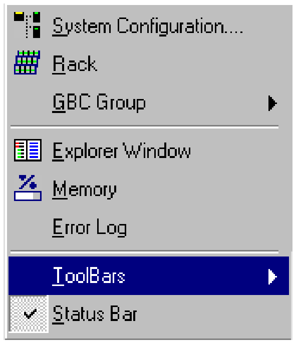
The Edit Menu includes both standard file editing features and GMR configuration editing features.



Cut the selected item and places it on the clipboard
Copy the selected item to the clipboard
Paste the item on the clipboard into the configuration
Move a selected item upward/left in the configuration
Move a selected item downward/right in the configuration
Delete the selected item
Edit the system configuration
Edit a rack configuration
Edit a GBC group

The View Menu

Use the View Menu to open/view a window, toolbar, or status bar.



Open / Bring to front the system configuration

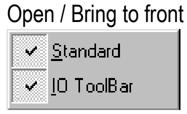
Open / Bring to front the rack configuration

Select and Open / Bring to front a GBC group

Open / Bring to front the Explorer window

Open / Bring to front the memory allocation window

Open / Bring to front the error log



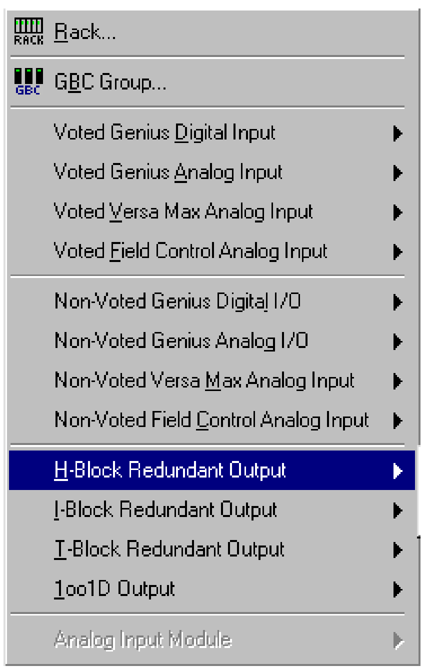
Toggle the standard toolbar on/off

Toggle the I/O toolbar on/off

Toggle the status bar at the bottom of the screen on or off

The Insert Menu

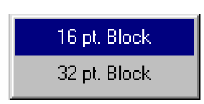
Use the Insert Menu to add racks, GBC Groups, and I/O groups to your configuration.



First, add additional PLC racks and reserve used slots

Next, add one or more GBC groups

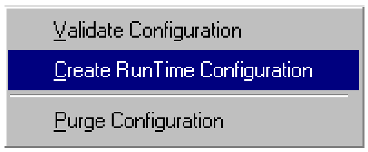
Then, add individual input and output groups to the GBC groups.



Select the type of group you want to add, and pull down submenus of additional choices.

The Tools Menu

The Tools Menu provides basic configuration utilities.



Validate the content of your configuration

Create the configuration output file for the system

Delete old versions of a configuration

The Windows Menu

Use the Windows Menu to create a new window, select another window, or close all open windows.

Create new window for GBC group (only)

Bring the next window to front

Bring the previous window to front

Close all open windows

List of currently open windows indicating the currently selected window

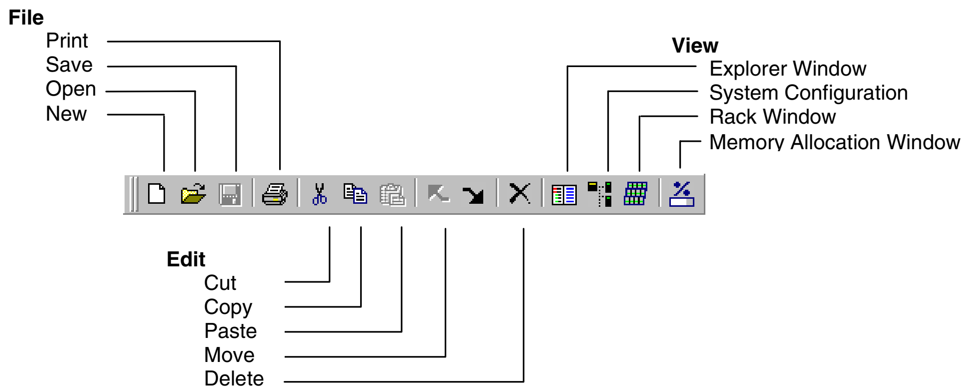
The Help Menu

Shows the registered user and software revision.

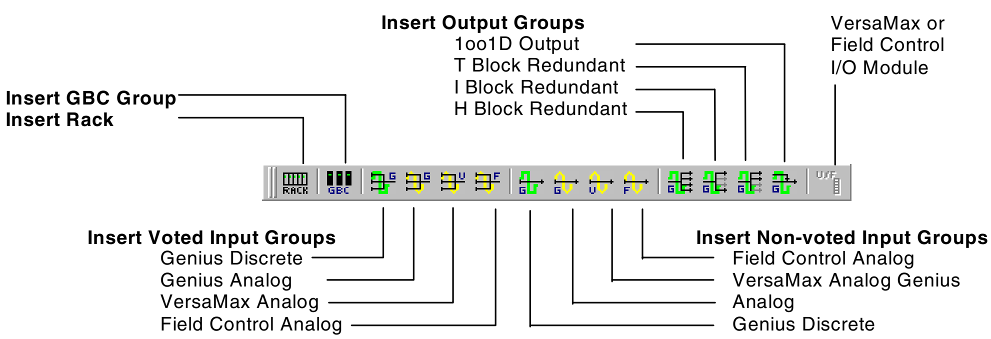
Toolbars

Toolbars provide convenient access to frequently-used functions.

The Standard Toolbar



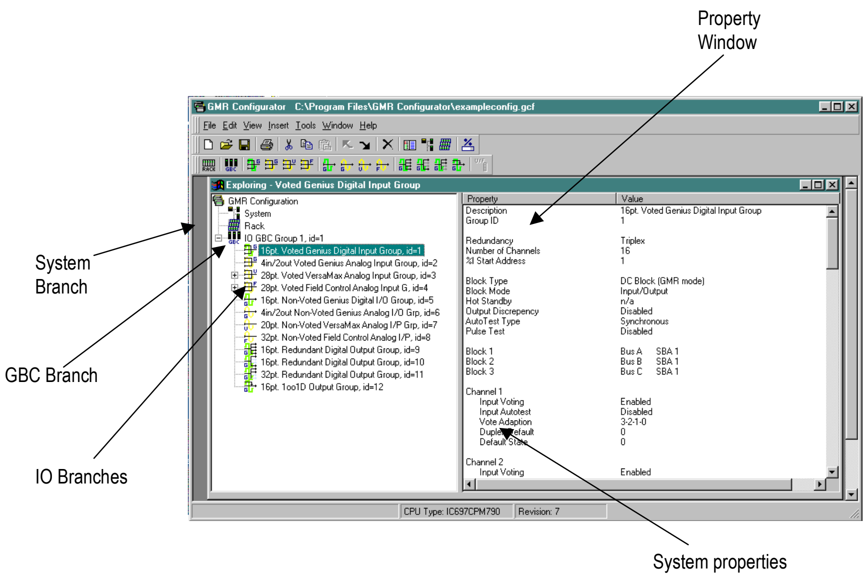
The I/O Toolbar



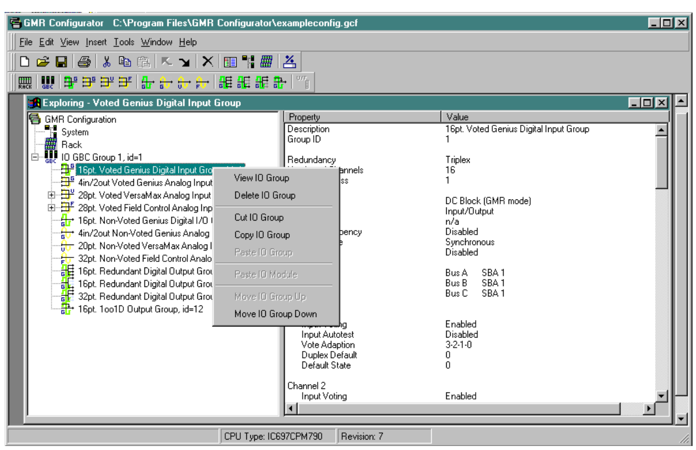
The Explorer Window

The Explorer window makes it easy to view the content and properties of a GMR configuration. The same icons that appear on the pulldown menus and toolbars are used to represent the elements in the configuration, as shown on the left below.

The Property window lists the content of the GMR configuration.

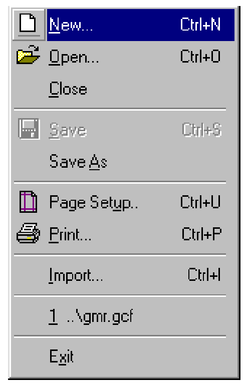


Right-clicking on the selected item in the Property window displays a popup that can be used to edit that item:



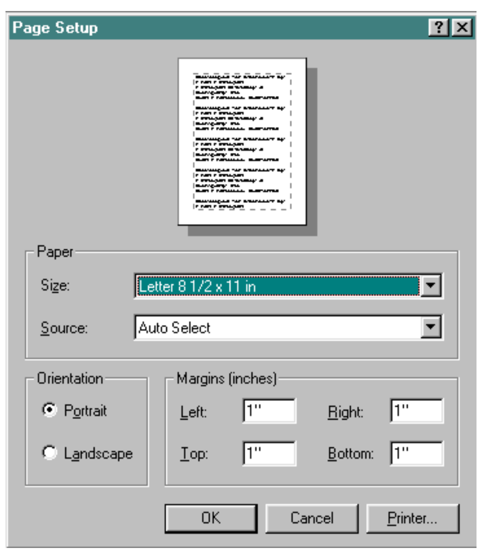
Printing the Configuration

The File Menu includes two selections for printing your configuration, Page Setup and Print:



Setting Up the Format for Printing

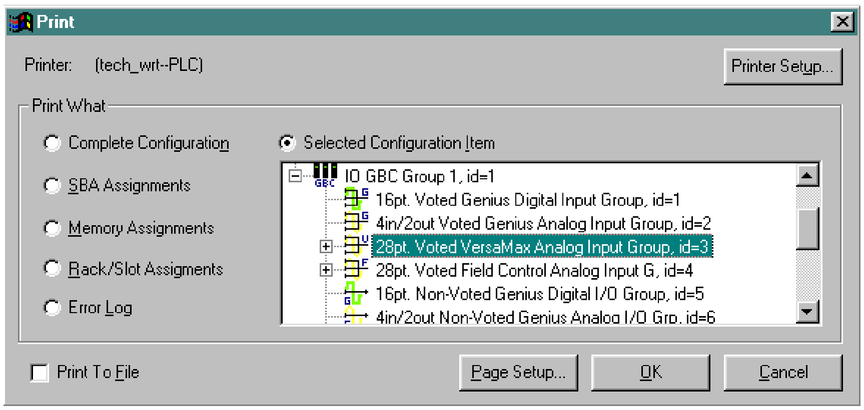
Select Page Setup if you want to change the appearance of printouts. You can also select the printer from here.



Printing Configuration Information

Select Print if you want to print part or all of the configuration. Click on the name of the portion of the configuration you want to print, or click on "Selected Configuration Item" , then click in the window below to expand the configuration and select an item.

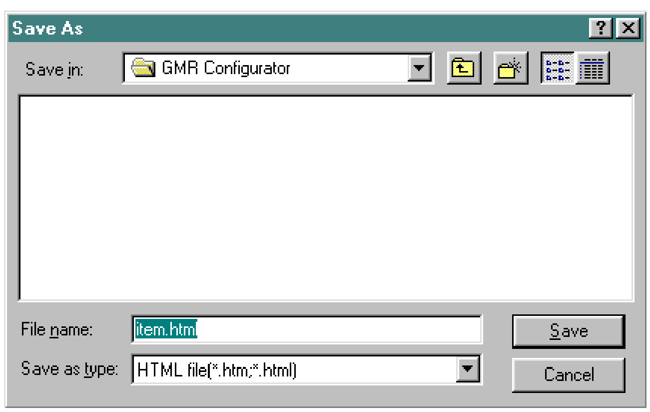
You can also access Page Setup and Printer Setup from here.



Printing Configuration Information to an HTML File

To save the selected item as a printable file, click on the Print to File box in the Print window.

The file will be saved in DHTML format. It can be displayed and printed using Microsoft Internet Explorer version 4.0 or later. The file can also be opened MS Word2000. It cannot be opened using Word95 or Word97.

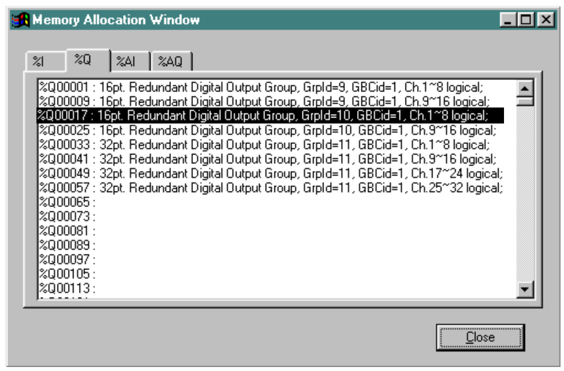


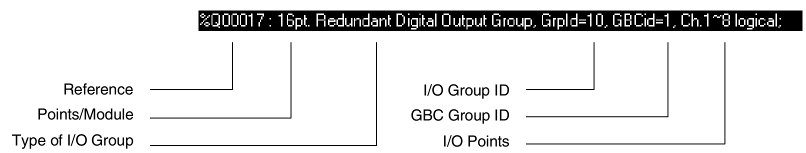
Choose the intended file location and click Save to print the chosen configuration element to a file.

Viewing I/O Memory Assignments

As you configure the elements of a system, you can view the I/O allocation by selecting Memory from the View menu.

Each I/O memory type (%I, %Q, %AI, and %AQ) is shown on a tab in the Memory Allocation window.





References are shown on byte boundaries. In the example above, for instance, output points %Q00017 through %Q00024 are allocated to outputs 1 through 8 of I/O Group 10, Bus Controller Group 1, which is a 16-point redundant discrete output group.

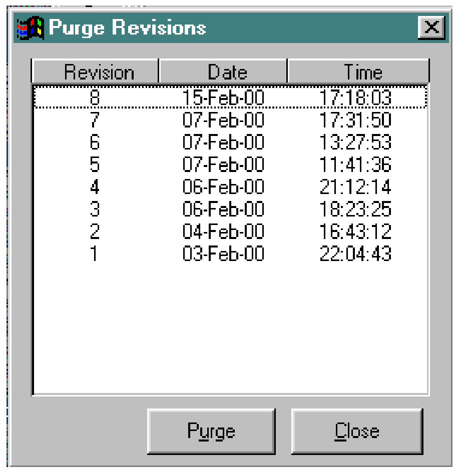
The I/O Memory assignments can also be printed from the File|Print menu.

Purging Versions of a Configuration

Each time you save changes to a configuration, the GMR Configuration Software creates a new revision of it.

You can purge old revisions of a configuration at any time by selecting Purge Configuration from the Tools menu.

The Purge Revisions window shows when each revision was last saved.



To delete all previous revisions except the current revision, click on Purge.

Updating an Older Configuration

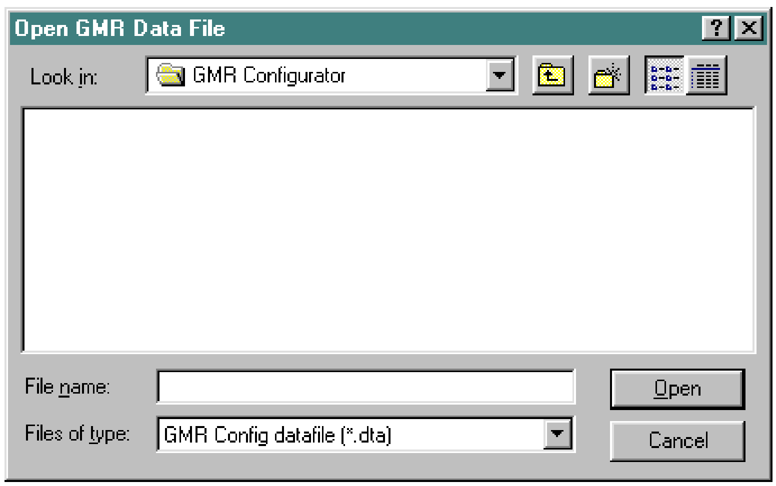
If you have an existing configuration created with the DOS-based version of the GMR Configuration Software, you can import the file and edit it. This allows you to add new features to a previously-configured system.

The existing configuration file must have been saved using version 7.01 of the GMR Configuration Software. If the file was created using an earlier version of the software, you will need to open the file using the version 7.01 software, then save it.

Attempting to import a file created with an earlier revision will result in a report that the file being imported is an invalid/incompatible format.

Importing a Configuration File

With the file saved in version 7.01 format, open the new GMR Configuration Software. In the File Menu, select Import.



Select the .dta file you want to import and click on Open.

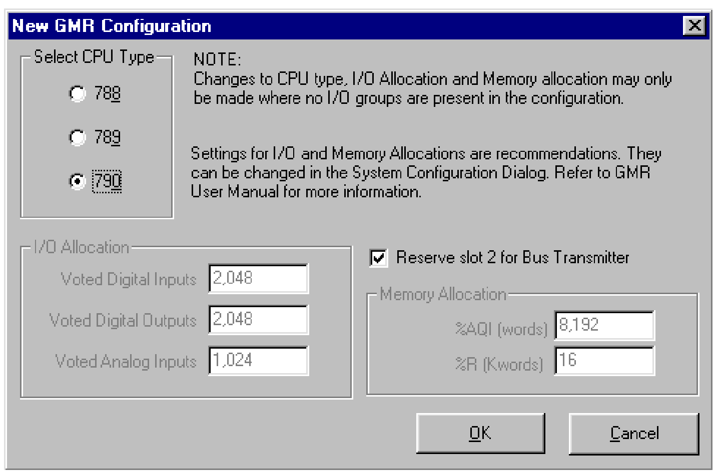
Creating a New GMR Configuration

You can create a new GMR configuration or copy an existing configuration and edit it to create a new version.

To create a new configuration, click on the New icon in the toolbar. Enter a name and click Save.

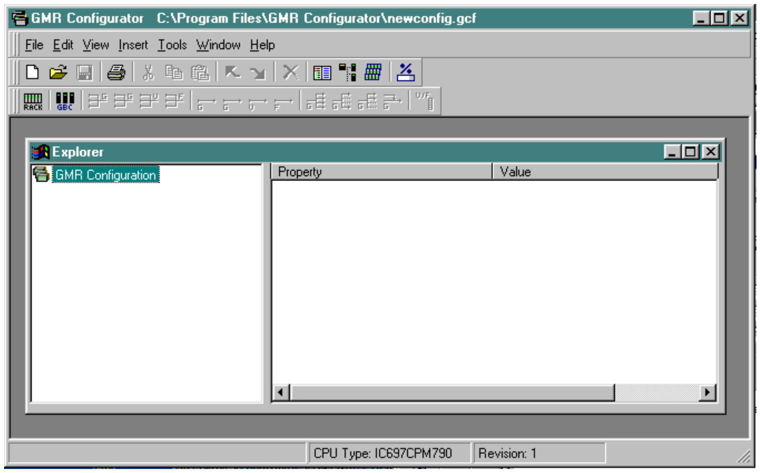
On the New GMR Configuration screen, select the CPU type as shown below. When you do that, the configuration software automatically supplies appropriate I/O and memory allocations. You can change them later in the System Configuration Dialog.

If the system will have only one PLC rack per redundant CPU, clear the checkbox for Reserve slot 2 for Bus Transmitter.

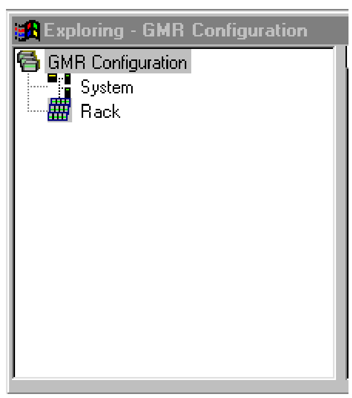


Click OK when you are finished.

The configuration software creates the new configuration and displays the basic Explorer screen with the “GMR Configuration” icon selected:



Double-click the GMR Configuration icon to display the System icon and the first Rack icon:



Basic GMR Configuration Steps

The rest of this chapter describes the details of creating a GMR configuration. The basic steps are:

Create the System Configuration. This includes: Number and type of CPUs, memory allocation, testing intervals, timeouts, selection of which bus controllers will exchange global data, data handling at startup, and granting write access.

Insert the PLC Racks in the Configuration. This sets the number of racks and reserves the slots used for non-GMR modules

Insert the Genius Bus Controller Groups in the Racks.

Add the I/O Groups to the Genius Bus Controller Groups. Group types include:

- Voted Input Groups
  - Voted Genius Discrete Input Group
  - Voted Genius Analog Input Group
  - Voted VersaMax Analog Input Group
  - Voted Field Control Input Group
- Non-voted I/O and Input Groups
  - Non-voted Genius Discrete I/O Group
  - Non-voted Genius Analog I/O Group
  - Non-voted VersaMax Analog Input Group
  - Non-voted Field Control Analog Input Group
- Output Groups
  - H-Block Redundant Output Group
  - I-Block Redundant Output Group
  - T-Block Redundant Output Group
  - 1oo1D Output Group

Check for Errors using the Validate Configuration Function from the Tools Menu.

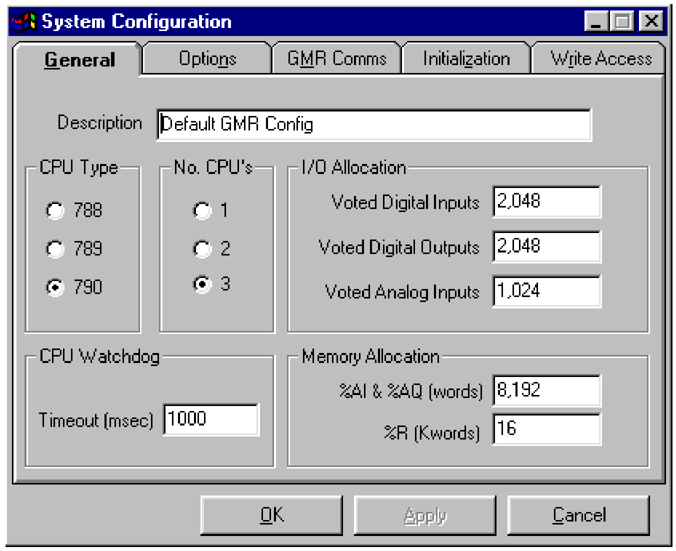
Create a Run-Time Configuration for an EXISTING Logicmaster 90 program folder (for CPU790) or **Create a Program Block** to be added to a Logicmaster 90 program folder (for 788 or 789 CPU).

Entering a System Configuration

To edit the configuration, select System Configuration from the Edit menu or right-click on the System icon in the Explorer window and View System.

System Configuration, the General Tab

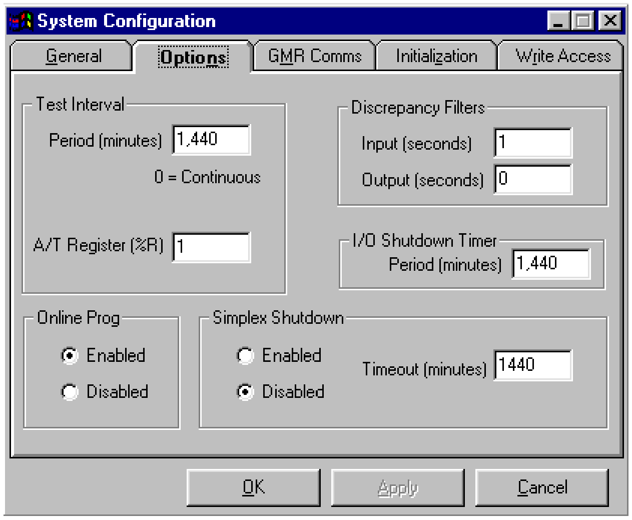
On the General Tab, you can edit the basic CPU parameters and system description:



CPU Type	This entry should be correct from the System Configuration screen, but it can be edited here. The CPU type cannot be changed once I/O groups are present in the configuration.
No. CPUs	Specify 1, 2, or 3 CPUs for the GMR system.
I/O Allocation	These default values should be appropriate for most applications. If you change I/O Allocation, it must be done before configuring any I/O groups. Chapter 5 gives detailed information about memory allocation, and explains how the system uses memory space for both raw data and voted data. You should be familiar with that information before changing I/O or memory allocation values. If you do change the allocation, remember to anticipate future needs and to reserve extra memory as appropriate.
CPU Watchdog	This must be the same value as the watchdog timer in the Logicmaster 90-70 CPU Configuration. The default is 1000mS.
Memory Allocation	These values are the amounts of word memory to be allocated to analog data (%AI and %AQ) and register data (%R). They must match the corresponding values configured using Logicmaster 90.

System Configuration, The Options Tab

On the Options tab, you can customize some basic operating characteristics of your GMR system.

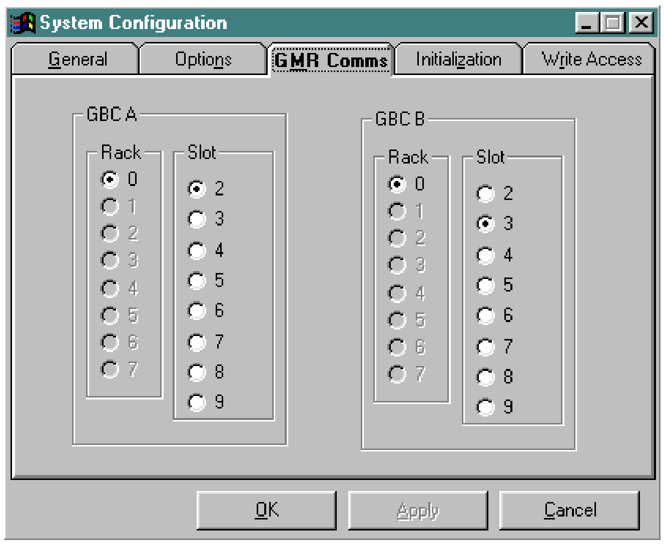


Test Interval Period (minutes)	Set up the frequency of autotest cycles. This is the time interval the system will wait between autotests of the I/O subsystem. The range is 0 to 65535 minutes. For continuous autotesting, enter 0.
Test Interval A/T Register	This is the memory location where the test interval configured above is stored. During system operation, the content of this register can be changed to alter the test interval as appropriate.
Discrepancy Filters	The discrepancy filter time applies to both discrete and analog inputs and discrete outputs. Input filter time defaults to one second. Output filter time defaults to 0. The range for input discrepancies is 1 to 65535 seconds, the range for output discrepancies is 0 to 65535 seconds.
I/O Shutdown Timer Period	This is the amount of time after a critical fault is detected by autotest before the CPU shuts down the group. Refer chapter 4 for a description of I/O Shutdown.
Online Prog	Online programming should be done only during system debug and commissioning, never during actual operation of a GMR system. If Online Programming is enabled, online Run mode stores, single word online changes, and block edits can be made without stopping the PLCs.
Simplex Shutdown	If Simplex Shutdown is enabled, a PLC will stop if it determines that it is the only PLC still operating. When the PLC stops, it sets its outputs to their default state or last state. Default states are set up as part of the I/O Group configuration.
Timeout (minutes)	The length of time until the system stops if Simplex shutdown is enabled and a PLC determines that it is the only PLC still operating. The timeout period may be 0 to 65535 minutes (approximately 45 days).

System Configuration, the GMR Comms Tab

Use the GMR Comms tab to identify the two bus controllers in the group that will exchange the communications that are part of basic GMR system operation.

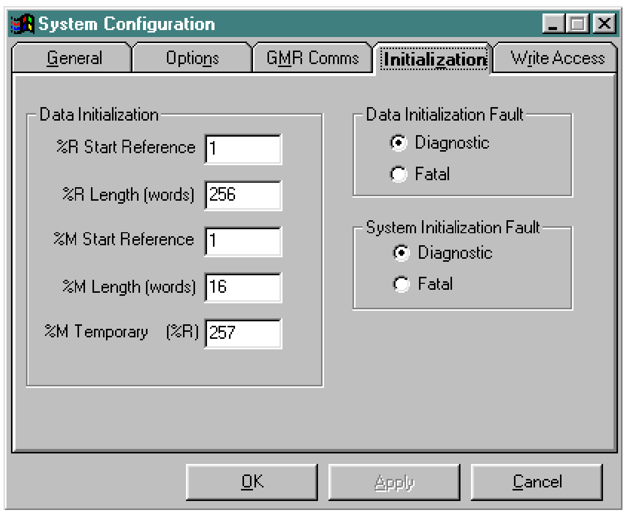
For a system with a Simplex CPU, it is not necessary to define GMR communications bus controllers.



GBC A **GBC B**	Enter the rack and slot locations for the two bus controllers. These can be any two bus controllers in the system, but they must be at the same rack and slot location in each PLC. There are 56 words of free global data available for your application. No GMR bus controllers may be used for user-defined datagram/global data.

System Configuration, the Initialization Tab

On the Initialization tab, you can edit the memory locations assigned to data that will be exchanged among the PLCs at startup. This data includes timers, counters, and latched logic states. If you change the memory assignments, make sure they do not conflict with %R and %M memory used in the application program or required by the GMR software. For more information about memory requirements for GMR, refer to the chapter 9, *Programming*.



%R Start Ref

If the PLCs will exchange %R data during startup, this will be its starting reference. By default, the starting reference is %R0001.

%R Length (words)

The length in words of the %R data. The amount needed depends on %R memory usage in the application program. The default length is 256. If the PLCs will not exchange %R data at startup, enter 0 for the length.

%M Start Ref

If the PLCs will exchange %M data during startup, this will be its starting reference. At startup, if one other PLC is already online, the initializing PLC will place %M data received from that PLC into its own %M memory in this location. If both other PLCs are already online, the initializing PLC will place %M data from the PLC with the highest serial bus address into this %M location.

%M Length (words)

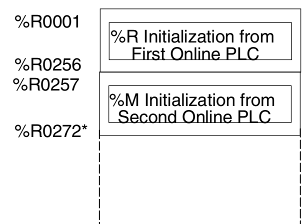
This is the length in words for the %M storage areas. It should equal the length of %M memory used in the application program. If the PLCs will not exchange %M data at startup, enter 0 for the length.

%M Temporary (%R)

If, when the PLC is starting up, the other two PLCs are already online, %M data from the second online PLC (the one with the lower serial bus address) is also received by the initializing PLC.

This entry is the starting reference in %R memory to receive %M data from the second online PLC. (In this entry, the %M refers only to the type of data being received. In the two fields above, it refers both to the type of data being received and the memory location where it will be placed).

Notice that this field shows an initial starting reference of 257. By default, the %M data from the second online PLC is stored directly after the %R data from the first:



* if following the previous example

Data Initialization Fault

When a GMR PLC is started up, it compares the two sets of %M data it has received from the other PLCs (see above). If those sets of data do not match, the GMR System Software in the initializing PLC set the Init Miscompare bit (%M12232).

The configuration entry made here controls whether such an initialization data error will halt the PLC (Fatal), or if the PLC will continue operating (the default) . If diagnostic operation is selected, the application program should monitor bit %M12232 and include logic to respond appropriately if the GMR software sets this bit..

System Initialization Fault

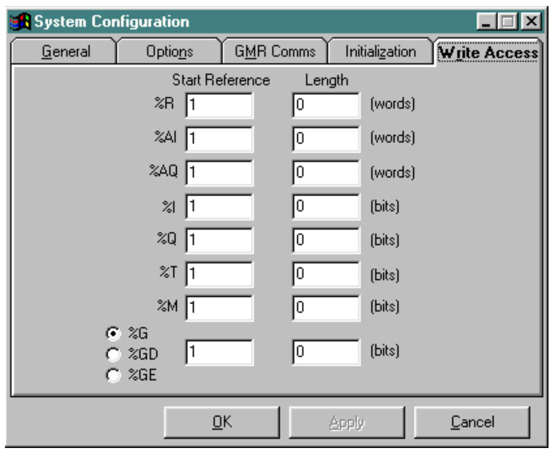
This entry determines if a hardware fault will halt the PLC (Fatal), or if the PLC will continue operating. With Diagnostic operation (the default), a system fault sets the System Fault bit (%M12234). By monitoring this bit, the application program can respond appropriately to the error.

The table below lists *total* limits for the initialization data.

Item	Parameters	Comment
Starting reference for %R initialization data	1 to 16384	Upper limit depends on the number of registers and length of memory reserved by GMR for bus controller operations. For example: 320+NumGBC*66
Length of %R initialization data	0 to 4096	0 if no %R initialization data. Cannot exceed upper limit
Starting reference for %M initialization data	1 to 12224	Must be on 8-bit boundaries. Excludes the last 64 bits used by GMR
Length of %M initialization data	0 to 764	Length in words. (start ref +16 X length)<=12288 0 if no %M init. Data. Excludes last 64 bits used by GMR
Starting reference for %M temporary initialization data (to be stored in %R)	0 to 16384	0 if length of %M init. data (above) is 0. Excludes last 64 bits used by GMR

System Configuration, the Write Access Tab

On the Write Access tab, you can assign the starting addresses and lengths for any memory areas that data can be written to through a CMM, PCM, or Ethernet Communications Module. This configuration does NOT affect memory access by Bus Controllers, or by the CPU's built-in port or the Logicmaster software.



The following memory areas can be written to:

%R	Registers. Write Access cannot use the areas used by GMR
%AI	Analog Input Table
%AQ	Analog Output Table
%I	Discrete Input Table
%Q	Discrete Output Table
%T	Temporary internal reference bits, not saved through power loss
%M	Internal reference bits that are saved through power loss. Write Access cannot use the areas used by GMR
%G	Global Data memory
%GD	Global Data memory
%GE	Global Data memory

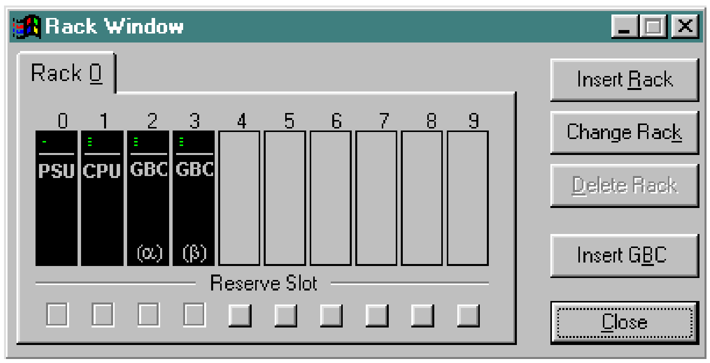
Global Data **%GA**, **%GB**, and **%GC** memories cannot be accessed directly. Those areas are used by the GMR system to exchange data (as explained in chapter 4).

Start Reference	The start of the address range to which write access will be permitted. It may be from 1 to the maximum table size.
Length	The length of the address range to which write access will be permitted. A length of 0 means the entire contents of that memory type is write-protected. For %R, %AI, and %AQ memory, length is in units of registers (words). For discrete (bit) memories: %I, %Q, %T, %M, %G, %GD, and %GE, the starting reference must be on a byte boundary (1, 9, 17, etc). For these memory types, the length is in units of points (bits). It must be specified in multiples of 8 bits (8, 16, 24, etc...)

Inserting a PLC Rack in the Configuration

Before configuring bus controllers or I/O modules, you need to configure the PLC racks in the system. Select and right-click on the Rack icon in the Explorer window to View (and edit) the rack 0 configuration, or to add another rack to the system.

When you Insert a rack, the Rack Window appears. By default rack 0 slot 2 is reserved for Bus Transmitter Module when a new configuration is created. To avoid this, you can clear the appropriate check in the New Configuration dialog box.



For duplex and triplex PLC systems, there are two bus controllers already present. These are the bus controllers that will exchange the system’s global data. They are identified as the global data bus controllers by the greek letter alpha and beta characters on the GBC graphics.

In the main rack (rack 0), a CPU is automatically placed in slot 1. In an expansion rack, an Expansion Receiver Module in automatically placed in slot 1.

On this screen, you can Change between a 5-slot rack (if slots 6 to 9 are unused) and a 9-slot rack, insert a new rack in the configuration, or delete the last rack. Rack 0 cannot be deleted. You can also insert a Bus Controller Group.

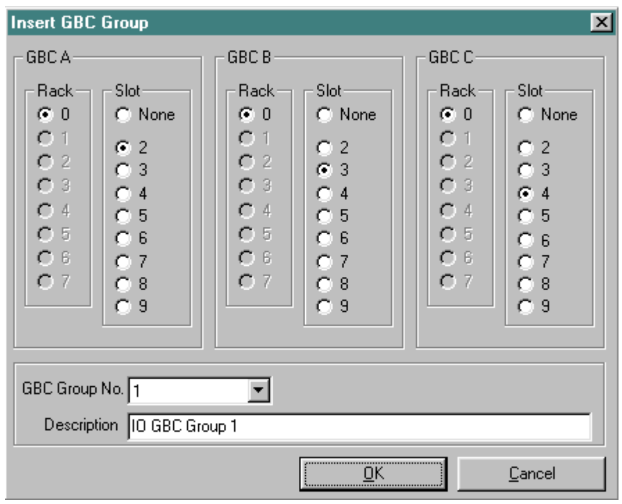
Reserving a Slot

If you want to reserve a slot in the rack for another module (for example, an Ethernet module) and not use that slot for GMR Bus Controllers, click the Reserve Slot box below the slot location, or right click on an empty slot. Any reserved slot will be ignored when you insert a Bus Controller group.

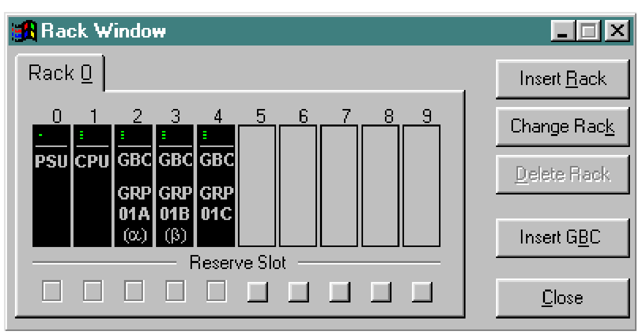
Inserting a Bus Controller Group in the Rack

To add a bus controller group, either select GBC Group from the Insert menu or click on Insert GBC in the Rack window. When inserting a new GBC group if there are less than 3 free slots, a prompt appears to confirm whether to proceed with fewer bus controllers or cancel the insertion. If you want to add free slots, insert a new rack. If you add an expansion rack be sure rack 0 has a slot reserved for an Expansion Transmitter Module.

The system may include non-GMR bus controllers. *Do not include non-GMR bus controllers in this GMR configuration.* (Non-GMR bus controllers are included in the Logicmaster configuration *only*).

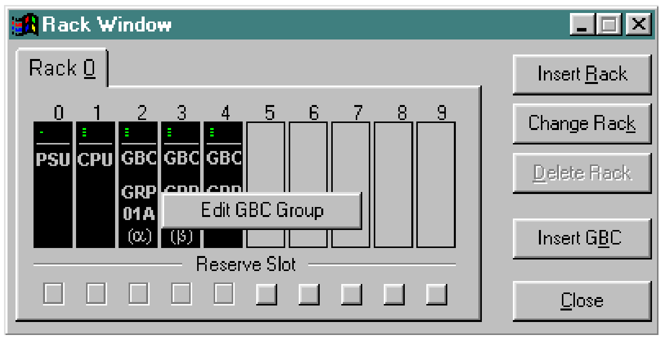


With the correct locations shown, click OK to add the group. You can now view the bus controllers in the Rack window.



Changing Rack/Slot Assignments of a Bus Controller Group

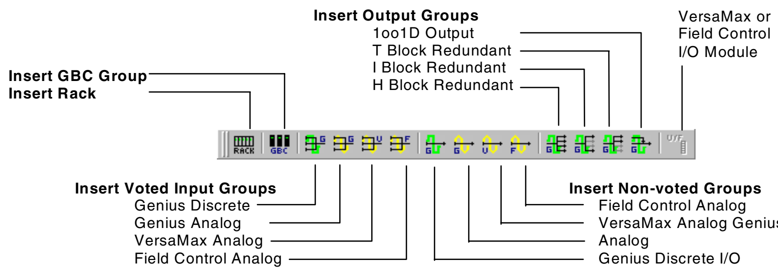
To change the Bus Controller locations you assigned on the Insert GBC Group screen, either select GBC Group from the Edit menu, right click on the group in the Rack window then click on Edit GBC Group, or right click on the group in the Explorer window.



Editing a GBC Group displays the rack and slot allocation screen shown on the previous page.

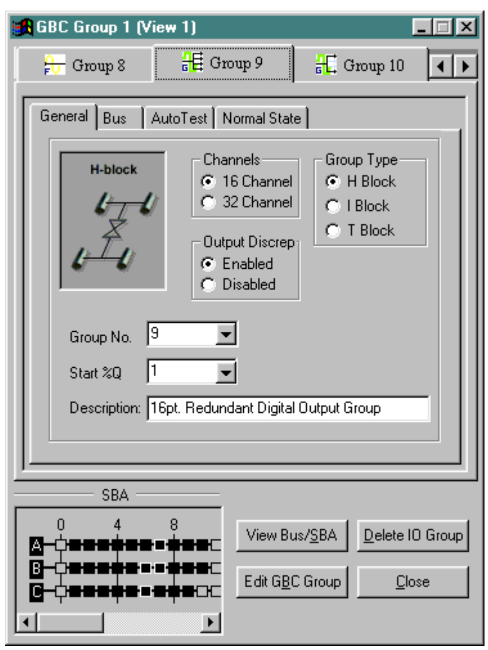
Configuring I/O Devices in a Bus Controller Group

After inserting a Bus Controller Group, you can add the individual I/O devices controlled by that Bus Controller Group. You can use the Insert Menu or the I/O Toolbar to select and insert I/O devices.

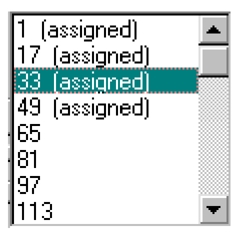


GBC Group Window

As you configure a GBC Group, new I/O Group tabs are added to the GBC Group window. You can move between configured I/O groups by selecting their tabs. For example, here the Group 9 tab is selected:



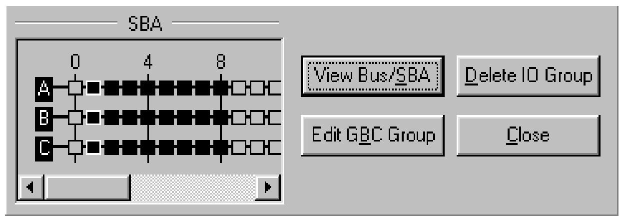
For each group type, the tabs show configurable features with a default selection that you can use as-is. For some selections, such as "Group No." and "Start %Q" as shown here, you can pull down a list of alternative selections:



The SBA window at the bottom of the screen shows the SBAs that are assigned to the individual blocks in the group. The four blocks in this particular group are assigned to SBA 7 on bus A, SBAs 6 and 7 on bus B, and SBA 6 on bus C.

Assigning Bus Addresses

Each device on a Genius bus has a Serial Bus Address (SBA) that is its communications address on that bus (or group of busses). The GMR Configuration Software automatically assigns a Serial Bus Address for each I/O group/device you add to a Bus Controller Group. You can see these Serial Busses graphically represented at the bottom of the GBC Group window.

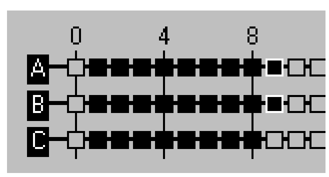


The SBAs already assigned on each of the GMR busses are shown as darkened boxes. Those that are still available appear as clear bosses. You can use the horizontal scrollbar to view additional SBAs on the bus.

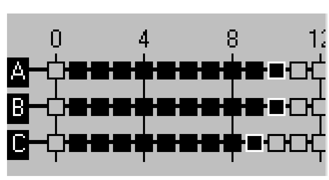
How the GMR Software Assigns SBAs

The GMR Configuration Software automatically assigns the next available SBAs on each bus, whether or not they are the same on all busses in the Bus Controller Group.

For example, if you configure a Duplex I/O group in a GBC Group with three Bus Controllers, the GMR Configuration Software assigns it the next two available references, here SBA 9 on busses A and B:



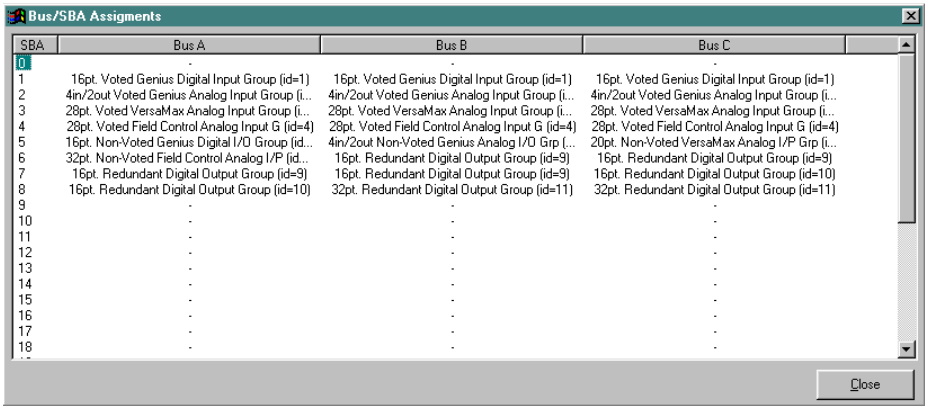
If you next configured a Triplex I/O group, the GMR Software would assign two blocks to SBA 10 on busses A and B, and the third block to SBA 9 on bus C:



You can select other SBAs if necessary when configuring an I/O Group.

Viewing the Bus Configuration

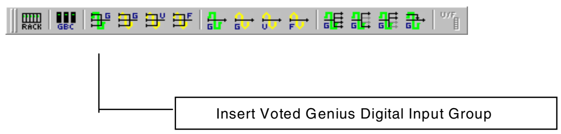
You can see descriptions of the I/O devices already configured for a Bus Controller Group by clicking on View Bus/SBA at the bottom of the GBC Group window.



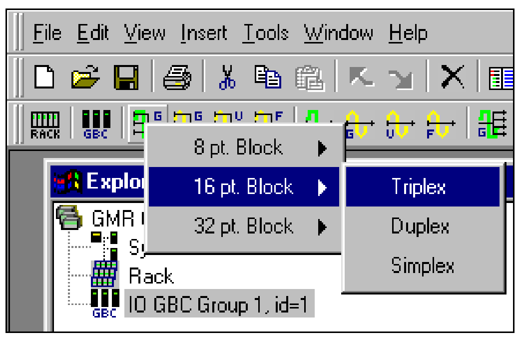
Adding and Configuring a Voted Genius Discrete Input Group

A Voted Genius Discrete Input Group is a GMR input group whose input data will use the voted portions of the input table (even though there may be only one block in the group).

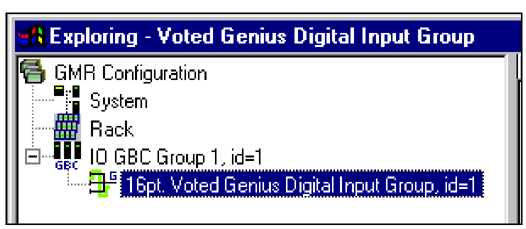
To add a Voted Genius Discrete Input Group to the Bus Controller Group, from the I/O toolbar or the Insert menu select Insert Voted Genius Digital Input Group.



Specify the number of points on the blocks in the group. Highlight Triplex, Duplex, or Simplex and click.

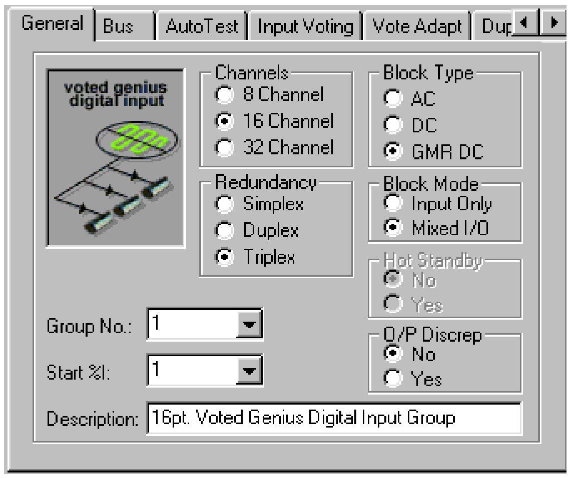


The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the group and select View I/O Group to display the I/O Group configuration in the GBC Group window.

Voted Discrete Genius Inputs, the General Tab



Description	You can enter a name or a description of up to 40 characters for the input group. This is for your information only. It is not used by the GMR software.
Group No	You can assign a unique number for the group, or use the default provided by the Configuration Software. For other choices, open the dropdown box.
Redundancy	The type of input group being configured. Simplex: One block on one bus Duplex: Two blocks on two busses Triplex: Three blocks on three busses
Channels	The number of points on each block in the group. A DC block can have either 16 or 32 points. An AC block can have 8 or 16 points.
Block Type	Specify an AC block, DC block or DC Block in GMR Mode. Select DC GMR for a DC block that will be autotested. AC blocks cannot be autotested.
Block Mode	The blocks in a discrete input group can be used as all-inputs or mixed I/O.
Start %I	The starting %I address of the voted input data, which is word-aligned. The actual %I references used for the input data from each block are configured using the Logicmaster 90 software. Duplicate addresses are not allowed within a GBC group. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.

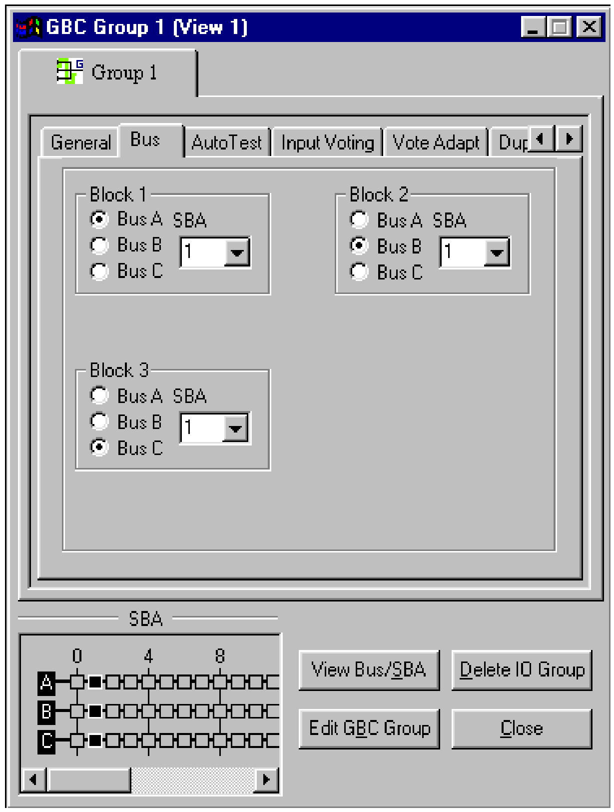
If you change the number of channels, block type or block mode, it may create an invalid configuration. It may also change other configuration settings for the group. After making such a change, check all group configuration settings carefully.

After verifying or editing the items above, you can configure the following depending upon block type and block mode:

Hot Standby	Circuits used as outputs may operate in Hot Standby mode. Selecting Hot Standby here configures the blocks to send fault reports to three PLCs.
Output Discrepancy	Select whether the System will check for and report output discrepancies (this should always be set to NO).

Voted Discrete Genius Inputs, the Bus Tab

The Bus tab is where you can change the bus assignments of the individual blocks in the group. This is the Bus tab for a Triplex input group, which has three blocks, A, B, and C. The Bus tab for a Simplex or Duplex input group shows two blocks or one block grayed out respectively.

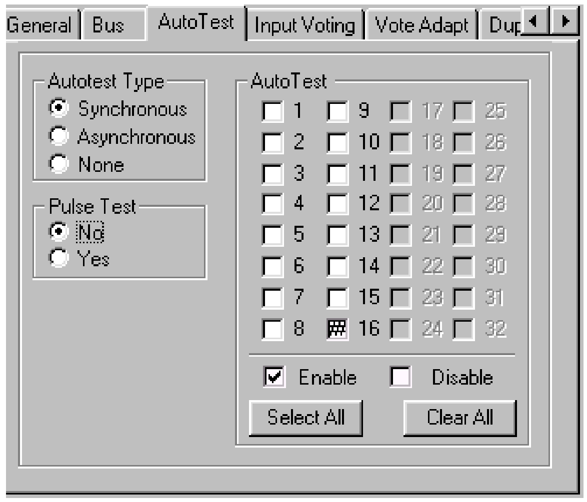


The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

SBA	The unique serial bus address of each block on its respective bus. The GMR Configuration software does not permit blocks to use the same bus addresses within the same GBC. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	Specify which bus each block is located on. Each block must be on a different bus, regardless of their serial bus addresses.

Voted Discrete Genius Inputs, the AutoTest Tab

For blocks configured as DC GMR Block Type, you can set up Autotest for inputs and Pulse Test for outputs.



Autotest Type

By default, Autotest Type is set to None. If you change it to either Synchronous or Asynchronous, you can use the checkboxes to configure individual circuits. For any unused points on the block, set autotest to off. You can click Select All to check all the boxes or Clear all to clear all the boxes. Click on individual boxes to toggle checks on and off as needed.

Synchronous: must be selected if non-redundant simplex discrete input devices are used without isolation between blocks (I.E. the power feed outputs of each block ARE wired together). With Synchronous Autotest, Loss of Block faults or certain autotest faults may prevent the autotest from continuing to execute for that input block group and thus cause a I/O shutdown for the inputs in the group.

Asynchronous: allows the input autotest to continue executing on other blocks in a group that are not affected by the fault. It can be selected if:

A. redundant discrete input devices are used (the power feed outputs of each block ARE NOT wired together).

B. non-redundant simplex discrete input devices are used with isolation between termination boards.

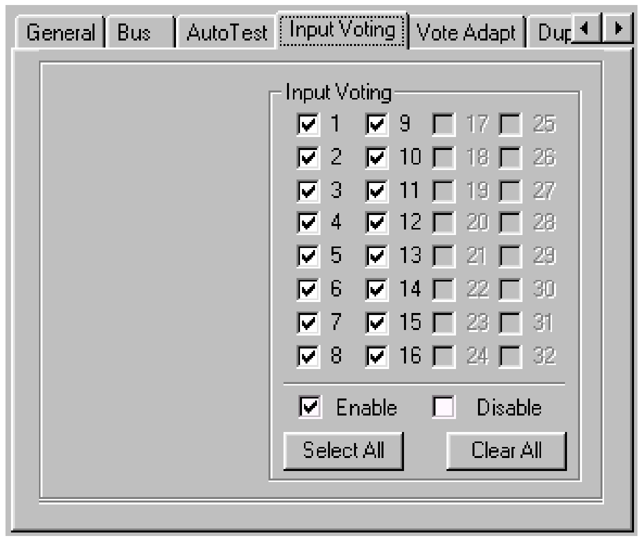
When DC GMR has been selected as the Block Type, allowing autotesting, circuit 16 (the powerfeed output) is always shown with autotest enabled on this screen. If no circuits should be autotested, the block should be configured as Block Type DC. In that case, circuit 16 is not reserved for use as a powerfeed output.

Pulse Test

Pulse test is only available for Mixed I/O blocks. By default, Pulse Test is set to No.

Voted Discrete Genius Inputs, the Input Voting Tab

The Voting tab allows you to enable or disable input voting on a per-point basis. Click Select All to check all the boxes or Clear all to clear all the boxes. Click on individual boxes to toggle checks on and off as needed.

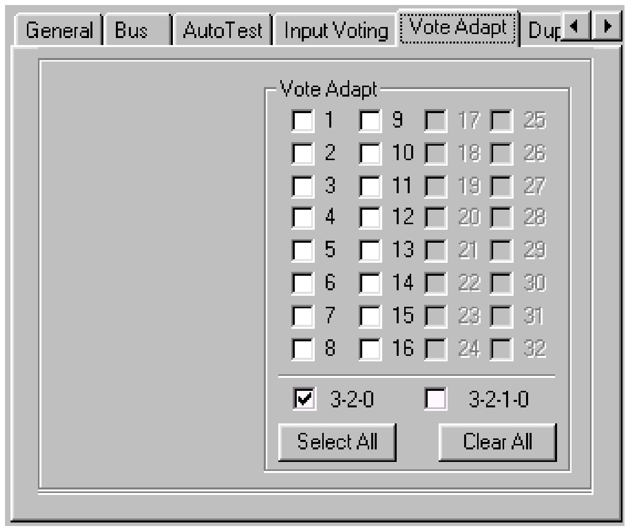


If you set input voting to No for any channels, it disables the voting options and input discrepancy reporting for that point.

Voted Discrete Genius Inputs, the Vote Adapt Tab

After you enable voting for an input, Voting Adaptation defines how that input will operate if a failure (discrepancy fault, Autotest fault, or Genius fault) occurs.

Select All to set all points to 3-2-0, Clear All to set all points to 3-2-1-0, or checkmark individual points to set them to 3-2-0.



For a three-block group, if input voting should go from three inputs to two inputs to one input, select 3-2-1-0. If voting should go from three inputs to two inputs to the default state, select 3-2-0.

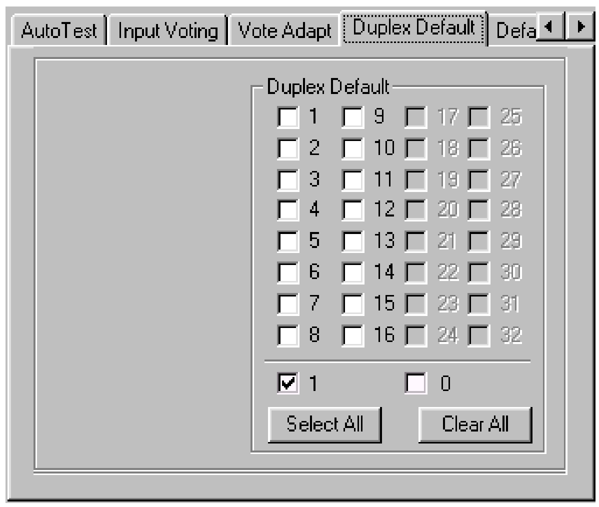
For a two-block group, if voting should go from two inputs to one, select 3-2-1-0. If voting should go from two inputs to the default state, select 3-2-0.

For a one-block group, always select 3-2-1-0. (If 3-2-0 were selected for a one-block group, the input would always be defaulted and never report the actual input state).

Voted Discrete Genius Inputs, the Duplex Default Tab

On the Duplex Default tab, set the Duplex default state for all inputs that have input voting enabled.

Select All to set all points to 1, Clear All to set all points to 0, or checkmark individual points to set them to 1.



For a three-block group, the Duplex State determines the vote type when there are just two inputs present.

- Using 0 as the Duplex State means that when two I/O blocks (duplex) are online, the voted input state will be 0 if either input sets it to 0. It will not be 1 unless both inputs set it to 1.
- Similarly, using 1 as the Duplex State means that when two blocks are online, the voted input state will be 1 if either input sets it to 1. It will not be 0 unless both of the inputs set it to 0..

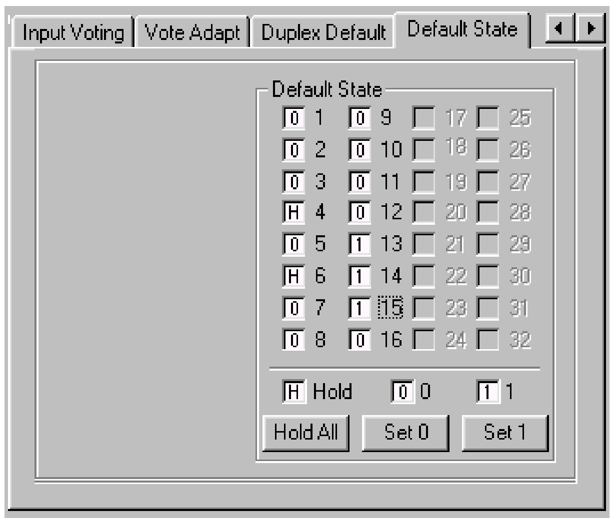
For a two-block group, this state is used as the third input in the 2 out of 3 vote.

For a one-block group, this field does not apply.

Voted Discrete Genius Inputs, the Default State Tab

On the Default State tab, choose a default state for all inputs that have input voting enabled. The default state of Hold Last State, 1, or 0 is the state that voted input will be set to if the selected type of voting adaptation fails to provide valid input data.

Select Hold All to set all points to H, Set 0 to set all points to 0, Set 1 to set all points to 1, or click on individual point boxes to select H, 1, or 0 for those points.



For a three-block group, this state will be provided to the application program if communications from all three blocks in the group are lost (if Voting Adaptation is 3-2-1-0). If Voting Adaptation is set to 3-2-0, this state is provided to the application program if communications from two blocks in the group are lost.

For a two-block group, this state will be provided to the application program if communications from both blocks in the group are lost.

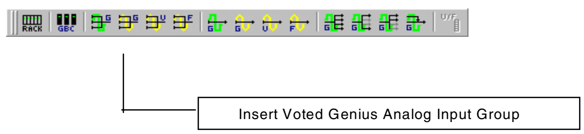
For a one-block group, this state will be provided to the application program if communications from the single block are lost.

Adding and Configuring a Voted Genius Analog Input Group

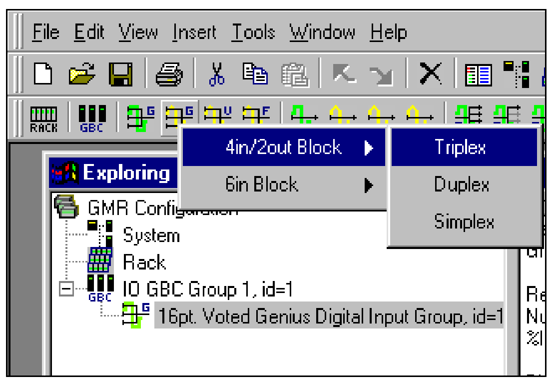
A Voted Genius Analog Input group provides redundant input data and can utilize GMR features such as discrepancy reporting. The group can consist of:

- Three blocks of the same type and three busses
- Two blocks of the same type and two busses
- One block and one bus. This option can be used to provide a desired default state upon failure.

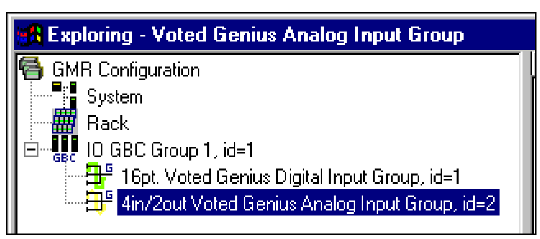
To add a Voted Genius Analog Input Group to the Bus Controller Group, from I/O toolbar or the Insert menu select Insert Voted Genius Analog Input Group.



Specify the number of points on the blocks in the group. Also select Triplex, Duplex, or Simplex redundancy.

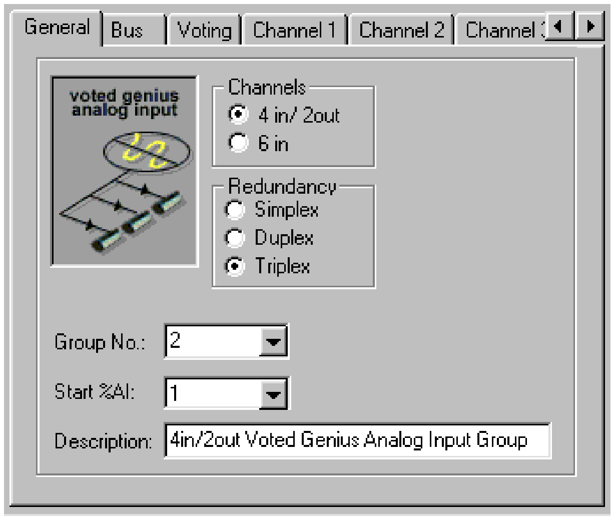


The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the group and select View I/O Group to display the I/O Group configuration screens.

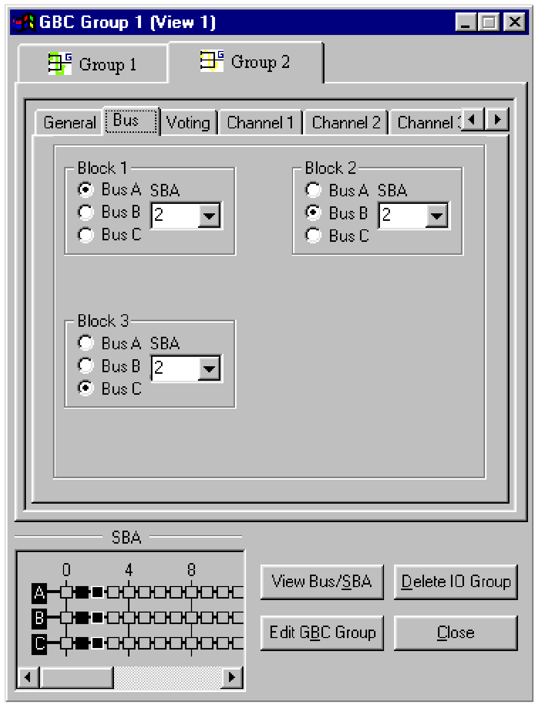
Voted Genius Analog Inputs, the General Tab



Description	You can edit the description of up to 40 characters for the input group. This is for your information only. It is not used by the GMR software.
Group No	You can assign a unique number for the group, or use the default provided by the Configuration Software. For other choices, open the dropdown box.
Channels	The group can consist of either 4 in/ 2 out or 6 input blocks.
Redundancy	The type of input group being configured. *Note:* A "simplex" input group has just one I/O block, installed on one bus, but configured as a GMR block. It is not the same a "non-voted" block. To configure a GMR group with just one analog block, select Simplex.
Start %AI	The starting %AI reference for the group's VOTED analog input data. The actual %AI references used for the input data from each block are configured using the Logicmaster 90 software. Duplicate addresses are not allowed within a GBC group. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.

Voted Genius Analog Inputs, the Bus Tab

The Bus tab is where you can change the bus assignments of the individual blocks in the group. This is the Bus tab for a Triple input group, which has three blocks, A, B, and C. The Bus tab for a Simplex or Duplex input group shows two blocks or one block grayed out respectively.



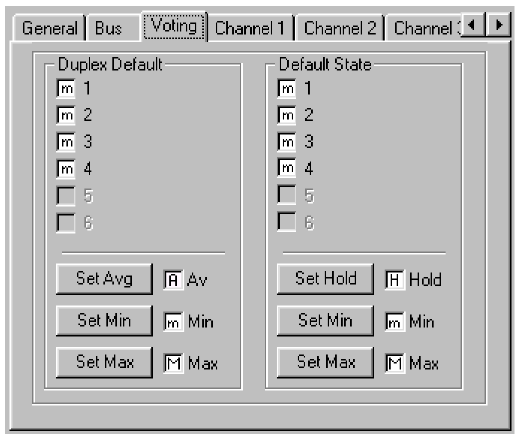
The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

SBA	The unique serial bus address of each block on its respective bus. The GMR Configuration software does not permit blocks to use the same bus addresses within the same GBC. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	Specify which bus each block is located on. Each block must be on a different bus, regardless of their serial bus addresses.

Voted Genius Analog Inputs, the Voting Tab

The Voting tab sets up both the Duplex Default and the Default State configuration for the group.

To set all points in a column to the same choice, click on the buttons at the bottom of each column. To toggle the selection for a point, click on the point.



Duplex Default

For a three-block group, the Duplex Default determines the vote type when there are only two analog inputs present. It may be configured as the higher actual input value (M), the lower value (m), or an average of the two (A). For more information, see chapter 2.

For a two-block group, the voted input data can be:

- an average of the two channels that are present (A).
- low-value based upon the two input channels that are present (m).
- high-value based upon the two input channels that are present (M).

For a one-block group, this information is not used.

Default State

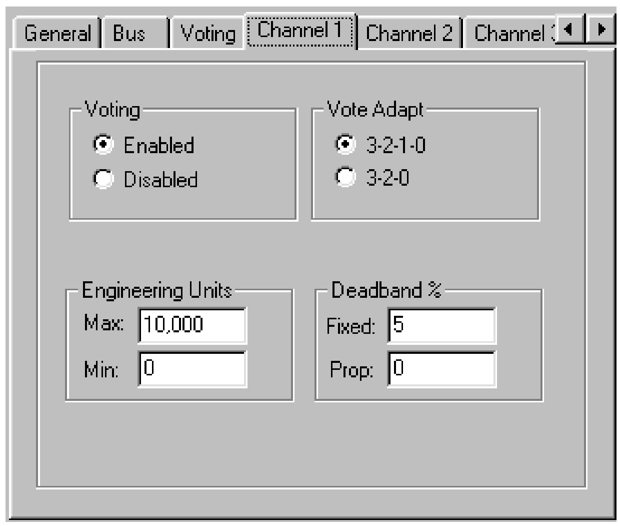
For a three-block group, if all three blocks in the group are lost or if only two blocks are lost and Voting Adaptation is selected as 3-2-0 on the Channel tab, the GMR system software will use a configured high (M) or low (m) value or hold the current value (H).

For a two-block group, select what should happen if both inputs for a channel are lost or if one block is lost and Voting Adaptation is selected as 3-2-0 on the Channel tab.

For a one-block group, select which of the above should be done if the input data for the channel is lost.

Voted Genius Analog Inputs, the Channel Tabs

Use the individual Channel tabs to configure input voting for each channel and to specify both defaults and a deviation deadband for the channel. In a 4 Input/2 Output Analog group, there are only 4 channel tabs for configuring the inputs. There are no channel tabs for the outputs, because the outputs are not part of the GMR redundancy operation.

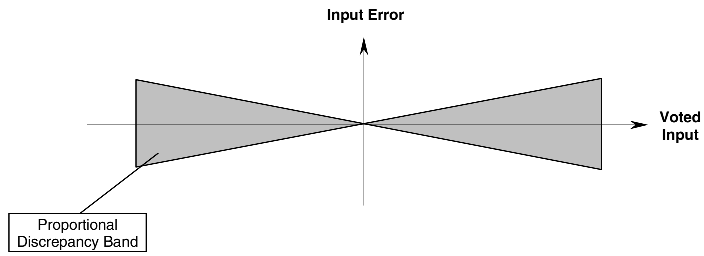


Here, you can configure input voting for each channel and specify both defaults and a deviation deadband for the channel.

Voting	Enable or disable voting for the channel.
Vote Adapt	Specify how each circuit in a three-block or two-block input group should utilize vote adaptation *For a one-block group*, this option should be set to 3-2-1-0. (If 3-2-0 were selected for a one-block group, the input would always be defaulted and never report the actual input state). *For a three-block group*, if voting should go from three inputs to two to one, select 3-2-1-0. If voting should go from three inputs to two to the default value, select 3-2-0. *For a two-block group*, if voting should go from two inputs to one, select 3-2-1-0. If voting should go from two inputs to the default value, select 3-2-0.
Engineering Units	The maximum and minimum values represent the block's configured engineering units. These values are used in two ways. First, either value can be used as the Default State if actual input data for that channel is not available. Second, the maximum and minimum values represent the full-scale deflection for the input. They are used by the software to monitor the point for fixed deviation. This is explained in more detail on the next page. The range for either maximum or minimum is -32767 to +32767.

Deviation Deadband: Proportional

Specify by what percent an individual input for the channel may deviate from the voted input value. For example, if the physical inputs for a channel were 91, 100, and 111 degrees, the voted input value would be 100 degrees. If the Discrepancy Threshold for the channel had been configured as 10%, the input reporting 111 degrees would be outside the acceptable range.

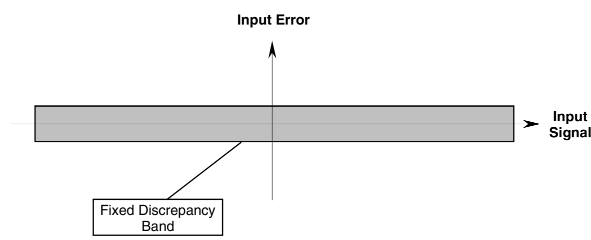


See chapter 4 for more information on analog discrepancy reporting.

Deviation Deadband: Fixed

Similarly, specify by what percent an individual input for the channel may deviate from the full scale deflection of the channel (represented by the entries maximum and minimum value).

For example, if the Engineering Units were configured as: Maximum = 150 and Minimum = 75, the full scale deflection of the input would be 75 (150 – 75). In this example, the Fixed Deadband is configured at 10%, so the fixed deviation would be 7.5 engineering units. In the example, the physical inputs for a channel are 91, 100, and 111. The voted input is 100. Both of the other inputs (91 and 111) have fixed discrepancies because they differ from the voted mid-value by more than 7.5 engineering units.

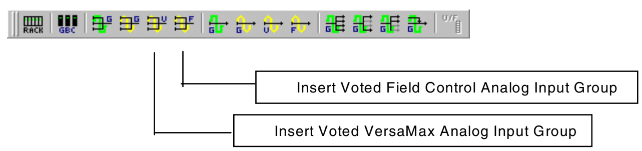


NOTE: Both a proportional deviation and a fixed deviation must exist for a input channel before an Analog Input Deviation is logged in the fault table.

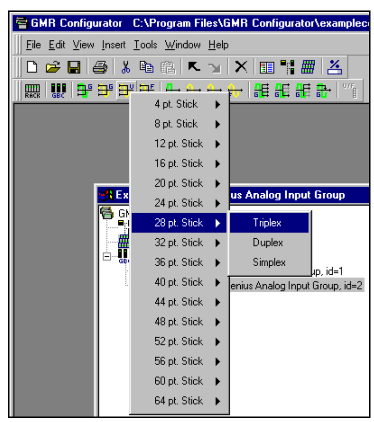
Adding and Configuring a Voted VersaMax or Field Control Analog Input Group

A Voted VersaMax or Field Control Analog Input Group consists of one or more I/O Stations. Each interfaces to the Genius busses through a Genius NIU or BIU interface module. Inputs from the group will use the voted portions of the analog input table (even though there may be only one I/O Station in the group). They may also use special GMR features such as deviation reporting.

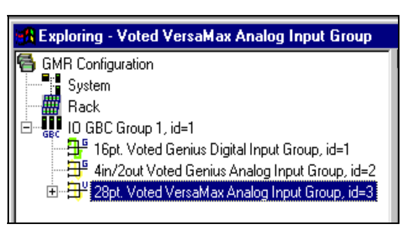
To insert a VersaMax or Field Control Voted Analog Group into the Bus Controller Group, from the I/O toolbar or the Insert menu select Insert Voted VersaMax Analog Input Group or Insert Voted Field Control Analog Input Group.



You need to specify the total number of input points (up to 64) on the modules in each the I/O Station. Also select Triplex, Duplex, or Simplex redundancy.

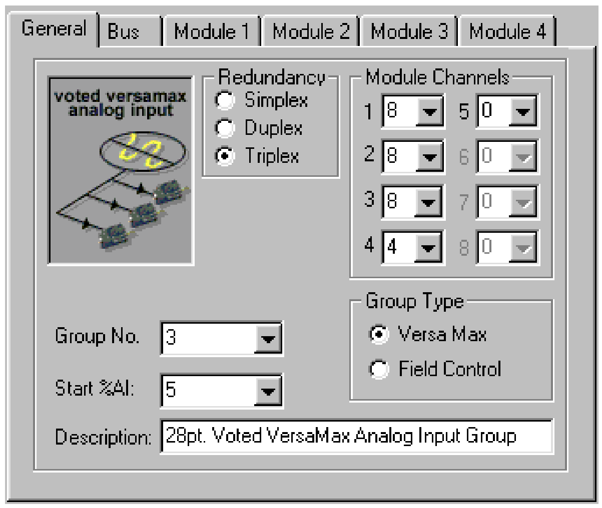


The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the group and select View I/O Group to display the I/O Group configuration screens.

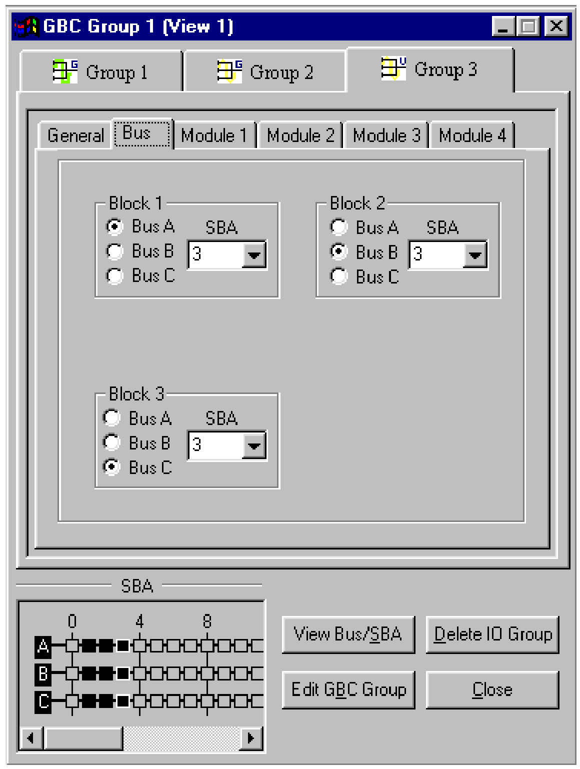
Voted VersaMax or Field Control Analog Inputs, the General Tab



Description	You can enter a name or a description of up to 40 characters for the input group. This is for your information only. It is not used by the GMR software.
Group No	You can assign a unique number for the group, or use the default provided by the Configuration Software. For other choices, open the dropdown box.
Redundancy	The type of input group being configured. Simplex: One I/O Station on one bus Duplex: Two I/O Stations on two busses Triplex: Three I/O Stations on three busses
Start %AI	The starting %AI reference for the group's VOTED analog input data. The actual %AI references used for the input data from each I/O Station are configured using the Logicmaster 90 software. Duplicate addresses are not allowed within a GBC group. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.
Module Channels	The number of analog inputs per module in each I/O station of the group. In the example shown above, each VersaMax I/O Station in the group has four analog input modules with 8, 8, 8, and 4 inputs respectively. Modules are added by changing the first empty module to the number of channels desired. Setting a module to 0 channels will delete all modules following the module being changed.
Group Type	Can be either a VersaMax or Field Control I/O Station.

Voted VersaMax or Field Control Analog Inputs, the Bus Tab

The Bus tab is where you can change the bus assignments of the individual I/O Stations in the group. This is the Bus tab for a Triple input group, which has three I/O Stations, A, B, and C. The Bus tab for a Simplex or Duplex input group shows two blocks or one block grayed out respectively.

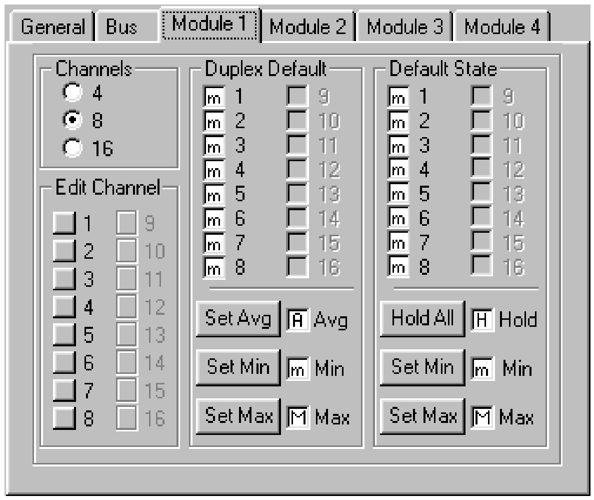


The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

SBA	The unique serial bus address of each block on its respective bus. The GMR Configuration software does not permit blocks to use the same bus addresses within the same GBC. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	Specify which bus each block is located on. Each block must be on a different bus, regardless of their serial bus addresses.

The Module Tabs for a VersaMax/Field Control I/O Station

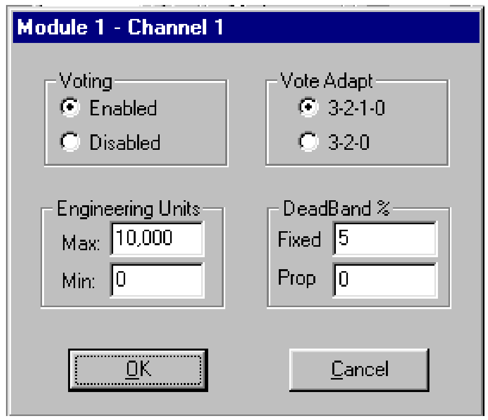
Complete a Module Tab for each GMR Analog module in the I/O Station.



Channels	The number of analog inputs on the module being configured.
Duplex Default	*For a three I/O Station group,* the Duplex Default determines the vote type when there are two analog inputs present. It may be configured as the higher actual input value (M), the lower value (m), or an average of the two (A). *For a two-block group*, the voted input data can be: ▪ an average of the two channels that are present (A). ▪ low-value based upon the two input channels that are present (m). ▪ high-value based upon the two input channels that are present (M). *For a one-block group*, this information is not used.
Default State	*For a three-block group*, if all three blocks in the group are lost or if only two blocks are lost and Voting Adaptation is selected as 3-2-0 on the Channel tab, the GMR system software will use a configured high (M) or low (m) value or hold the current value (H). *For a two-block group*, select what should happen if both inputs for a channel are lost or if one block is lost and Voting Adaptation is selected as 3-2-0 on the Channel tab. *For a one-block group*, select which of the above should be done if the input data for the channel is lost.
Edit Channel	To edit the channel properties, click on the individual Edit Channel boxes.

Voted VersaMax/Field Control Analog Input Group, the Channel Tabs

When you click on Edit Channel, the Channel popup appears.

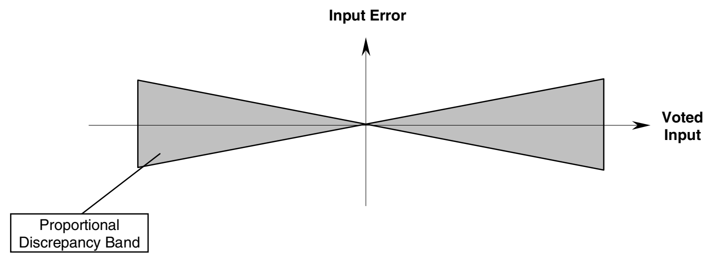


Here, you can configure input voting for each channel and specify both defaults and a deviation deadband for the channel.

Voting	Enable or disable voting for the channel.
Vote Adapt	Specify how each circuit in a three-station or two-station input group should utilize vote adaptation *For a one-station group*, voting must be set to 3-2-1-0. (If 3-2-0 were selected for a one-block group, the input would always be defaulted and never report the actual input state). *For a three-station group*, if voting should go from three inputs to two to one, select 3-2-1-0. If voting should go from three inputs to two to the default value, select 3-2-0. *For a two-station group*, if voting should go from two inputs to one, select 3-2-1-0. If voting should go from two inputs to the default value, select 3-2-0.
Engineering Units	The maximum and minimum values represent the station's configured engineering units. These values are used in two ways. First, either value can be used as the Default State if actual input data for that channel is not available. Second, the maximum and minimum values represent the full-scale deflection for the input. They are used by the software to monitor the point for fixed deviation. This is explained in more detail on the next page. The range for either maximum or minimum is -32767 to +32767.

Deviation Deadband: Proportional

Specify by what percent an individual input for the channel may deviate from the voted input value. For example, if the physical inputs for a channel were 91, 100, and 111 degrees, the voted input value would be 100 degrees. If the Discrepancy Threshold for the channel had been configured as 10%, the input reporting 111 degrees would be outside the acceptable range.

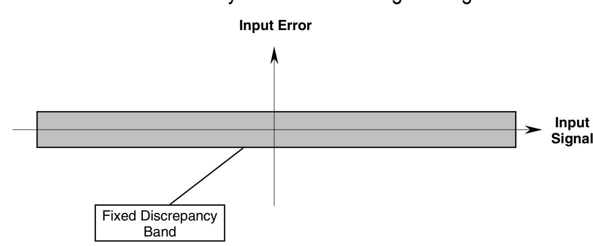


See chapter 4 for more information on analog discrepancy reporting.

Deviation Deadband: Fixed

Similarly, specify by what percent an individual input for the channel may deviate from the full scale deflection of the channel (represented by the entries maximum and minimum value).

For example, if the Engineering Units were configured as: Maximum = 150 and Minimum = 75, the full scale deflection of the input would be 75 (150 – 75). In this example, the Fixed Deadband is configured at 10%, so the fixed deviation would be 7.5 engineering units. In the example, the physical inputs for a channel are 91, 100, and 111. The voted input is 100. Both of the other inputs (91 and 111) have fixed discrepancies because they differ from the voted mid-value by more than 7.5 engineering units.

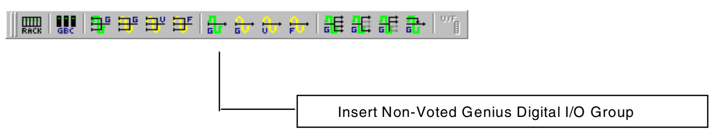


NOTE: Both a proportional deviation and a fixed deviation must exist for a input channel before an Analog Input Deviation is logged in the fault table.

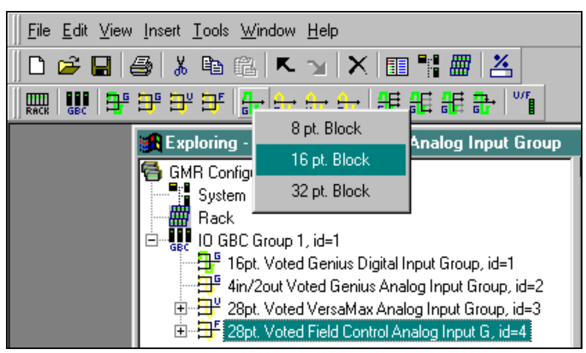
Adding and Configuring a Non-Voted Genius Discrete I/O Group

A Non-Voted Genius Discrete Input Group is a GMR input group whose input data will use the non-voted portions of the input table. The block will be considered part of the GMR system, and can utilize the GMR autotesting and output discrepancy reporting features. A bus can also include I/O blocks that are not part of the GMR system. *Do not include such non-GMR blocks in the GMR configuration.* Non-GMR blocks are included in the Logicmaster configuration and in the Genius block configuration, however.

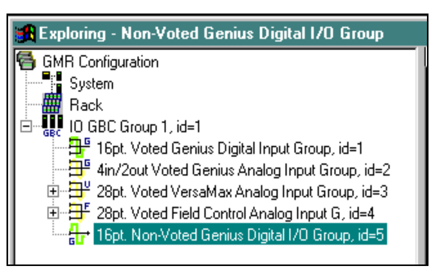
To add a Non-Voted Genius Discrete Input Group to the Bus Controller Group, from the I/O toolbar or the Insert menu, select Insert Non-Voted Genius Digital I/O Group.



Specify the number of points on the blocks in the group.



The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the item and select View I/O Group to display the configuration screens.

Non-voted Discrete Genius I/O, the General Tab

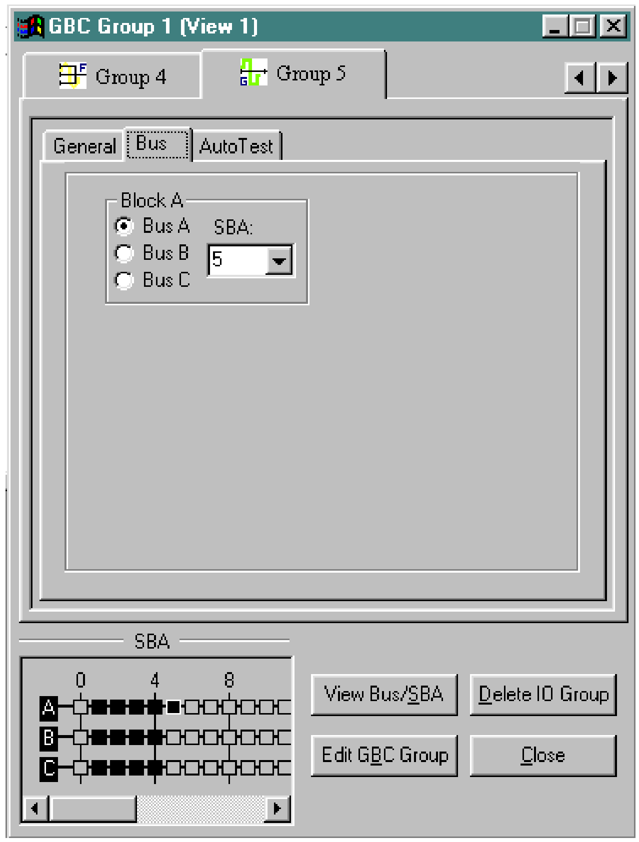
Description	You can enter a name or a description of up to 40 characters for the input group. This is for your information only. It is not used by the GMR software.
Group No	You can assign a unique number for the block, or use the default provided by the Configuration Software. For other choices, open the dropdown box.
Channels	The number of points in the group. A DC block can have either 16 or 32 points. An AC block can have 8 or 16 points.
Block Type	Specify an AC block, DC block or DC Block in GMR Mode. Select DC or DC GMR for a DC block that will be autotested. AC blocks cannot be autotested.
Block Mode	The points can be used as all-inputs, all outputs, or mixed I/O.
Start %QI	The starting %I and %Q addresses for the block's data. The actual references are configured using the Logicmaster 90 software. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.

If you change the number of channels, block type or block mode, it may create an invalid configuration. It may also change other configuration settings for the group. After making such a change, check all group configuration settings carefully. After verifying or editing the items above, you can configure the following:

Hot Standby	For AC or DC blocks (but not for DC GMR blocks), select whether circuits used as outputs will operate in Hot Standby mode. Selecting Hot Standby here configures the blocks to send fault reports to three PLCs. Hot Standby mode is a type of output redundancy. It must also be configured in the Genius device configuration, as explained in chapter 8. Chapter 8 describes Hot Standby mode in greater detail.
Output Discrepancy	For "DC GMR" blocks in Mixed or Output Only Block Mode, select whether the System will check and report for output discrepancies.

Non-voted Discrete Genius I/O, the Bus Tab

The Bus tab is where you can change the bus assignment of the block.

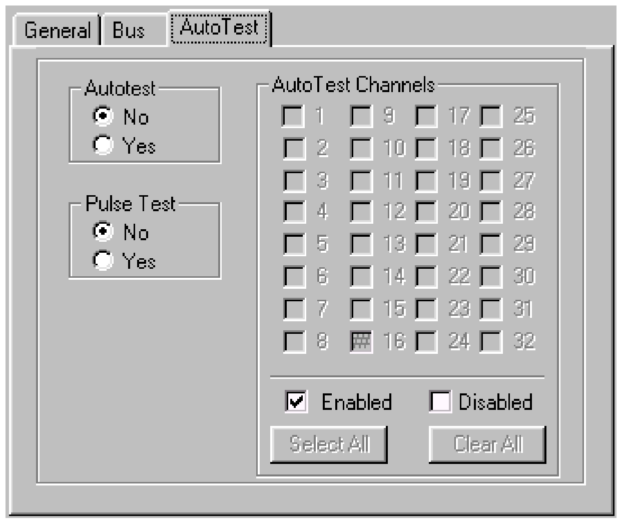


The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

SBA	The unique serial bus address of the block on its respective bus. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	The bus the block is located on.

Non-voted Discrete Genius I/O, the Autotest Tab

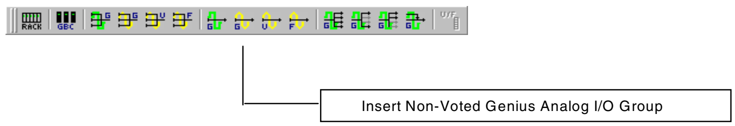
For blocks configured as DC GMR Block Type, you can set up Autotest for inputs and Pulse Test for outputs.



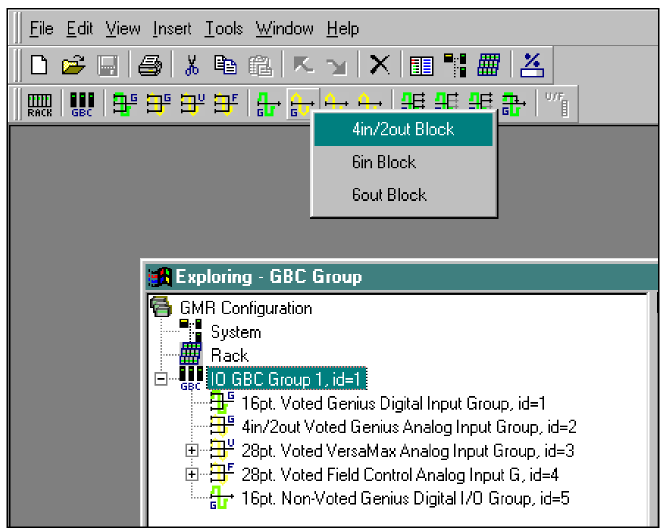
Input Autotest	If any input points on a DC block should be autotested, select Yes. You can enable or disable autotesting for all points, or select the individual points on this tab. When DC or DC GMR has been selected as the Block Type, allowing autotesting, circuit 16 (the powerfeed output) is always shown with autotest enabled on this screen. If no circuits should be autotested, the block should be configured as Block Type DC. If the block is not to be autotested, circuit 16 is not reserved for use as a powerfeed output. If the Block Type has been set to DC, autotesting will report Open-Circuit faults. If the Block Type has been set to DC GMR, autotesting will report Short-Circuit faults instead. If there are any unused points on a block, autotest should be set to off for those points by clearing their boxes under Auto Test Channels.
Pulse Test	Pulse Test can be enabled or disabled for all the outputs on the block. Pulse Test is not configurable on a point-by-point basis.

Adding and Configuring a Non-Voted Genius Analog I/O Group

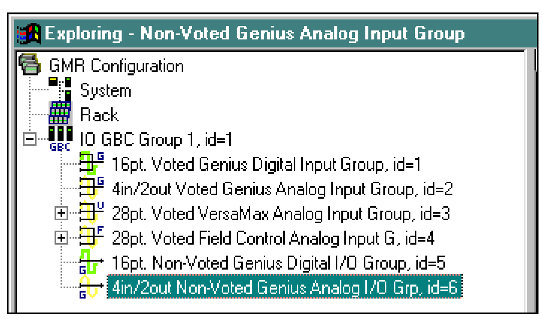
A Non-Voted Genius Analog Input Group is a GMR input group whose input data will use the non-voted portions of the analog input table. To add a Non-Voted Genius Analog Input Group to the Bus Controller Group, from the I/O toolbar or the Insert menu, select Insert Non-voted Genius Analog I/O Group.



Specify the number of points on the blocks in the group.

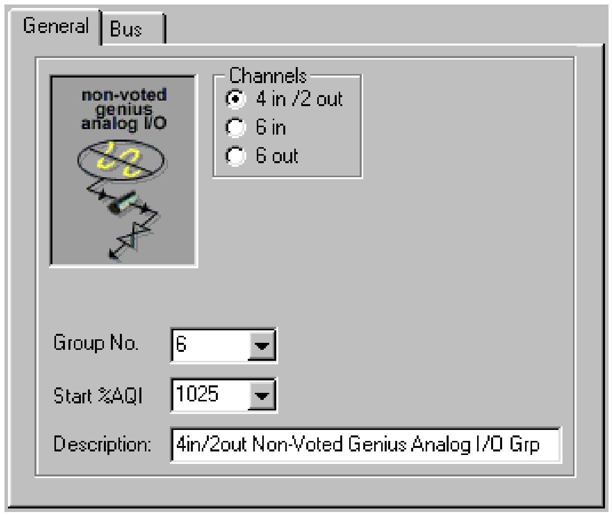


The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the item and select View I/O Group to display the configuration screens.

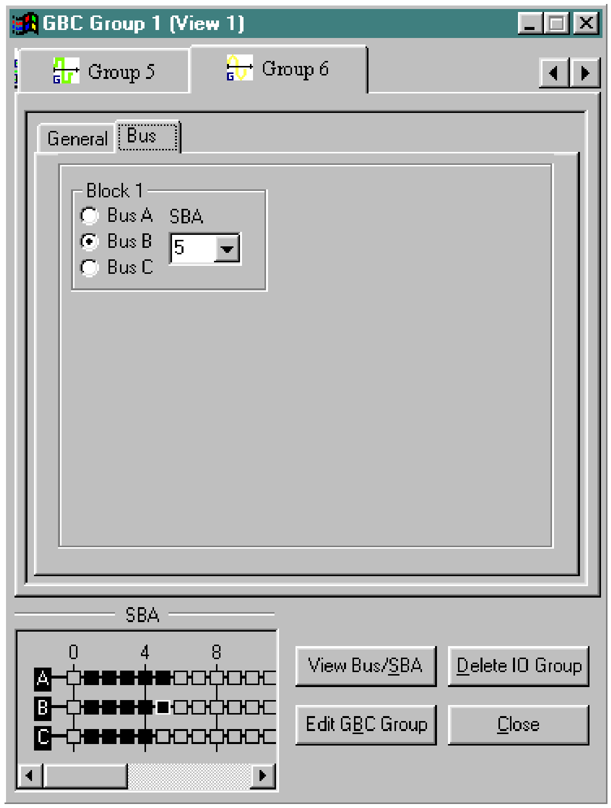
Non-voted Analog Genius I/O, the General Tab



Description	You can enter a name or a description of up to 40 characters for the group. This is for your information only. It is not used by the GMR software.
Group No	You can assign a unique number for the group, or use the default provided by the Configuration Software. For other choices, open the dropdown box.
Channels	The number of points on the block.
Start %AQI	The starting %AI and %AQ addresses for the block's data. The actual references used by the block are configured using the Logicmaster 90 software. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.

Non-voted Analog Genius I/O, the Bus Tab

The Bus tab is where you can change the bus assignments of the block.

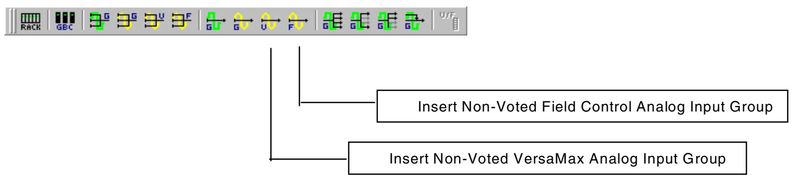


The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

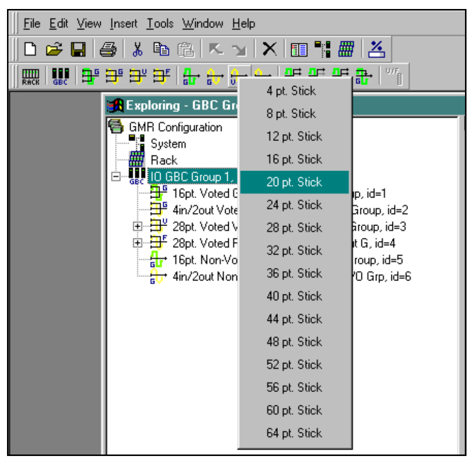
SBA	Specify the unique serial bus address of each block on its respective bus. The GMR Configuration software does not permit blocks to use the same bus addresses within the same GBC.
Bus	The bus the block is located on.

Adding and Configuring a Non-voted VersaMax or Field Control Analog Input Group

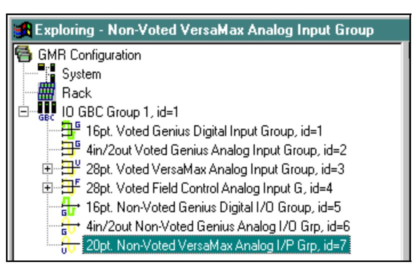
A Non-voted VersaMax or Field Control Analog Input Group is add an individual I/O Station whose input data will use the non-voted portions of the analog input table. The I/O Station will be considered part of the GMR system. To add a Non-voted VersaMax or Field Control Analog Input Group to the Bus Controller Group, from the I/O toolbar or the Insert menu, select Insert Non-voted VersaMax Analog Input Group or Insert Non-voted Field Control Analog Input Group.



Specify the number of inputs on the modules in the I/O Station.

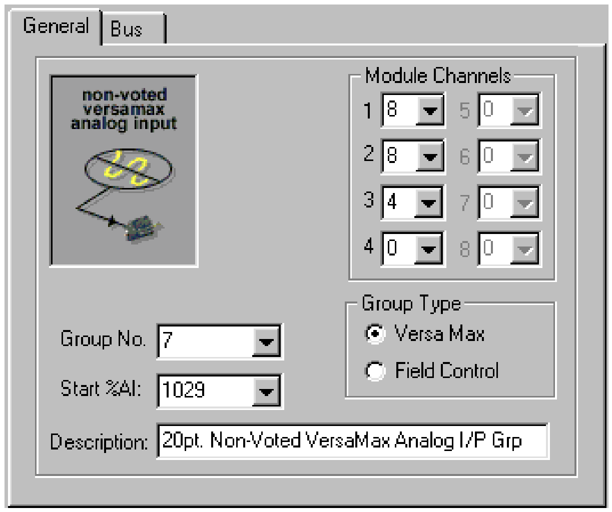


The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the group and select View I/O Group to display the Input Group configuration screens.

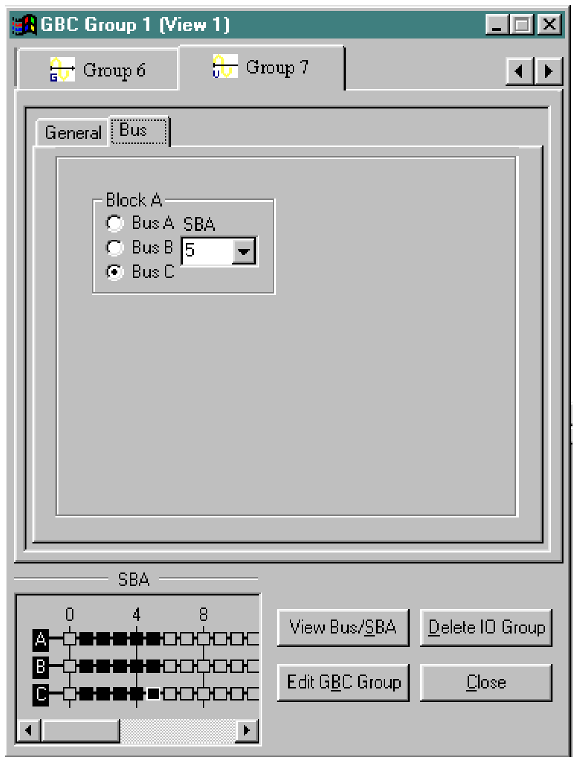
Voted VersaMax/Field Control Analog Inputs, the General Tab



Description	You can enter a name or a description of up to 40 characters for the group. This is for your information only. It is not used by the GMR software.
Group No	You can assign a unique number for the group, or use the default provided by the Configuration Software. For other choices, open the dropdown box.
Start %AI	The starting %AI and %AQ addresses for the I/O Station's data. The actual references used by the I/O Station are configured using the Logicmaster 90 software. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.
Module Channels	The number of analog inputs per module in the I/O station. In the example shown above, there are three analog input modules with 8, 8, and 4 channels respectively. Modules are added by changing the first empty module to the number of channels desired. Setting a module to 0 channels will delete all modules following the module being changed.
Group Type	Can be either a VersaMax or Field Control I/O Station.

Non-voted VersaMax/Field Control Analog Inputs, the Bus Tab

The Bus tab is where you can change the bus assignment of the I/O Station.

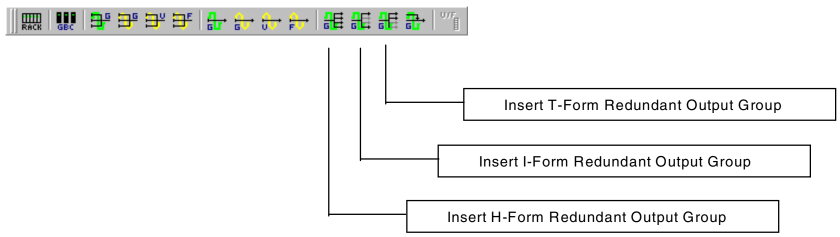


The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

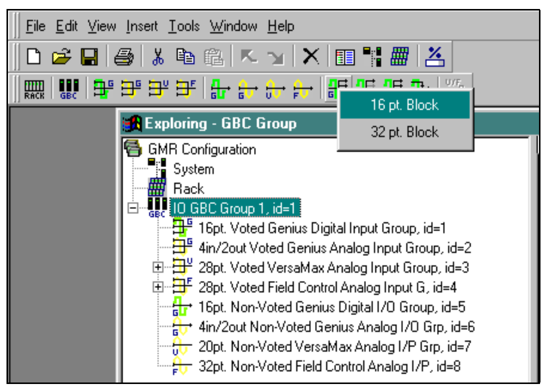
SBA	The unique serial bus address of the I/O Station on its respective bus. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	Specify which bus the I/O Station is located on.

Adding and Configuring an H-Form, T-Form, or I-Form Redundant Output Group

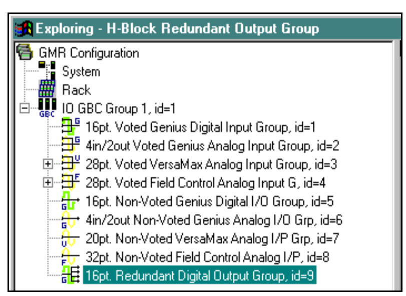
Select H-Form, T-Form, or I-Form Redundant Output Group to add one of these GMR output group types to the GBC Group. Using the I/O toolbar or the Insert menu, select the output group type:



Specify the number of points on the blocks in the group and click.

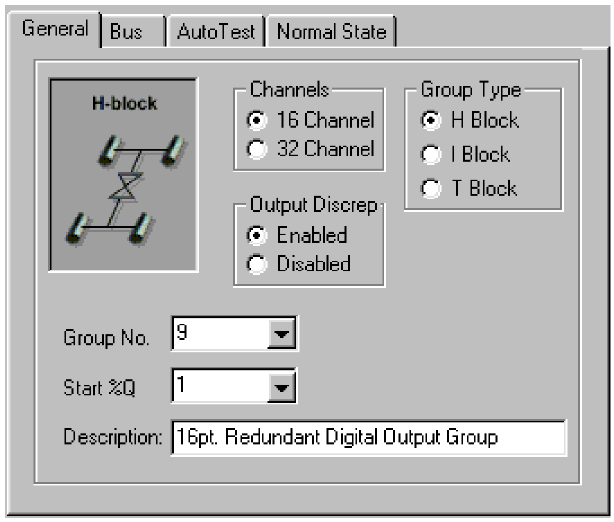


The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the group and select View I/O Group to display the I/O Group configuration screens.

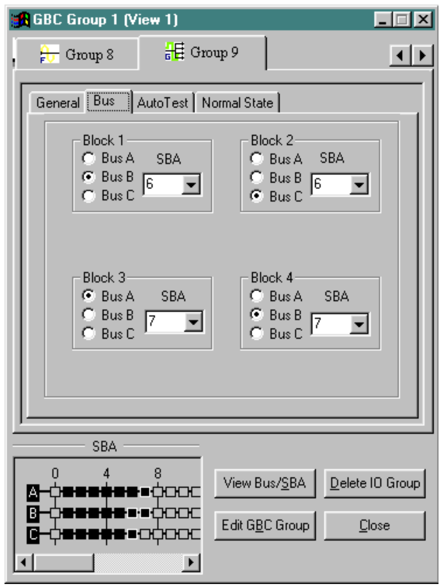
H-Form, I-Form, or T-Form Redundant Outputs, the General Tab



Channels	Select whether the group will consist of 16-circuit or 32-circuit blocks. (If you change this selection later, it may also change some other items).
Group Type	The type of output group being configured. H Block: Two DC Sink Blocks and Two DC Source Blocks I Block: Two DC Sink or DC Source Blocks connected in parallel T Block: Two DC Sink or DC Source Blocks connected in series
Output Discrepancy	Select whether the System will check for and report output discrepancies.
Group No	You can optionally assign a unique number for the group, or use the default provided by the Configuration Software.
Start %Q	The starting %Q address for the group (all blocks in the group will have the same Output Table reference addresses). The actual %Q references used for the group are configured using the Logicmaster 90 software. You can use the suggested reference or enter a different reference. For other choices, open the dropdown box. For information about memory allocation please see chapter 5.
Description	You can enter a name or a description of up to 40 characters for the group. This is for your information only. It is not used by the GMR software.

H-Form, I-Form, or T-Form Redundant Outputs, the Bus Tab

This is the Bus tab for an H-block output group. The Bus tab for an I-block or T-block output group shows two blocks grayed out.



H-Block Group on 3 or 2 Busses: The blocks of an H-block group must be distributed across the busses such that blocks A and B, and blocks C and D are not the same Bus. The block SBAs must be unique on the bus to which it is connected but they do not need to be the same within the group.

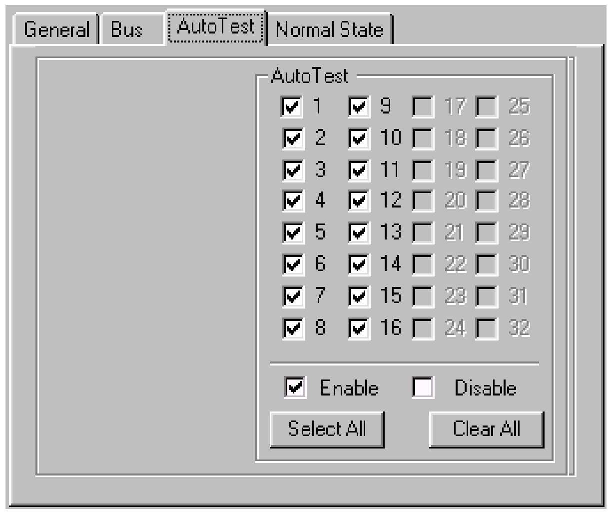
For a 2-block I-Block Group or T-Block Group, each block must be on a separate bus. The block SBA must be unique on the bus to which it is connected but they do not need to be the same within the group.

The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

SBA	The unique serial bus address of each block on its respective bus. The GMR Configuration software does not permit blocks to use the same bus addresses within the same GBC. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	Specify which bus each block is located on. Each block must be on a different bus, regardless of their serial bus addresses.

H-Form, I-Form, or T-Form Redundant Outputs, the AutoTest Tab

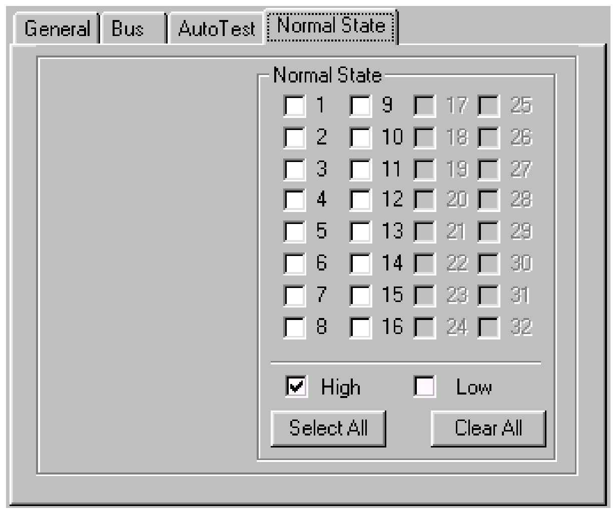
The Autotest tab can be used to set up Autotest for outputs.



Auto Test	By default, Autotest is Enabled for all points on the block. If there are any unused points on a block, autotest should be set to off for those points. Click Select All to check all the boxes or Clear all to clear all the boxes. Click on individual boxes to toggle checks on and off as needed.

H-Form, I-Form, or T-Form Redundant Outputs, the Normal State Tab

By default, each circuit is set up to have Low as its Normal State for purposes of autotesting. The Normal State should be set to Low when the demand state is OFF (as in an ESD application). The Normal State should be set to High when the demand state is ON (as in a fire and gas application).

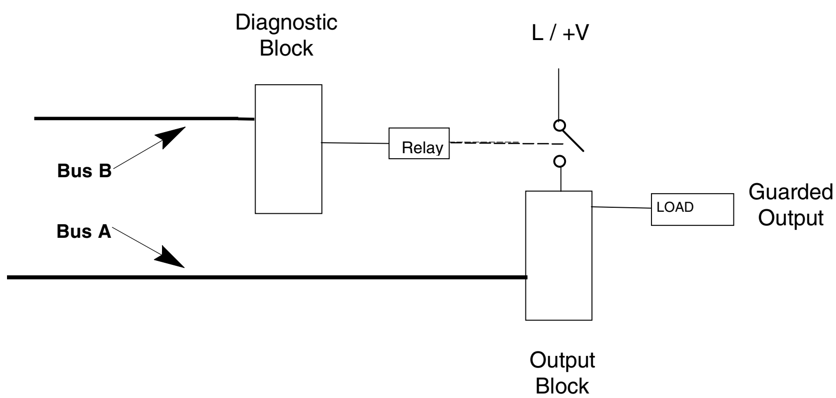


Adding and Configuring a 1oo1D Redundant Output Group

Select 1oo1d Redundant Output Group to configure the Output Block in a 1oo1D Output Group. A 1oo1D Output Group consists of one Genius block that drives *Normally Energized* loads. This block, called the " Output Block", has its power supply controlled by another block, which is called the "Diagnostic Block". The Diagnostic Block must be on a separate bus from the Output Block. The Diagnostic Block is configured separately, as explained in this section.

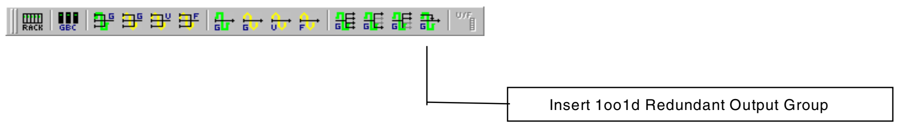
Non-Guarded Outputs in a 1oo1D Output Group

In a 1oo1D Output Group, some outputs on the Output Block can be used as non-guarded outputs, by providing just those outputs with a separate power supply and configuring them as non-guarded outputs.

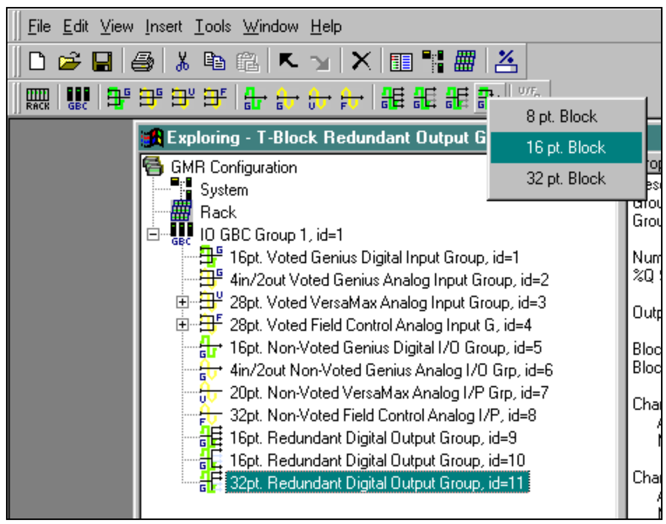


Adding a 1oo1D Redundant Group to the Bus Controller Group

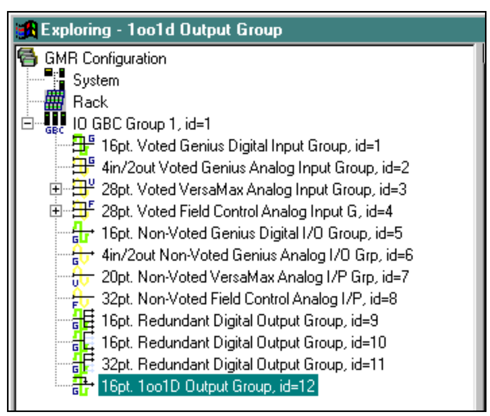
Using the I/O toolbar or the Insert menu, select 1oo1d Redundant Output Group.



Specify the number of points on the Output Block in the group and click.



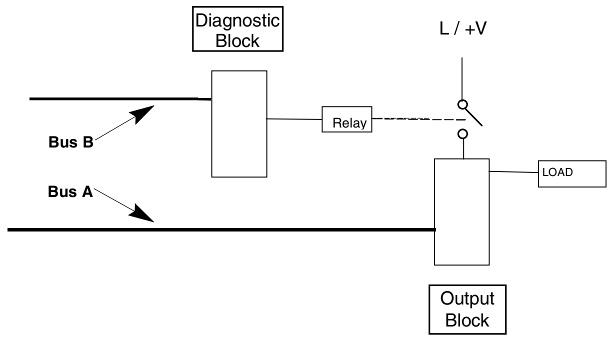
The I/O Group is added to the GBC Group in the Explorer pane.

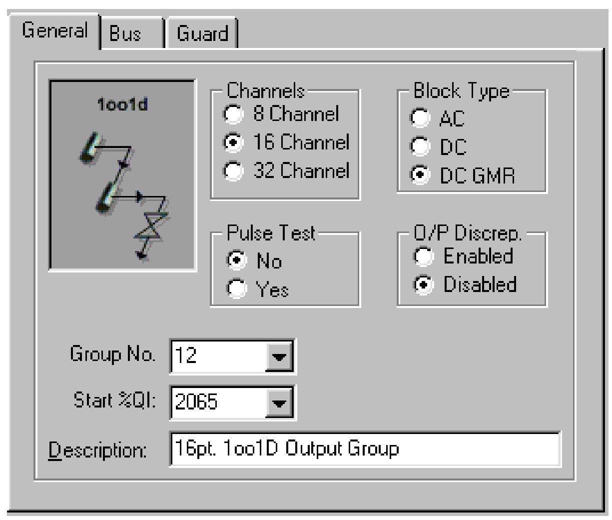


Right-click on the group and select View I/O Group to display the I/O Group configuration screens.

1oo1d Redundant Outputs, the General Tab

On the General tab, configure the parameters of the Output Block.





Channels

Specify the total number of channels on the Output Block: 8, 16, or 32. (If you change this selection later, it may also change some other items).

Block Type

Specify whether the Output Block is an AC block, a DC block, or DC block in GMR Mode. If the block will be configured for Output Discrepancy reporting, select DC GMR.

Pulse Test

Select whether all the outputs on the Output Block will be pulse-tested automatically by the GMR System Software during system operation.

Output Discrepancy

Select whether the system will check for and will report output discrepancies on DC GMR blocks.

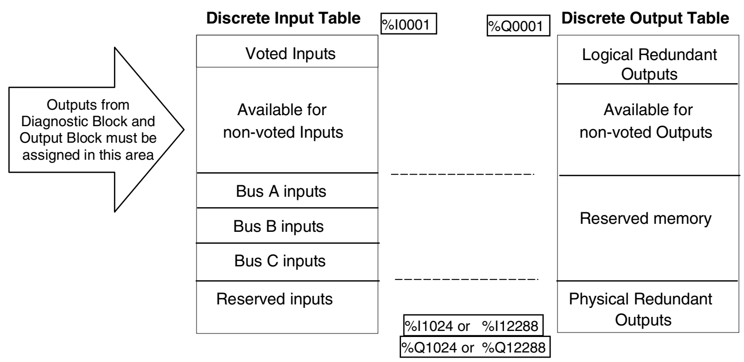
Group No

You can optionally assign a unique number for the group, or use the default provided by the Configuration Software.

Start %QI

Enter the starting references for the Output Block's output points. Corresponding references will also be used in the Input (%I) table for feedback from the outputs.

I/O mapping for this group type must fall within the non-voted area of the overall I/O maps as shown below. The allowable reference ranges of the non-voted area depend on system configuration settings.



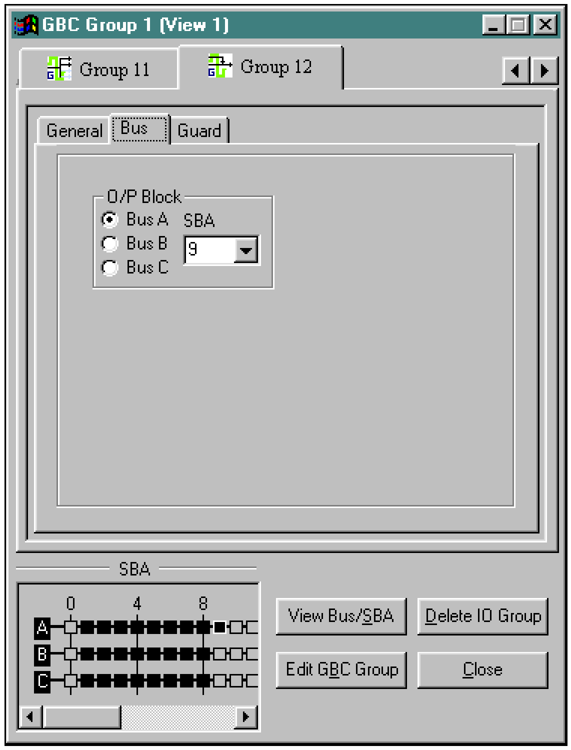
Each %Q output reference will contain the logic demand state for a guarded output. with the corresponding point input feedback (%I). When the output is tripped (0), if the feedback indicates that the output is stuck on (1), the corresponding Diagnostic Block's output is turned off. This forces all outputs on the block that have not been bypassed using a separate power supply, to their de-energized safe state.

Description

You can enter a name or a description of up to 40 characters for the group. This is for your information only. It is not used by the GMR software.

1oo1d Redundant Outputs, the Bus Tab

This is the Bus tab for 1oo1d output group. The output blocks must be located on a separate bus from the diagnostic block.



The GMR Configuration Software automatically assigns Serial Bus Addresses, indicated at the bottom of the GBC Group window. You can edit them on this tab if necessary.

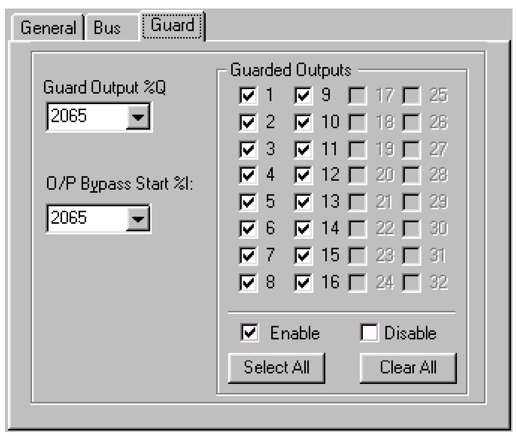
SBA	The unique serial bus address of the Output Block on its bus. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	Specify which bus the Output Block is located on. The Output Block and the Diagnostic Block must be on different busses.

1oo1d Redundant Outputs, the Guard Tab

The Guard tab is used to set up the output address of one output on the Diagnostic Block that will control power to the Output Block. The configuration settings of the Diagnostic Block itself are defined when the Diagnostic Block is configured as a separate Non-Voted IO Group in the GMR configuration.

A 1oo1D Output Block can have both guarded outputs and non-guarded outputs. A guarded output is one that monitored by the system and controlled by the power feed from the Diagnostic Block. A non-guarded output is not monitored by the GMR software.

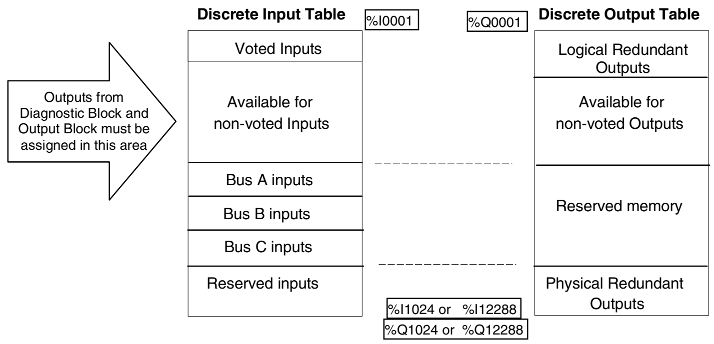
On this screen, specify which outputs on the Output Block will be guarded outputs. On this screen also, specify the point on the Diagnostic Block that will control power to the Output Block. During the separate configuration of the Genius I/O Blocks, all guarded outputs must be set up as outputs with input feedback and must have the No Load Reporting feature disabled and the Pulse Test feature enabled.



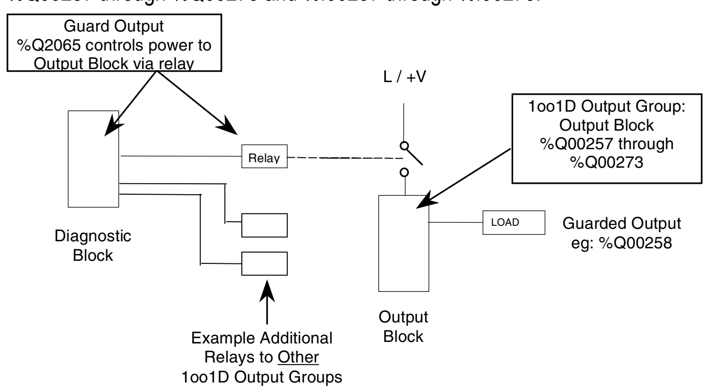
Guard Output %Q	You can select one single %Q output reference for the Guard Output on the Diagnostic Block that will control power to the Output Block. Note that the same Diagnostic Block can be used to control power to more than one 1oo1D Output Block. The Guard Output %Q references for other 1oo1D Output Blocks are made by configuring additional 1oo1D Output Groups for those blocks.

Guard Output %Q (continued)

The %Q reference for the Guard Output must fall within the non-voted area of the overall I/O maps as shown below. The reference selected here must also match the reference assignment made for the Diagnostic Block. The Diagnostic Block is configured separately, as described next in this chapter.



In this example, the Guard Output on the Diagnostic Block is assigned to reference %Q2065. The Guarded Outputs on the Output Block use the %Q and %I references assigned on the General Tab. In this example, they use %Q00257 through %Q00273 and %I00257 through %I00273.



By default, when inserting a new 1oo1D Output Group this reference is the same as %QI reference for the group. <u>This is only correct for the first output on the Diagnostic Block. If this 1oo1D Output Block uses a different output on the Diagnostic Block, the reference assigned here must be changed accordingly.</u>

O/P Bypass Start %I

Here, you can select a starting %I input reference for the guarded output bypass bits. These references will be used to inform the GMR System Software that an output(s) has been bypassed and if used would be wired to the bypass switches.

By default when inserting a group this reference is the same as the group, This setting **must** be changed before the configuration can be generated

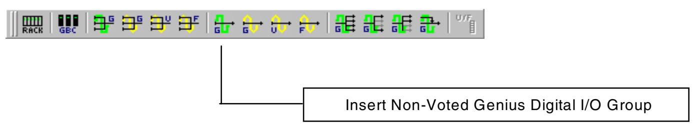
Guarded Outputs

Select the outputs on the Output Block that will be guarded. You can click Select All or Clear All to set all the outputs to either enabled or disabled. Click the point boxes to select or clear individual points.

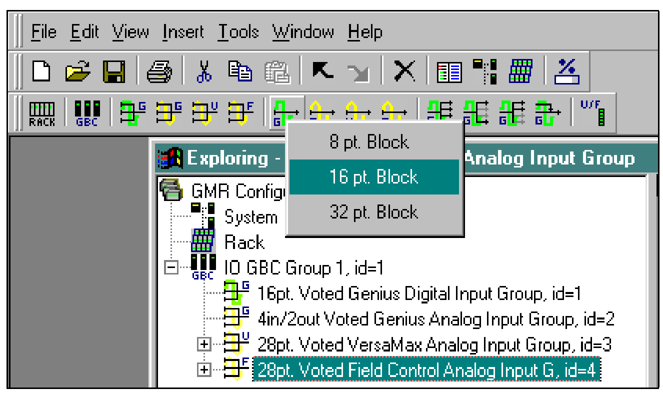
Configuring the Diagnostic Block in a 1oo1D Output Group

The Diagnostic Block for a 1oo1D Output Group is a separate discrete block that controls power feed into the Output Block via a relay. The Diagnostic Block must be on a separate bus from the Output Block. Because the Diagnostic Block in a 1oo1D group can control multiple 1oo1D Output Groups, it must be configured separately from its Output Block(s).

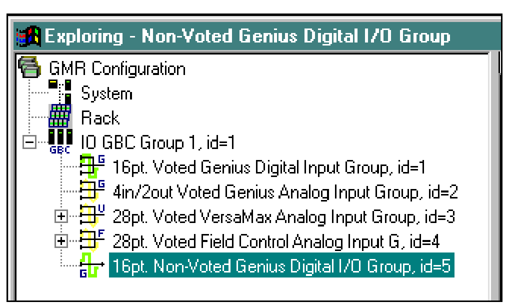
To add a 1oo1D Diagnostic Block to the Bus Controller Group, from the I/O toolbar or the Insert menu, select Insert Non-Voted Genius Digital I/O Group.



Specify the number of points on the Diagnostic Block (only).



The I/O Group is added to the GBC Group in the Explorer pane.



Right-click on the item and select View I/O Group to display the configuration screens.

1oo1D Diagnostic Block, Completing the General Tab

Description

You can enter a name or a description of up to 40 characters for the Diagnostic Block. This is for your information only. It is not used by the GMR software.

Group No

You can assign a unique number for the block, or use the default provided by the Configuration Software. Note that this is not the same as the group number for the Output Block. For other choices, open the dropdown box.

Channels

The number of points on the Diagnostic Block. A DC block can have either 16 or 32 points. An AC block can have 8 or 16 points.

Block Type

Specify an AC block, DC block or DC Block in GMR Mode. Select DC GMR for a DC block that will be autotested. AC blocks cannot be autotested.

Block Mode

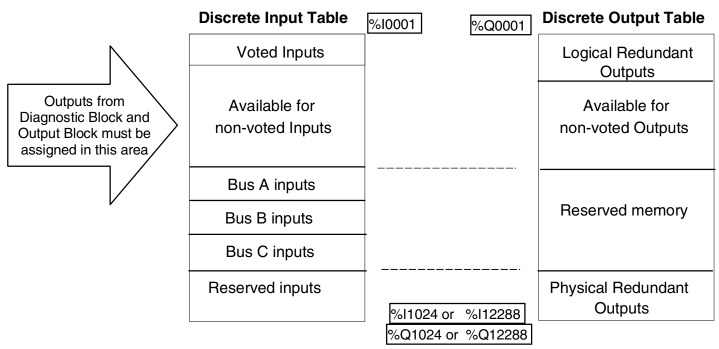
The points can be used as all-inputs, all outputs, or mixed I/O.

Start %QI

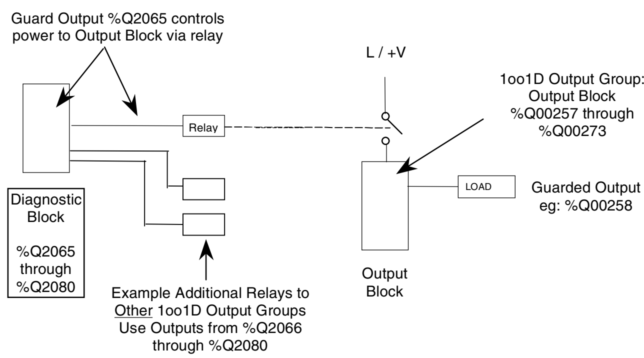
Enter the starting references for the Diagnostic Block's output points. The range of references selected must include the individual references selected for the outputs when configuring associated 1oo1D Output Groups.

Start %Q (continued)I

I/O mapping for the Diagnostic Block must fall within the non-voted area of the overall I/O maps as shown below. The allowable reference ranges of the non-voted area depend on system configuration settings.



In the example configuration for a 1oo1D Output Block shown previously, the Guard Output on the Diagnostic Block was assigned to reference %Q2065. So in configuring the Diagnostic Block, the reference range must include this point. In this example, the Diagnostic Block uses %Q2065 through %Q2080.



By default, when inserting a new 1oo1D Output Group this reference is the same as %QI reference for the group. <u>One of these two settings **must** be changed before the configuration can be generated.</u>

If you change the number of channels, block type or block mode, it may create an invalid configuration. It may also change other configuration settings for the group. After making such a change, check all group configuration settings carefully. After verifying or editing the items above, you can configure the following:

Hot Standby

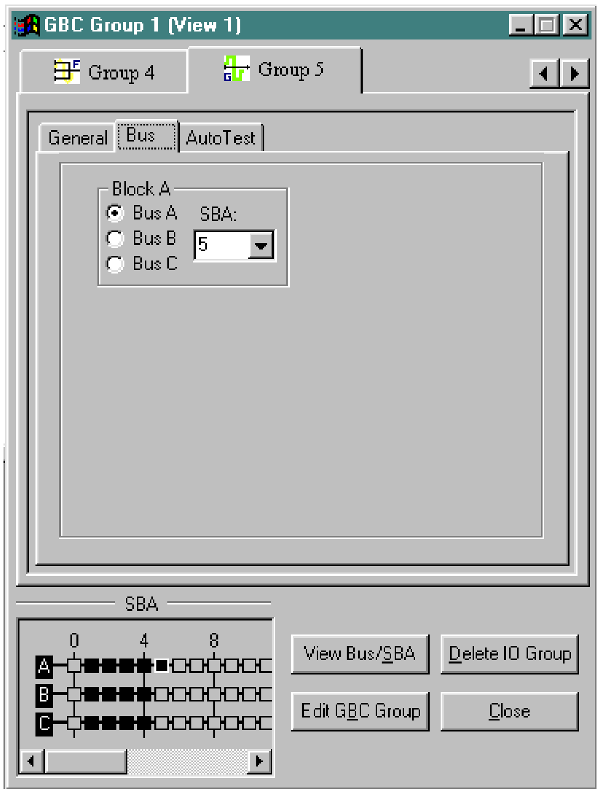
For AC or DC blocks (but not for DC GMR blocks), select whether unused circuits used as outputs will operate in Hot Standby mode. Selecting Hot Standby here configure the blocks to send fault reports to three PLCs.

Output Discrepancy

For “DC GMR” blocks in Mixed or Output Only Block Mode, select whether the System will check and report for output discrepancies.

1oo1D Diagnostic Block, Completing the Bus Tab

The Bus tab is where you can change the bus assignment of the Diagnostic Block. The Diagnostic Block must be on a different bus than the Output Block(s) it controls.

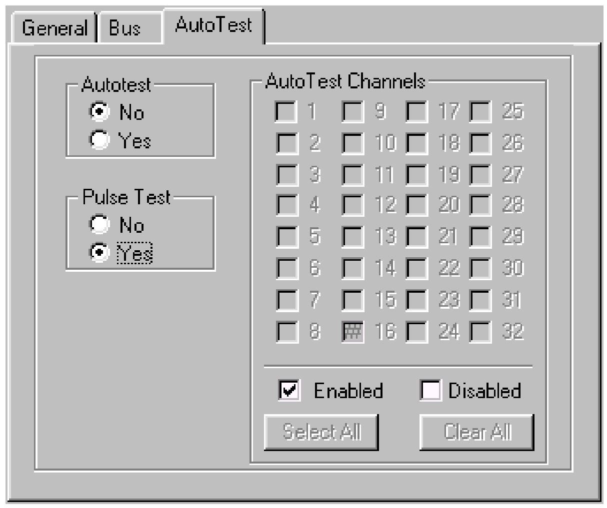


The GMR Configuration Software automatically assigns a Serial Bus Address, indicated at the bottom of the GBC Group window. You can edit both parameters on this tab if necessary.

SBA	The unique serial bus address of the Diagnostic Block on its bus. The GMR Configuration Software supplies the next available SBA. You can change it to any available SBA (shown as clear boxes in the SBA window).
Bus	The bus the Diagnostic Block is located on.

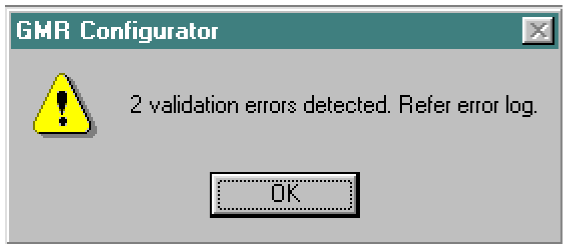
1oo1D Diagnostic Block, Completing the AutoTest Tab

For the Diagnostic Block, set Autotest to No, and Pulse Test to Yes. When Pulse Test is selected, it applies to all outputs on the block.

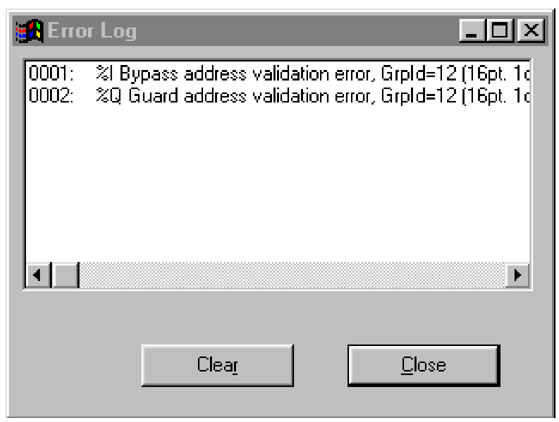


Validating the Configuration

After completing the GMR configuration, select Validate Configuration in the Tools Menu. Validation will check the configuration for errors, and report any that have occurred so you can fix them.



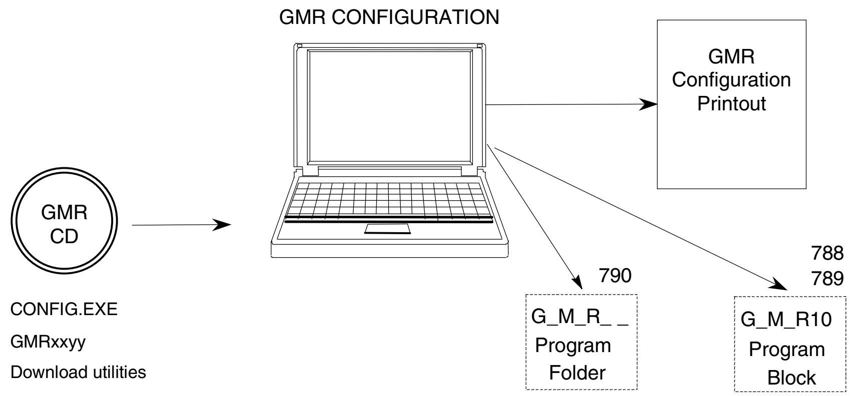
The error log describes the errors and gives their location.



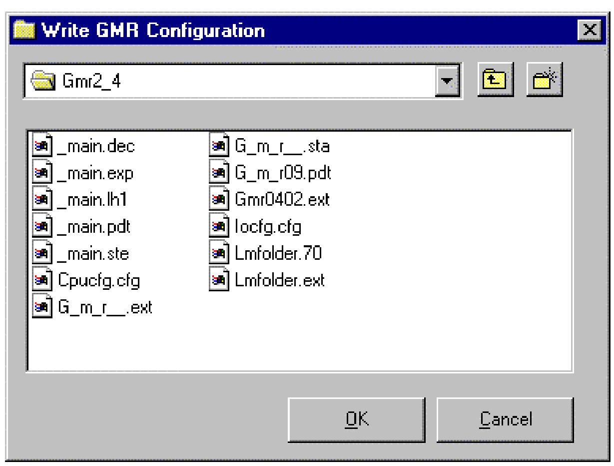
Creating a Run-Time Configuration

After completing the configuration entries and resolving any errors, you can create a Run-Time configuration. For 790 CPUs, after creating the GMR configuration software as described in this chapter, you will generate output to the Logicmaster 90 program folder containing the GMR System Software and application program. The Logicmaster folder must already have been created.

For 788 and 789 CPUs, the GMR configuration software outputs a program block file named G_M_R10.EXE. This program block must be added to the folder containing the GMR System Software and the application program. By default, this file is located in the GMR Configuration Utility subdirectory.

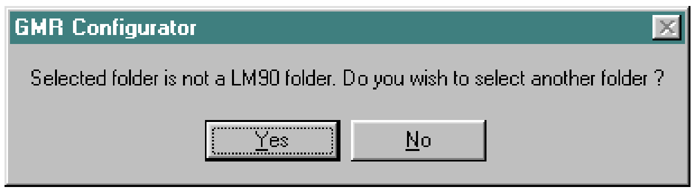


To create a Run-Time Configuration, in the Tools menu, select Create Run-Time Configuration. The GMR Configuration Software compiles your entries and creates an output file.



Instructions for a Model 790 CPU

When the Write GMR Configuration window opens, select the Logicmaster 90 folder where you want to place the file. If you do not select a Logicmaster 90 folder, the GMR Configuration Software will not write the output file. If you do select a Logicmaster 90 folder, the configuration software will automatically add the GMR configuration to the Logicmaster folder and create a run-time configuration.



Instructions for a Model 788 or 789 CPU

If the configuration is for a CPU 788 or 789, the GMR Configuration Software will write an output file with the name g_m_r10.exe to another folder location. Follow the instructions in chapter 11 to add it to the Logicmaster 90 configuration.

Chapter 7

Completing the PLC Configuration for GMR

In a GMR system, there are three basic configuration steps:

- Creating the GMR configuration using the GMR configuration software. This should be done before the PLC or Genius configuration. GMR configuration steps are described in chapter 5.
- Completing the Series 90-70 PLC configuration, as described in this chapter.
- Completing the Genius device configuration. See chapter 8 for details.

Use the GMR Configuration as a Reference

Before beginning the PLC configuration, you should complete the GMR configuration as instructed in chapter 6. The GMR configuration sets up the parameters that will be used by the system, *including reference addresses*. Print the completed GMR Configuration and use it as a reference while working on the PLC configuration.

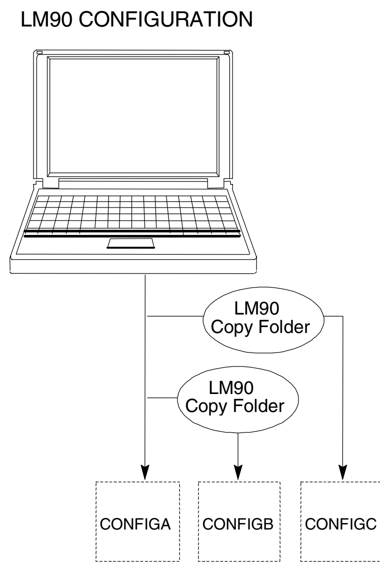
```
Utility Version:     08.05
Report Date/Time :   13-Jun-00 16:51:36
Configuration File:  C:\Program Files\GMR Configurator\exampleconfig.gcf
File Revision:       8
CRC Checksum:        EE94

                         SYSTEM CONFIGURATION

SYSTEM
      Description
            Default GMR Config
      Processors
            CPU Model:                      IC697CPM790
            Number of CPU's:                          3
            Watchdog Setting:                      1000 msec
            Simplex CPU Shutdown:              Disabled
            Simplex CPU Shutdown Timeout:           n/a mins
            On-line Programming:                Enabled
            Input Discrepancy Filter:                 1 secs
            Output Discrepancy Filter:                0 secs
            Autotest Register:                  %R00001
            Autotest Interval:                     1440 mins
            I/O Shutdown Timeout:                  1440 mins
      Voted Discrete Input Reference Limits
            Total:                                 2048
            Used:                                    16
            Free:                                  2032
      Redundant Output Reference Limits
            Total:                                 2048
            Used:                                    64
            Free:                                  1984
      Non-Voted Discrete I/O Reference Limits
            Total:                                 2048
            Used:                                    16
            Free:                                  2032
      Physical Discrete I/O Point Limits
            Total:                                12288
            Used:                                   224
            Free:                                 12064
```

Creating and Copying the PLC Configuration

All redundant PLCs in the GMR system normally use the same application program, but slightly different configurations:



Because the configuration and program for the redundant PLCs in a GMR system are nearly identical, it is easiest to complete the PLC configuration for one PLC, then copy that configuration and edit the copies for the other PLCs.

A. Create a Folder for PLC A, PLC B, and PLC C. In this discussion, PLC A is considered to be the PLC using serial bus address 31, PLC B is the one that uses serial bus address 30, and PLC C is the one that uses 29.

B. Select the folder for PLC A. With the GMR configuration printout as a reference, complete its Logicmaster configuration. Summary steps are described on the following pages.

C. After completing the configuration for PLC A, use the Copy Folder feature of the Logicmaster 90 programming software to copy the configuration of PLC A to the folders for PLC B and PLC C.

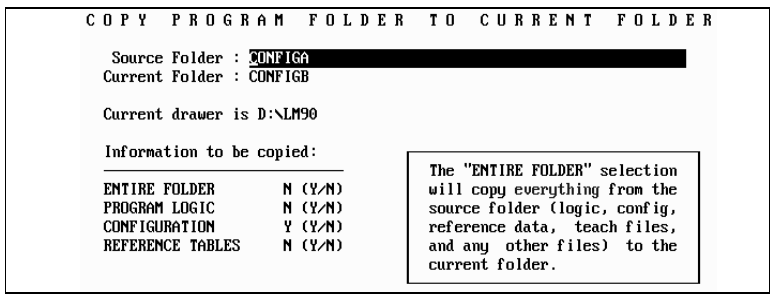
(1) From the Logicmaster configuration software, return to the Logicmaster programming software. Select the Program Folder functions.

(2) In the Program Folder functions menu, select **F1 ... Select/Create a Program Folder**. On the Select/Create screen, select the folder for the second PLC (for example CONFIGB) as the current folder.

(3) In the Program Folder functions menu, select F10, **Copy Contents of Program Folder to Current Program Folder.** On the Copy Folder screen:

(a) For Source Folder, enter the name of the folder containing the configuration of PLC A (for example, CONFIGA).

(b) For **Information to be copied:** set only **Configuration** to yes.



D. If there are three PLCs, repeat this for the other PLC.

E. Return to Logicmaster configuration and edit the configurations for PLC B and PLC C. For example, update and revise the bus controller serial bus addresses and Global Data send and receive addresses for the additional PLCs.

CPU Configuration for GMR

In general, the Logicmaster 90 configuration steps for a PLC in a GMR system are the same as for a non-GMR system. Refer to the *Logicmaster 90 Software User's Manual* (GFK-0263) for detailed configuration instructions.

Special Configuration Requirements for GMR

When competing the CPU configuration, make the following selections for GMR:

- In the Logicmaster configuration, select rack 1 slot 0 (the CPU slot) and press F10 to display the CPU detail screen.
- Press CPU (F1) to display a list of CPU modules. Select the CPU module type being used in the GMR system (790, 789, or 788), and press the Enter key. Replace displayed module (Y).
- If the CPU includes memory expansion, configure the memory by selecting the appropriate memory module in the same way.
- Press Rack (shift F1) or the ESC key to return to the rack display.
- Zoom into the CPU slot to display the CPU detail screen.
- In the CPU configuration, on the CPU detail screen, set the CPU Sweep mode to Normal (the default).
- In the CPU configuration, on the CPU detail screen, change the background task time from the default (0) to some non-zero value. (This is a requirement for applications that require TÜV approval).

```
Sweep Mode  : NORMAL    Bkgnd Tmr   :   0      msec
Prg Window  : LIMITED   Prg Wnd Tmr:  10      msec
Sysconm Mde: COMPLETE  SysComm Tmr: 255      msec
Chksum Wrds:    16
```

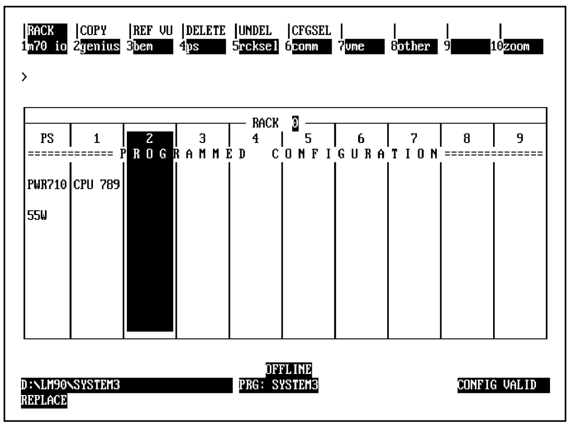
- Other CPU configuration selections can be made as appropriate for the PLC system.

Configuring the Bus Controllers

A Series 90-70 PLC can have up to 31 Genius bus controllers. In a GMR system, bus can optionally perform the dual function of supporting Genius I/O and providing inter-PLC communications. The number of bus controllers supporting GMR functions in a GMR system must be the same in each PLC. Other, non-GMR, bus controllers can be added to an individual PLC configuration.

To configure a Bus Controller:

1. Move the cursor to the rack and slot location for the first Bus Controller.

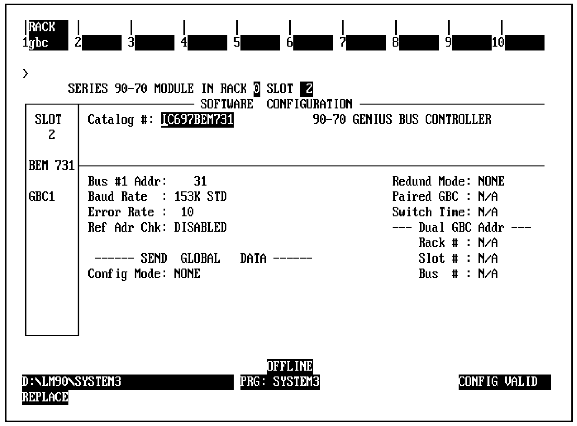


2. Be sure the location matches the entry made with the GMR Configuration Software.
3. Press F2 (Genius).
4. From the Catalog # screen, press F1 (GBC).
5. From the Description screen, press Enter.

Complete the Bus/Bus Controller configuration as described in this section.

Each bus controller that serves the same input and/or output groups is configured similarly; so it is usually easiest to copy the first completed bus/bus controller in a group to configure the other bus controller(s) in the same group. Any additional changes can be made to the individual bus controller/bus configurations as needed (for example, to accommodate non-voted I/O on a bus, or the "D" block of an H-Block Output Group.)

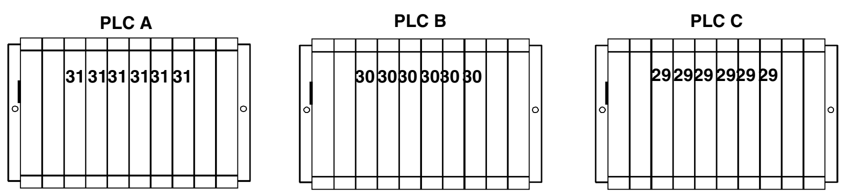
Configure the Bus Controller's Serial Bus Address



Configure the Serial Bus Address to match the address set up in the GMR configuration. *Remember that in an individual PLC, all GMR Bus Controllers use the same serial bus address (device number)*:

PLC A bus address 31
PLC B bus address 30
PLC C bus address 29

For example, if the system consists of three PLCs with two triple-bus GMR I/O subsystems, each PLC would require six bus controllers. All six in PLC A would have to be configured at bus address 31, all six in PLC B at bus address 30, and all six in PLC C at bus address 29.



Configure Other Bus Controller Parameters

On the Bus Controller configuration screen:

1. Leave the **Ref Adr Chk** selection disabled (the default).
2. Leave **Redund Mode** set to NONE. The entries below it cannot then be edited.
3. *If this Bus Controller was configured in the GMR COMMS tab of the System window of the GMR Configuration Software* as one of the two GMR communications GBCs, then set the field for **Config Mode** to MANUAL.

   Refer to the GMR configuration printout to find the beginning %R reference that will be used for Global Data. For example:

Inter-PLC Communications

Comms Bus	Rack	Slot
Alpha	0	2
Beta	0	3

Inter-PLC Global Data Communications

PLC A					
Alpha Bus			Beta Bus		
SBA	Ref.	Action	SBA	Ref.	Action
29	%R16193	Rx	29	%R16321	Rx
30	%R16129	Rx	30	%R16257	Rx
31	%R16065	Tx	31	%R16065	Tx

PLC B					
Alpha Bus			Beta Bus		
SBA	Ref.	Action	SBA	Ref.	Action
29	%R16193	Rx	29	%R16321	Rx
30	%R16065	Tx	30	%R16065	Tx
31	%R16129	Rx	31	%R16257	Rx

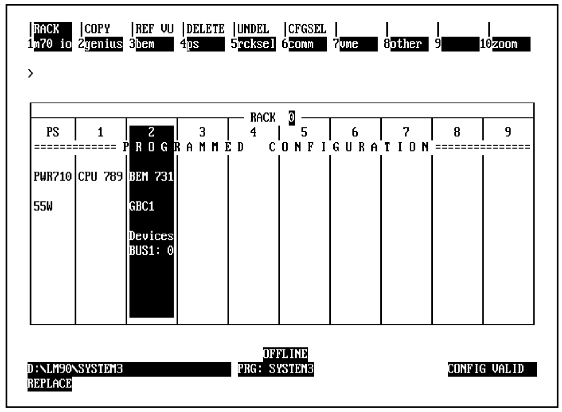
PLC C					
Alpha Bus			Beta Bus		
SBA	Ref.	Action	SBA	Ref.	Action
29	%R16065	Tx	29	%R16065	Tx
30	%R16193	Rx	30	%R16321	Rx
31	%R16129	Rx	31	%R16257	Rx

   Enter that %R reference on the Logicmaster Bus Controller configuration screen. Enter a length of 64 for the global data.

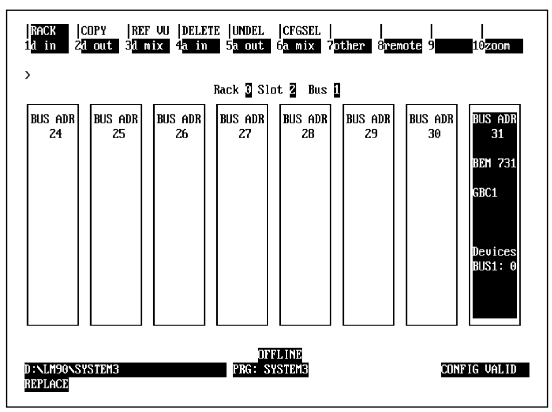
4. Press the ESC key to return to the rack configuration screen.

Configure the Devices on the Bus

The rack configuration now includes the Bus Controller.



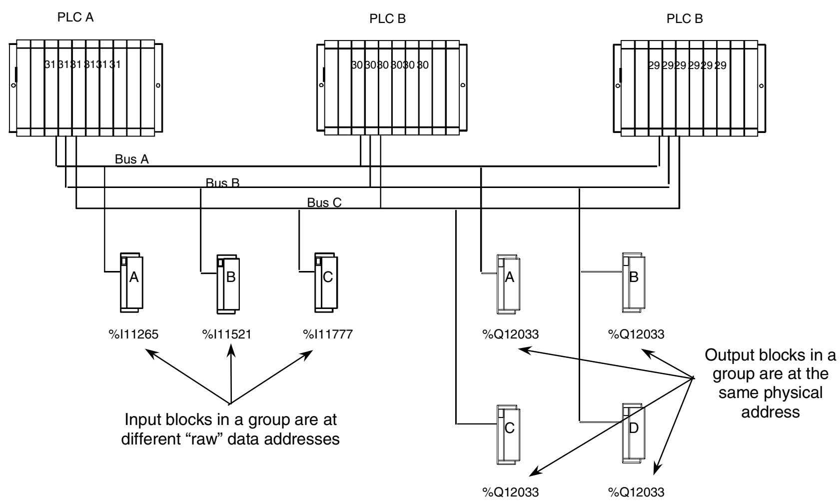
1. From the rack configuration screen, press F10 (zoom) to go to the bus configuration screen.
2. On the bus configuration screen, the Bus Controller appears at its configured Bus Address, 31 in this example.



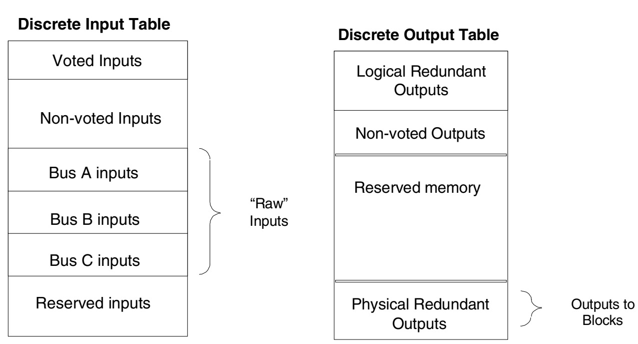
3. From here, you can configure the devices on the bus, including the other Bus Controllers in the group.
   - Each Bus Controller must be configured both individually and as a device on the bus of the other Bus Controller(s) on the same bus.
   - The Bus Controllers on a GMR communications bus must be configured with an appropriate Global Data address and length.
   - VersaMax and Field Control I/O Stations must be configured as “Generic” I/O on the bus.

Configuring the Other Devices on the Bus

GMR voted *input* blocks in a group each have a unique raw data address on each bus in the same PLC. GMR redundant *output blocks* in a group have the same reference addresses on each bus in the group.



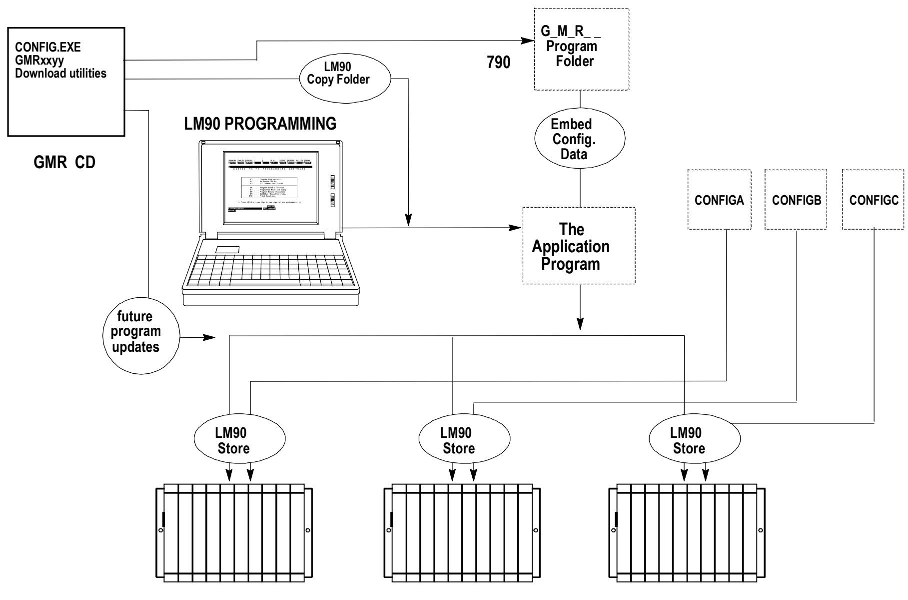
For input blocks in a voted GMR group, the I/O addresses configured on the Logicmaster software screens are for the “raw” input data received directly from the blocks (for the A, B and C areas of the discrete and analog input tables, as shown below. See chapter 5 for more information.



For output blocks in GMR groups, the output addresses configured in Logicmaster are for the physical redundant output data (not the logical addresses used in the application program). These addresses are produced by the GMR Configuration Software, and are listed in the configuration printout.

Non-voted I/O blocks and I/O Stations use the non-voted areas of memory, as shown above for discrete I/O. Use the references listed in the GMR configuration printout.

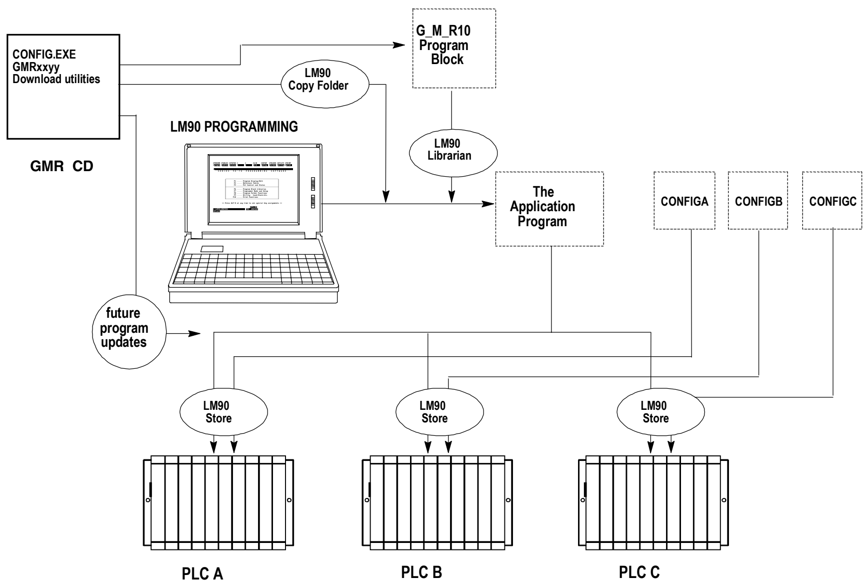
Combining the GMR Configuration and the Application Program: 790 CPU



The GMR configuration software updates the application program folder by embedding the configuration data in the G_M_R_-_ standalone program.

1. Enter the Logicmaster programming software and go to the folder functions. Create a new Program Folder, such as GMRPROG.
2. Add the GMR system software to the new program folder.
3. Using the Copy Folder feature of Logicmaster, copy the GMR system software folder GMRxxyy to the new program folder.
4. The application program can now be added to this folder. It can be newly-created and edited into the folder, or imported via the library.
5. Start up the GMR Configuration software. Open the configuration file and select Create Runtime Configuration and generate its output to the new folder.
6. After completing the application program and the configuration(s), store them to the PLCs. Supplying the configuration and program as separate files makes it easier to perform program updates in the future.

Combining the GMR Configuration with the Application Program: 788/789 CPU



The GMR configuration software outputs a program block file named G_M_R10.EXE, which must be added to the folder with the application program. By default, this file is located in the GMR Configuration Utility subdirectory.

1. Enter the Logicmaster programming software and go to the folder functions. Create a new Program Folder, such as GMRPROG.
2. Add the GMR system software to the new program folder.
3. Using the Copy Folder feature of Logicmaster, copy the GMR system software folder GMRxxyy to the new program folder.
4. The application program can now be added to this folder. It can be newly-created and edited into the folder, or imported via the library.
5. Start up the GMR Configuration software. Open the configuration file and select Create Runtime Configuration and generate its output to the new folder.
6. Add the external program block containing the GMR configuration parameters (G_M_R10) to the LM90 library, using the Logicmaster librarian as described on the next page.
7. After completing the application program and the configuration(s), store them to the PLCs. Supplying the configuration and program as separate file makes it easier to perform program updates in the future.

Using the Logicmaster Librarian: 788/789 CPU

To add the G_M_R10 program block to the application program folder, use the Librarian function of the Logicmaster software. There are two basic procedures:

- Add G_M_R10 to the Logicmaster librarian.
- Import G_M_R10 from the Librarian to the application Program Folder.

Adding GMR_10 to the Logicmaster Librarian

1. In the Logicmaster 90 software, select Program Block Librarian. **Press F6 from the Programming Software menu.** The Librarian menu appears:

```
L I B R A R I A N   F U N C T I O N S

F2  ... List Contents of Library
F3  ... Import Library Element To Folder
F4  ... Import Library Block To Folder and Redefine Variables
F5  ... Export Folder Element To Library
F6  ... Add Element To Library
F7  ... Create/Edit Reference Offset Templates
```

2. Select F6 (Add Element to Library).

```
A D D   E L E M E N T   T O   L I B R A R Y

NEW ELEMENT: D:\GMR\G_M_R10.EXE
ELEMENT TYPE: EXTERNAL BLOCK (PROGRAM BLOCK, EXTERNAL BLOCK, PROGRAM SEGMENT)
RENAME TO:
CURRENT LIBRARY: D:\LM90\P70_LIB

<< Type full path for new element; Press Enter to add element to library. >>
<< Use PgUp/PgDn to scroll list of existing elemnts. >>
```

3. Type the full path and name of the G_M_R10.EXE file that was created with the GMR configuration software. **You must enter a valid path and filename before you can exit this field. For example:** D:\GMR\G_M_R10.EXE.
4. Select “External Block” as the Element Type. Press the Tab key to display “External Block” in the Element Type field, as illustrated above. ***Do not*** rename the file. Be sure the selection for “Current Library” is the correct destination for the file.
5. Add G_M_R10 to the library **by pressing the Enter key.**
6. When prompted for the number of paired input and output parameters, enter 2.
7. Press ESC to return to the Librarian menu.

Importing G_M_R10 from the Librarian to the Application Program (788/789 only)

After G_M_R10 has been added to the Librarian, it can be imported to the Program Folder that contains the application program at any time.

1. From the Librarian menu, select Import (F3).

```
                L I B R A R I A N    F U N C T I O N S

F2  ... List Contents of Library
F3  ... Import Library Element To Folder
F4  ... Import Library Block To Folder and Redefine Variables
F5  ... Export Folder Element To Library
F6  ... Add Element To Library
F7  ... Create/Edit Reference Offset Templates
```

2. In the upper window on the Import screen, select G_M_R10 from the files available in the Librarian.

```
     I M P O R T   L I B R A R Y   E L E M E N T   T O   F O L D E R

RENAME TO:  _
CURRENT LIBRARY:  D:\LM90\P70_LIB

G_M_R_10

CURRENT FOLDER:  D:\LM90\GMRPROG

MYBLOCK

<< Use cursor keys to select a library element.  Press Enter to start Import. >>
<< Use PgUp/PgDn to scroll library.  Use Ctrl-PgUp/Ctrl-PgDn to scroll folder.>>
```

The lower window lists the blocks currently in the selected folder.

Caution

Be sure you want to import the element before you continue. If you abort an import operation, it is not always possible to completely restore the folder to its original contents.

3. DO NOT RENAME G_M_R10.
4. Press the Enter key to begin the operation.
5. The original GMRxxyy folder contains a “null” G_M_R10 Program Block. This causes the prompt “Import G_M_R10, Replacing Element in Folder?”-Enter Y for Yes.

Chapter 8 Completing the Genius Configuration for GMR

In a GMR system, there are three basic configuration steps:

- Creating the GMR configuration using the GMR configuration software. This should be done before the PLC or Genius configuration. See chapter 6 for instructions.
- Completing the Series 90-70 PLC configuration. See chapter 7 for details.
- Completing the Genius device configuration, as summarized in this chapter.

What the Genius Configuration Does

The Genius device configuration defines the operating characteristics of each Genius I/O block, VersaMax I/O Station, and Field Control I/O Station in the overall system.

The Genius configuration is usually completed last, which makes it possible to take advantage of serial bus addresses, reference addresses and other information already developed for the GMR configuration and the PLC configuration. Use a copy of the GMR configuration as a reference during Genius device configuration to assure consistency.

The information in this chapter summarizes specific Genius configuration requirements for I/O blocks and I/O Stations in a GMR system. Use this information in conjunction with the data descriptions and configuration instructions provided in the I/O block and I/O Station product documentation. In addition to the product datasheets shipped with many modules, you will find configuration details in the following user manuals:

For more information about Configuring:	Use this Manual:
Bus Controllers	*Series 90-70 Genius Bus Controller User's Manual* (GFK-0398)
Genius I/O blocks	*Genius Discrete and Analog Blocks User's Manual* (GEK-90486-2)
A VersaMax I/O Station	*VersaMax Genius NIU User's Manual* (GFK-1535)
A Field Control I/O Station	*Field Control Genius BIU User's Manual* (GFK-0825) *Field Control I/O Modules User's Manual* (GFK-0826)

Configuration Guidelines for All I/O Device Types

Make the following configuration selections for all I/O devices in the GMR system:

Serial Bus Address (Device Number)	Use the Serial bus Address from the GMR Configuration
Bus Locations	Use the bus assignments set up in the GMR configuration.
Reference Address	Use the Reference Addresses from the GMR Configuration.
Baud Rate	All devices on a bus must use the same baud rate. The baud rate should be selected on the basis of the calculations in the *Genius I/O System and Communications User's Manual* (GEK-90486). For correct autotesting in a GMR system, the Genius bus scan time should not be more than 60mS.

Configuring Genius I/O Blocks

Configuring Genius devices for a GMR system is similar to configuration for a non-GMR system. Use the basic block configuration information for configuring analog input blocks and non-voted blocks in the GMR system.

Copying Block Configurations with a Hand-held Monitor

Because the blocks in a voted input or redundant output group usually have the same configuration, it would be most convenient to copy configuration from one block to another. However, the Copy Configuration feature of the Genius Hand-held Monitor only works when blocks are online on the same bus (and GMR blocks in a group are on separate busses). It is possible to use the Copy Configuration feature between similar blocks on a bus that are not in the same group.

Configuration Requirements for Discrete Genius Blocks

Block I/O Type	In a voted input group (triplex, duplex, or simplex) that will be autotested, configure each block as a “combination” (I/O) block In an output group, configure each block as an outputs-only block
Pulse Test for Outputs	In an input group, disable Pulse Test unless the blocks have output circuits you need to pulse test, as is the case for input autotest. For all GMR output blocks, enable pulse testing.
Input Filter Time	Input Filter Time should be set up according to the needs of the application. For an input block with outputs that will be pulse-tested, Input Filter Time must be at least 20mS. On 16-circuit blocks, if any circuits are configured as tristate inputs, configure an Input Filter Time of at least 30mS.
Circuit I/O Type	GMR input circuits on 16-circuit blocks should be configured as tristate inputs to permit short-circuit detection. In a system with normally-energized inputs, short circuit represents Fail to Danger mode. (Short-circuit detection requires the installation of a zener diode in series with the field switch. See chapter 2 for information.) If the block will be set up for Input Autotest, circuit 16 must be configured as an output (regardless of whether it is a 16 or 32-circuit block). On blocks in output groups, all circuits should be configured as outputs. GMR output blocks must not be configured as “outputs with feedback” blocks. GMR fault monitoring provides this feature. On non-voted blocks in the system, circuits can be any mix of inputs and outputs.

Report Faults	Set to YES for all GMR block circuits, usually. However, for 32-point discrete blocks, see the note below. Configuring a block for Redundancy Mode = GMR automatically sets up the block to send three fault reports when a fault occurs; one fault report each to serial bus addresses 29, 30, and 31. The blocks require no further setup to send multiple fault reports. Inputs-only blocks automatically send up to two Fault Reports to serial busses 30 and 31. However, non-GMR output and mixed I/O blocks must be configured for Hot Standby redundancy to send two Fault Reports to serial bus addresses 30 and 31. Note: The standard Genius block fault reporting shall be disabled for 32 point "T" or "H" GMR system configuration output blocks, while the GMR Autotest MUST be enabled. The "Enhanced GMR Autotest" provides the maximum diagnostic coverage possible for circuit and system testing, as calculated for IEC 61508 certification. When the standard 32-point block fault reporting is disabled, the user MUST select the GMR Autotest time interval to be no greater than 8 hours, up to continuous testing (preferred). Without these provisions IEC 61508 will not be met.
Hold Last State	If the block will use Input Autotest, circuit 16 must be configured as an output, as explained above. For circuit 16, configure Hold Last State to NO.
Output Default State	If the block will use Input Autotest, circuit 16 must be configured with Output Default set to ON. An output goes to its powerup default state when the block is first powered up. If Hold Last State was NOT enabled, the block will also default the output if CPU communications are lost. On a single bus, this occurs approximately 250mS after the third bus scan passes with no CPU communications.
Detect No Load	By default, each block is configured to report No Load diagnostics. Energizing the output activates a no-load current level. If the load does not continuously draw 50mA or more from the output circuit, the block sends a No Load diagnostic. This diagnostic should be disabled for any output where a very small load will draw less than 50mA. Note that blocks in an H-Block Output Group and blocks in a T-Block Output Group require 100mA minimum.
Overload Shutdown	Overload Shutdown protects output loads, field wiring, and switching devices. If a load exceeds 2.8 amps DC for 100mS and Overload Shutdown is enabled, the block turns the output off and sends an Overload diagnostic. For a load that draws more than 2 amps DC, this diagnostic can be disabled, but only if: Maximum load current: 5 amps Maximum duty cycle: (load current) x (% ON) =less than 1.0 amp Maximum ON time: 1 minute Maximum total load current with all outputs on = less than 16 amps
BSM Present	Should be set to No.
BSM Controller	N/A
Output Default Time	N/A

Redundancy Mode

For 16-circuit and 32-circuit DC blocks, select GMR mode for blocks that will be part of GMR input or output groups. GMR mode can be selected even if there is just one block in an input group, if it should use the extra diagnostics capabilities provided by GMR.

Select no redundancy for non-critical individual blocks that do not require any type of redundancy.

Select duplex CPU redundancy for blocks on a bus with two PLCs. This is not the same as duplex GMR redundancy. Conventional duplex CPU redundancy, which is described in the Genius I/O System User's Manual does not provide autotesting, or the other special features of GMR described in this book.

Hot standby CPU redundancy can be selected for blocks in a GMR system. Instead of voting on CPU output data, blocks that are set up for hot standby mode give preference to outputs received from bus controller 31. Should outputs from 31 fail, a block in hot standby mode starts using outputs received from bus controller 30. Finally, should outputs from 30 fail, the block will use outputs from bus controller 29. (Only the specific types of enhanced 16-circuit and 32-circuit DC discrete blocks listed in this book are capable of receiving outputs from bus controller 29. Other types of blocks can only receive outputs from bus controllers 30 and 31.)

Duplex Default

For output blocks set up for GMR redundancy, the duplex default state is used when a block determines that only two PLCs are online. The Duplex Default state of On or Off is used by the 2 out of 3 voting algorithm in the block, instead of the state that would have been supplied by the third PLC. The Duplex Default state determines whether voting will be 1 out of 2 or 2 out of 2 in the On or Off state when only two PLCs are providing outputs.

Configuring a VersaMax I/O Station

The NIU and I/O Station can be autoconfigured, or configured using the NIU configuration utility. Autoconfiguration utilizes the default features of the input modules in the I/O Station, which are suitable for many applications. If any of the default features must be changed, the NIU Configuration utility is required. For more information about these options, please refer to the *VersaMax Genius NIU User's Manual* (GFK-1535). Descriptions of specific module features are in the *VersaMax Modules, Power Supplies, and Carriers User's Manual* (GFK-1504).

Configuring a VersaMax Genius NIU

The Serial Bus Address and baud rate are set using the rotary switches on the front of the module. Instructions are in the *Genius NIU User's Manual.* Refer to GMR Configuration and use the same Serial Bus Address here. The baud rate must match that of the other devices on the bus.

Additional configurable features of the NIU are listed below.

Report Faults	Set to YES (the default). The NIU will automatically send up to two Fault Reports to serial busses 30 and 31.
BSM Present	Should be set to No (default).
BSM Controller	N/A (defaults to no).
Output Default Time	Not applicable (defaults to 2.5 seconds).
Redundancy Mode	Select no redundancy (the default) for a VersaMax I/O Station with analog input modules.
Duplex Default	Not applicable for analog inputs

Configuring I/O Data in a VersaMax I/O Station

The analog modules that may be in a Field Control I/O Station in a GMR system have the data requirements listed below.

	%AI words
IC200ALG230: Analog Input Module, 12-Bit Voltage/Current, 4 Channels	4
IC670ALG240: 16-Point Grouped Analog Input Module	8
IC200ALG620: Analog Input Module, 16-Bit RTD, 4 Channels	4

If the I/O Station is autoconfigured, modules are automatically assigned reference addresses in ascending order. For the NIU, these reference addresses are assigned within its own memory tables. References start at 0001 within each memory type.

Discrete Inputs Begin at I00001 (bit data)

Discrete Outputs Begin at Q00001 (bit data)

Analog Inputs Begin at AI0001 (word data)

Analog Outputs Begin at AQ0001 (word data)

These reference addresses are used locally by the Network Interface Unit. They do not need to match the addresses assigned in the GMR configuration.

Configuring VersaMax I/O Module Parameters

A GMR analog input group can include the following VersaMax analog input modules:

IC200ALG230: Analog Input Module, 12-Bit Voltage/Current, 4 Channels.

IC200ALG260: Analog Input Module, 12-Bit Voltage/Current, 8 Channels.

These two modules have no configuration parameters. Selection of voltage or current operation, and selection of unipolar or bipolar operation in voltage mode are done using jumpers on the module's terminal assembly. With no jumpers installed, both modules operate in +/-10V mode. Corresponding modules in all VersaMax I/O Stations in a GMR input group must use the same jumper settings.

IC200ALG620: Analog Input Module, 16-Bit RTD, 4 Channels. This module has several configurable parameters. If the default selections are correct for an application, the module can be autoconfigured. Otherwise, the NIU Configuration utility must be used to configure the module.

Configuring a Field Control I/O Station

The BIU and I/O Station must be configured using a Genius Hand-held Monitor as described in the *Field Control Genius BIU User's Manual* (GFK-0825).

Configuration for an analog module includes selecting parameters such as voltage or current operation and scaling. For an RTD or thermocouple module, there are additional parameters related to RTD and thermocouple operation. These basic configuration parameters are the same for GMR and conventional applications.

Configuring a Field Control Genius BIU

Refer to GMR Configuration and use the same Serial Bus Address here. The baud rate must match that of the other devices on the bus.

Additional configurable features of the BIU are listed below.

Report Faults	Set to YES (the default). The NIU will automatically send up to two Fault Reports to serial busses 30 and 31.
BSM Present	Should be set to No (default).
BSM Controller	N/A (defaults to no).
Output Default Time	Not applicable (defaults to 2.5 seconds).
Redundancy Mode	Select no redundancy (the default) for a VersaMax I/O Station with analog input modules.
Duplex Default	Not applicable for analog inputs

Configuring I/O Data in a Field Control I/O Station

The Field Control Bus Interface Unit operates as a "block" on the Genius bus, exchanging up to 64 words of discrete and/or analog inputs and 64 words of discrete and/or analog outputs each bus scan. An important part of the configuration process is understanding reference allocation and properly assigning reference addresses for the Bus Interface Unit.

The analog modules that may be in a Field Control I/O Station in a GMR system have the data requirements listed below.

As the table indicates, although a Field Control I/O Station can include up to 8 modules, the actual number that can be used may be limited by the Genius maximum data length. For example, an I/O Station could only include four 16-point analog input modules if all their inputs were used, and it would still be necessary to configure a length of 0 for their %I discrete input bits (the default length is 88 bits).

	%I bits	%AI words	%Q bits	%AQ words
IC670ALG230: Current Source Analog Input Module	0	8	0	0
IC670ALG240: 16-Point Grouped Analog Input Module	88 (optional, configurable)	16	16 (optional, configurable)	0
IC670ALG620: RTD Analog Input Module	32 (optional, configurable)	4	8 (optional, configurable)	0
IC670ALG630: Thermocouple Analog Input Module	48 (optional, configurable)	8	16 (optional, configurable)	8

The %I and %Q bits that are listed as optional and configurable are intended for exchanging diagnostics and control data with a PLC. In a GMR system, the optional %Q control bits, which permit an application program to clear individual circuit faults, can be used, but they must be mapped to the non-voted area of %Q memory.

For more information about module data, please refer to the individual module descriptions in the *Field Control I/O Modules User's Manual* (GFK-0826).

Chapter 9 Programming Information for GMR

This chapter describes some general programming considerations in a GMR system.

- The Instruction Set for GMR Programs
- Application Program Size
- Programming for Startup
- Programming Data Exchange between the PLCs
- Monitoring/Clearing Faults in a GMR System
- Using I/O Point Fault Contacts
- Using Fault and Alarm Contacts for GMR
- Checking for Discrepant Outputs
- Detecting I/O Forces and Overrides
- Programming for a 1oo1D Output Group
- Programming Associated with I/O Shutdown
- Reading Sets of Diagnostic Data
- Reporting the GMR Version and Checksum to the PLC Fault Table
- Combining the GMR Configuration and the Application Program: 790 CPU
- Combining the GMR Configuration and the Application Program: 788/789 CPU
- Adding the GMR System Software to the Application Folder

9

The Instruction Set for GMR Programs

The Series 90-70 PLCs used for GMR support these ladder logic instructions:

Contacts	***Coils***	***Bit Operation***	***Conversion***	***Control***	***Data Table***	***Data Move***
Any Contact	Any Coil	AND	to BCD-4	CALL	TBLRD	MOVE
-| |-	-( )-	OR	to BCD-8	DOIO	TBLWR	BLKMOV
-|/|-	-(/)-	XOR	to UINT	SUSIO	LIFORD	BLKCLR
-|#|-	-(#)-	NOT	to INT	MCR	LIFOWRT	SHFR
-|∃|-	-(∃)-	SHL	to DINT	ENDMCR	FIFORD	BITSEQ
-[FAULT]-	-(S)-	SHR	BCD-4 to UINT	JUMP	FIFOWRT	SWAP
-|NOFLT]-	-(r)-	ROL	BCD-4 to INT	LABEL	SORT	COMMREQ
-[HIALR]-	-(SM)-	ROR	BCD-8 to DINT	COMMENT	ARRAY_MOVE	VMERD
-[LOALR]-	-(RM)-	BTST		SVCREQ	SRCH_EQ	VMEWRT
<+>---	-(M)-	BSET		PIDISA	SRCH_NE	VMERMW
	-(/M)-	BLCR		PIDIND	SRCH_GT	VMETST
	---<+>	BPOS		FOR	SRCH_GE	VME_CFG_RD
		MCMP		END_FOR	SRCH_LT	VME_CFG_WRT
				EXIT	SRCH_LE	DATA_INIT
Timers	***Counters***	***Links***	***Relational***	***Math***		DATA_INIT_COMM
ONDTR	UPCTR	Horizontal	EQ	ADD		DATA_INIT_ASCII
OFDT	DNCTR	Vertical	NE	SUB		
TMR			GT	MUL		
			GE	DIV		
			LT	MOD		
			LE	SQRT		
			CMP	ABS		

Programming Restrictions for GMR

Do Not Program Do I/O and Suspend I/O: The Do I/O and Suspend I/O program functions can interfere with the output autotest. They should not be used in any GMR application program.

Do Not Pulse Test Outputs from the Application Program: The application program must not command pulse testing on GMR outputs.

Programming Guidelines for TÜV Applications

Some of the program instructions listed above cannot be used for a GMR system in an application for which for a TÜV site application approval will be sought. (Note that not all versions of the GMR software have TÜV approval). Please see appendix A for information about restrictions for a program that must meet TUV requirements.

Application Program Size

For the model CPM790 CPU, version 4.02 of the GMR system software consists of two programs:

- The default ladder logic program, which is approximately 19808 bytes.
- The C standalone, G_M_R_ _, which is approximately 217552 bytes. This may not be changed.

  (An additional amount of memory, over 270K, is used for reference memory by GMR. That includes %R, %AI, %AQ, %P, %L, and other internal memory buffers specific to GMR)

There can be up to 16 programs on a CPM790 CPU. No program can exceed 512K in size, and all programs combined cannot exceed the 1 Megabyte memory limit of the CPU module. Of these, only one can be a ladder logic program. Up to fourteen more (non-ladder) programs can be added to the two supplied with the GMR system software. Because the ladder logic provided as part of the GMR system software is approximately 19808 bytes in size, approximately 492K remains available for additional ladder logic. To determine about how much of the memory remains for the ladder logic application program, use this equation (Shift-F3, F9 from Programmer side of Logicmaster):

Max. Ladder Logic Application Program Size = 524,288 bytes – Ladder Logic space already used
(As shipped, GMR 4.02 uses 19,808 bytes of Ladder Logic Space)

This gives available memory under the program size limit, but the following equation must be considered due to the memory limit of the CPU (Shift-F3, F5 from the Programmer side of Logicmaster):

Max. Ladder Logic Application Program Size = 1,048,576 bytes – PLC memory already used - User Reference Tables
(As shipped, GMR 4.02 uses 516,272 bytes of total PLC memory)

The smaller result of the two equations determines the space available for the ladder logic program.

For the model 788 and 789 CPUs, program and memory references cannot exceed 512K in size. To determine how much of the 512 Kbyte memory (IC697MEM735) used on the CPU788 and CPU789 remains for the ladder logic application program, use this equation (Shift-F3, F5 from the Programmer side of Logicmaster):

Max. Ladder Logic Application Program Size = 524,288 bytes – PLC memory already used - User Reference Tables
(As shipped, GMR 4.02 uses 457,680 bytes of total PLC memory)

See the *LM90-70 Programming Software User's Manual* (GFK-0263) for information about estimating the reference tables size for a model 788/789 CPU.

Programming for Startup

This section describes the PLCs' startup sequence and gives information about program actions for startup.

The GMR software in the PLCs only allows one PLC to come online at a time.

- First, a PLC determines its ID by reading the serial bus addresses of the GMR Bus Controllers (PLC A = 31, PLC B = 30, PLC C = 29).
- It then sets the corresponding PLC Identification status bit: %M12225 for PLC A or %M12226 for PLC B, or %M12227 for PLC C.

While a PLC is initializing, the GMR software automatically sets the Inhibit status flag (%M12231). This Inhibit flag keeps the application program from executing until initialization is complete. It also disables the PLC's outputs. If outputs do not disable successfully, the GMR software automatically stops the PLC.

If the initializing PLC is PLC C, the GMR software automatically commands any discrete Genius blocks configured for Hot Standby operation to accept outputs from the PLC at serial bus address 29. If this function fails to complete successfully, the GMR software sets the System status flag (%M12234) to 1.

During initialization, a PLC communicates with the GMR I/O blocks and with Bus Controllers in other PLCs. If any of these communications fails, the GMR software automatically sets status bit %M12234 on (1). This bit indicates System Failure at Powerup.

The application program can use %M12234 as a permissive for continuing and annunciation.

As each PLC starts up, it checks to see whether another PLC is already online and sending outputs.

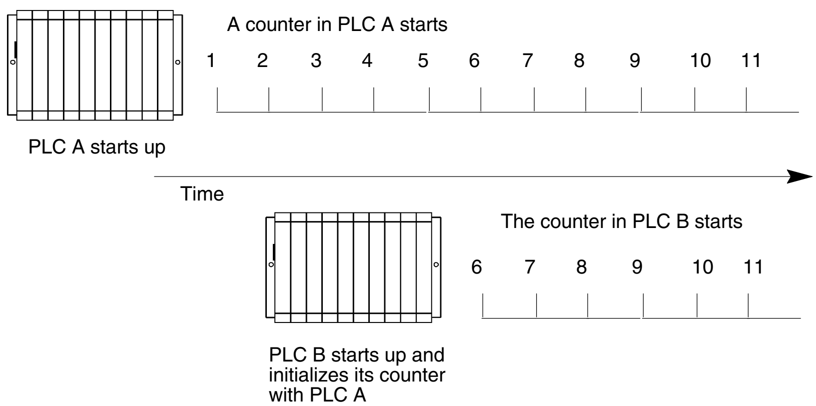
- If not, the PLC sets the Cold Start flag (%M12237).

The application program can use %M12237 to initialize selected memory areas (%R and %M) as appropriate The %M data is typically latched logic states and the %R data is typically timer/counter data.

- If one other PLC is already online (running the application program and transmitting output data), the initializing PLC reads that PLC's initialization data (%M and %R). It places this data into a configurable area of %R memory.

  It may take several CPU sweeps to read all the data from both PLCs. Data is read in quantities of up to 64 words at a time. The data transfer is divided across the busses to minimize the total time required. Therefore the overall time depends on the data lengths and the number of busses available.

- It then sets its own %M and %R initialization data areas to match. This is shown by the following simplified example:



- If both of the other PLCs are already online, the initializing PLC reads the %R (only) initialization data from the other PLC with the higher serial bus address. It then sets its own data to match as shown above.

Each PLC reads data only once. If data in the online PLC changes after the initializing PLC reads it, the change is not noticed. To minimize data differences on continually changing data such as timer and counter accumulators, they should be located at the end (top) of the configured %R memory space. That part of the %R initialization data is copied last. Locating changeable data at the top of the %R data assures that the most recent values are included when the data is copied.

The third initializing PLC also reads any %M (bit) initialization data from *both* of the online PLCs , and compares the two sets of data. If the data does not match, it tries again. After a total of three retries, if the data still doesn't match, the initializing PLC may either:

- Halt the PLC (if this fault is configured as fatal)
- Allow the PLC to continue operating (if it is configured as diagnostic) and set the appropriate %M status flag.

  %M12232 Init Miscompare at startup

  The action taken is determined by the GMR configuration (see page 6-21).

If the initializing PLC is unable to successfully read all the data from the other PLC(s), it sets the flag "SYSFLT" %M12234 (System Fault at Startup) for the application program. The entire initialization sequence then begins again, excluding the Genius bus with which communications failed.

When the PLC completes its data initialization, the GMR software clears the Inhibit status flag (%M12231).

> The application program must use this bit to prevent execution of the program until it has been cleared.
>
> The program should begin executing when the Inhibit flag (%M12331) is cleared to 0. It may then check the startup status, as described next.

Monitoring Startup Status

> Depending on the needs of the application, the program may check the startup status flags before continuing startup. If any is found to be 1, the application program may decide to process the initialized data before continuing.

Checking for Other PLCs Online

If %M12237 (COLDST) is 1, it means a PLC detected no other PLC(s) online when it started up.

> If %M12237 is 1, the application program must initialize its own %M and %R initialization data.

Checking for Discrepant %M Initialization Data

If %M12232 (MISCMP) is 1, it means when the PLC started up, the other two PLCs were already online and running their application programs. When the PLC compared the %M initialization data from the other PLCs, it found a discrepancy.

Checking for Communications

If %M12234 (SYSFLT #) is 1, it means when the PLC started up, it experienced a problem trying to communicate with one of the bus controllers.

Enabling Outputs At Startup

Following initialization, the application program begins to execute. As a result of one or more sweeps through the logic, output data is generated. However, outputs remain disabled, and the output data is not sent on the bus.

> The application program must enable outputs by turning on control bit %M12257 (CONTINUE). This should occur at the *end* of the program, so the outputs have been solved at least once before being enabled.

If outputs fail to be enabled successfully, the GMR software sets the System Fault status flag (%M12235) to 1.

Checking Output States at Startup

As mentioned above, each PLC starts sending outputs when bit %M12257 is set to 1 in its application program. When the first PLC starts sending outputs, its outputs are compared to the configured default states for each output. When each subsequent PLC starts sending outputs, its outputs are compared to the voted output states at each output block group.

If the states do not agree for any output block, status bit %M12240 (LOGONFT) is set to 1.

> The application program can monitor bit %M12240 (LOGONFT). If this bit is 1, the output states do not agree at one ore more output blocks.
>
> If suitable, the application program can set control bit %M12263 (FORCLOG) to 1 (on). That will force the output block groups to vote on and respond to output data from all online PLCs.
>
> If set, the LOGONFT status bit remains set until the I/O fault table is cleared, by setting the IORES control bit (%M12258).
>
> Typically, the FORCLOG and IORES control bits are set through the application program via an operator interface or simple pushbutton wired to an input circuit.

The block ignores the new output data until either:

- voted output states match for the complete output block or
- the application program sets the Force PLC Logon bit as described above.

Force Logon for 1oo1D Output Groups

At system start-up the GMR software automatically turns on (sets to 1) the %Q reference of a guarded output.

If the 1oo1D Diagnostic Block is in GMR mode when the first CPU comes on-line, the commanded output states may not be the same as the Default states programmed in the blocks. Therefore, a Force Logon could be needed to enable the I/O, enabling the Guard Relay output on (1). That provides initial power to the output block if there had been no active 'Diagnostic defeat' bypass.

A Force Logon may also be required by other CPUs when they come online.

Performing I/O Fault Reset

It is very unlikely, but possible, that I/O faults would occur during the initialization (powerup or stop/start cycle) of one of the GMR CPUs. Faults occurring during the initialization of a GMR CPU are reported to that CPU. Therefore it is recommended that an I/O Fault Reset be performed when any of the GMR CPUs are initialized, which will cause any current I/O fault information to be re-reported.

If manual output controls are used in a GMR system and the appropriate GMR Autotest inhibit inputs are used to block faults created by the manual controls, any standard Genius type fault (open, overload, short, etc.) is also blocked during the time the inhibit input is on. It is therefore recommended that after the inhibit input is turned off, an I/O fault reset be performed, which will cause any current I/O fault information to be re-reported.

Powering Down One Output Block for Maintenance

When an output block is powered down for maintenance purposes, a Force Logon may be required when the output block has power restored. That will cause the block to start accepting data from the PLC(s). It is not required if the current output data the PLC(s) is sending matches the output default states at the block. An I/O fault reset should executed after restoring power to a block in an output group.

> The application program can monitor bit %M12240 (LOGONFT). If this bit is 1, the output states do not agree at one or more output blocks.
>
> The application program can set control bit %M12263 (FORCLOG) to 1 (on). That will force the output block to vote on and respond to output data from all online PLCs.
>
> If set, the LOGONFT status bit remains set until the I/O fault table is cleared, by setting the IORES control bit (%M12258).
>
> Typically, the FORCLOG and IORES control bits are set through the application program via an operator interface or simple pushbutton wired to an input circuit.

The block ignores output data until either:

- voted output states match for the complete output block or
- the application program sets the Force PLC Logon bit as described above.

Resetting the %M Startup Flags

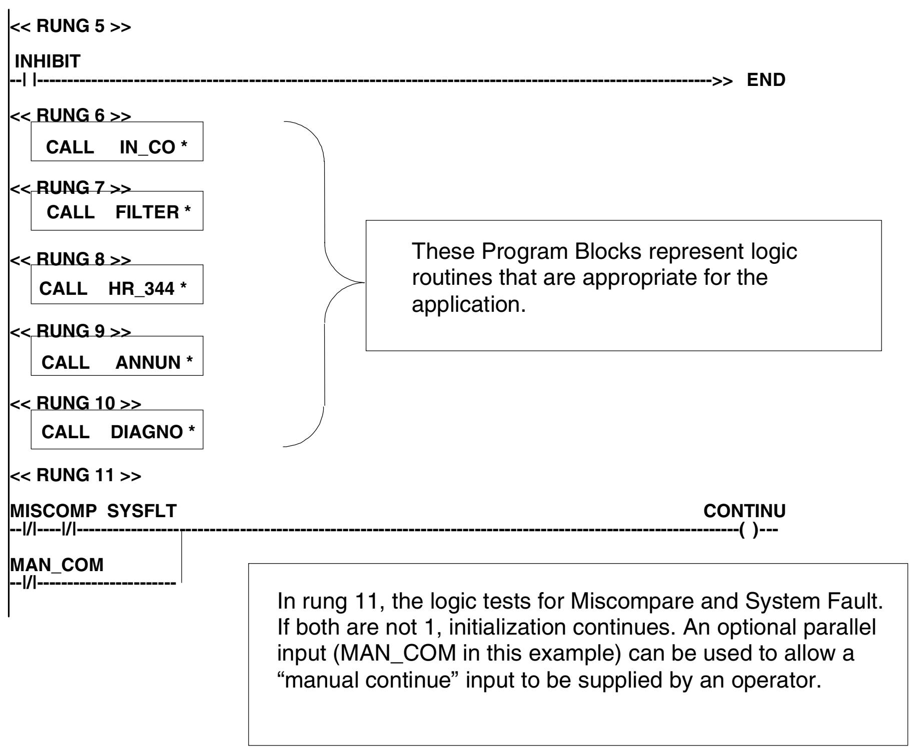
%M startup status flags remain set until the system is restarted or until reset from the application program. To reset a %M Startup bit from the application program, enter 0 in its %M reference.

Example Ladder Logic for Startup

The following example shows some typical program startup logic.

Important Note

This is only an example, to illustrate how the system operates. You will need to modify the logic shown for your application. Also, see Appendix A for TÜV guidelines on using the IORES contact.



```
<<  RUNG 12  >>
IORESIP                                                                 IORES
--|↓ |------------------------------------------------------------------(R)----
```

In rung 12, the transition of IORESIP (I/O Reset in Progress) to the Off state indicates that the requested I/O fault reset has been completed. This rung resets command bit IORES (I/O Reset) to the Off state.

```
<<  RUNG 13  >>
LOGONFT                                                                FORCLOG
--|↓ |------------------------------------------------------------------(R)---
```

In rung 13, the transition of LOGONFT (Logon Fault) to the Off state indicates that the requested I/O fault reset has been completed. This rung resets command bit FORCLOG (Force Logon) to the Off state.

```
<<  RUNG 14  >>
|DUPLEX   LOGONFT                                                      FORCLOG
--|  |----+-|  |-+--------------------------------------------------------(S)---
TRIPLEX   |      |                                                     IORES
--|  |----+      +--------------------------------------------------------(S)---
```

In rung 14, if the GMR system is in DUPLEX mode (two CPUs are online) and a logon fault occurs at an output block, LOGONFT turns on. This turns on the Force Login (FRCLOG) control bit, which forces the output block to accept outputs from the newly-online CPU, even if the output states do not agree with the present voted outputs at the output block. This logic also turns on the control bit IORES (I/O Reset). IORES is required to clear the Logon Fault status bit (LOGONFT). This last action also clears the fault tables in all running PLCs. The TRIPLEX bit is optional; the need for this bit depends on the application. If used, it provides the same type of PLC logon control when a third PLC comes on line.

```
|-END:
```

Caution

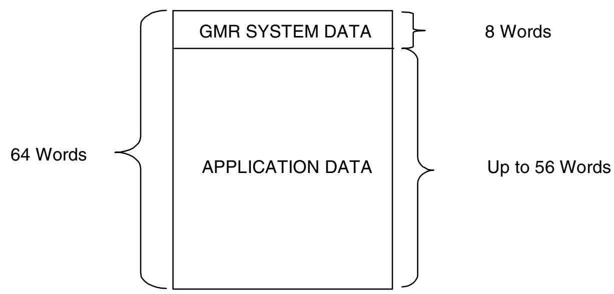
Depending on the application, you may prefer to use only the DUPLEX logic shown above to turn on the FORCLOG (Force Logon) command bit. The purpose of PLC logon control is to prevent a CPU that is coming online from changing the state of a critical voted output. Automatic PLC logon is sensible with the DUPLEX status bit, because it ensures that at least two PLCs are driving output information before outputs that disagree with the voted outputs are used when a system is initially powered up. The third PLC coming online has the ability to change an output state if the first two PLCs are already online and already disagree. Because of this, it may not be suitable to automatically log on the third PLC.

Programming Data Exchange between the PLCs

The GMR system can use Global Data to exchange data among the PLCs. Global Data is automatically broadcast by a PLC bus controller, each bus scan. In a duplex or triplex PLC GMR system, each GMR PLC sends one Global Data message each bus scan.

The GMR Global Data message is 64 words in length. The first 8 words the message are always reserved for GMR system data.

A Global Data Message



The rest of the message can be any data one GMR PLC wants to share with the others. For example, one PLC might send the others information from non-GMR devices, or its current timer and counter states.

Sending this additional application data does not impact the bus scan timing. The Global Data exchange takes the same amount of time whether or not the message includes any application data.

Sending and Receiving Application Global Data

To send data to the other PLCs, the application program in each PLC must place the data in references %G0001 through %G0896. It is not necessary to use all of the references. The program logic should refresh the data in %G memory as often as necessary.		
To access Global Data received from other GMR PLCs or to see a copy of the Global Data sent by a PLC, the application program reads the data from the assigned areas of %GA, %GB, and %GC memory. See below.		
PLC A (SBA 31)	Read copy of transmitted Global Data (SBA 31)	%GA0001-%GA0896
	Read data received from PLC B (SBA 30)	%GB0001-%GB0896
	Read data received from PLC C (SBA 29)	%GC0001-%GC0896
PLC B (SBA 30)	Read data received from PLC A (SBA 31)	%GA0001-%GA0896
	Read copy of transmitted Global Data (SBA 30)	%GB0001-%GB0896
	Read data received from PLC C (SBA 29)	%GC0001-%GC0896
PLC C (SBA 29)	Read data received from PLC A (SBA 31)	%GA0001-%GA0896
	Read data received from PLC B (SBA 30)	%GB0001-%GB0896
	Read copy of transmitted Global Data (SBA 29)	%GC0001-%GC0896

Monitoring/Clearing Faults in a GMR System

In a GMR system, both the PLC Fault Table and the I/O Fault Table are controlled by the GMR System Software, *not* the programmer software. In a GMR system, the fault tables must be monitored and cleared from the application program logic.

The application program can use the special %M references described below to monitor the PLC and I/O Table for faults, and to clear all faults in the PLC Fault Table or I/O Fault Table.

Caution

Do not use the Logicmaster F9 key to clear the Fault Tables.
Fault Table Clearing from the Logicmaster software can be prevented by keeping it in Monitor mode.

Monitoring the Status of the PLC Fault Table

When %S0009 (SY_FULL) is set (1), the PLC Fault Table is full.

When %SC0010 (SY_FLT) is set (1), a new fault has been placed in the PLC Fault Table.

When %SC0012 (SY_PRES) is set (1), there is at least one fault in the PLC Fault Table.

Monitoring the Status of the I/O Fault Table

When %S0010 (IO_FULL) is set (1), the I/O Fault Table is full.

When %SC0011 (IO_FLT) is set (1), a new fault has been placed in the I/O Fault Table.

When %SC0013 (IO_PRES) is set (1), there is at least one fault in the I/O Fault Table.

Clearing the PLC Fault Table

To clear the PLC Fault Table in a single PLC, set reference %M12259 to 1 for at least one PLC sweep.
To clear the PLC Fault Table in all PLCs, set reference %M12264 to 1 for at least one PLC sweep.

Clearing the I/O Fault Table

To clear the I/O Fault Table and corresponding fault contacts in all PLCs, set reference %M12258 to 1 for at least one PLC sweep.
Monitor %M12238 (IORESIP) to determine when an I/O Fault Table reset is complete.

Using I/O Point Fault Contacts

The application program for a GMR system can include the standard Series 90-70 I/O Point Fault references.

The I/O Point Faults feature allocates a bit reference for each potential discrete point fault and a byte reference for each potential analog point fault.

Note that space for these references is taken from the space available for the application logic.

With I/O Point Faults enabled, when a fault occurs the fault reference (IO_FLT) is set. The [FAULT] and [NOFLR] contacts can be used to access the point fault.

Point fault data is written to the references at the start of each CPU sweep, so they always contain the most recent data.

Configuration Required to Enable I/O Point Faults

The use of I/O point faults requires the following setup during Logicmaster 90 configuration:

During CPU configuration, select Memory Allocation and Point Fault Enable (F4) from the CPU Configuration menu.

Change the Point Fault Reference setting from DISABLED to ENABLED.

Using Fault and Alarm Contacts for GMR

This section explains how the basic Fault Contacts and Alarm Contacts of the Series 90-70 PLC can be used in a GMR application program.

Fault and No Fault Contacts

The application program can use Fault and No Fault contacts to check for fault or lack of fault conditions on a discrete (%I or %Q) or analog (%AI or %AQ) reference.

A Fault contact is programmed using the reference address to be monitored. It passes power flow if the associated reference has a fault.

A No Fault contact passes power flow while the associated reference has no fault.

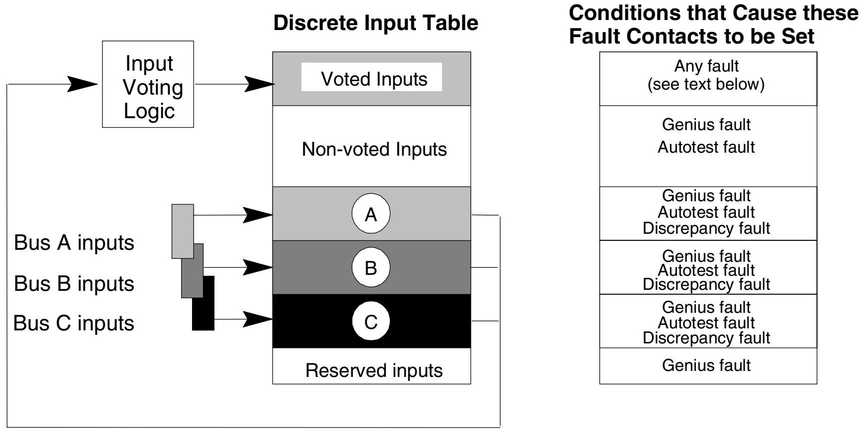
In a GMR system, there are fault contacts associated with voted inputs, with the original block inputs, and with logical outputs.

Fault and No Fault Contacts can also be programmed with the Series 90-70's built-in fault-locating references, as explained in this section.

Unless they are used ONLY with fault-locating references, fault memory for their use must be set up using the CPU Configuration function of the Logicmaster 90 software.

Discrete Input Fault Contacts for GMR

In the discrete Input Table there are fault contacts associated with each item of voted input data, non-voted input data, and "raw" data input from bus A, B, and C:



Conditions that Cause Discrete Input Fault Contacts to be Set

For voted inputs, a fault contact is set if any of the physical inputs has an associated fault contact set. For example, if a there is an autotest fault on input A, a fault contact is set both for input A and for the voted input.

For non-voted inputs, the single fault contact is associated with the physical input. It is set under the following conditions:

- *Autotest fault.* Set on discrete inputs configured for autotesting, if autotesting detects a fault.
- *Genius faults*, including Loss of Block.
- *Line fault*. These are a feature of the 16-circuit DC blocks. To report line faults, an input must be configured for tristate operation.

  For blocks in GMR mode, a line fault represents a short circuit fault on the field wiring.

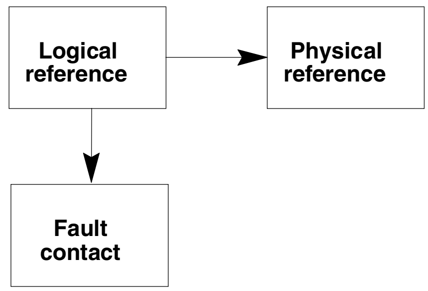
  For non-GMR blocks, a line fault represents an open circuit fault in the field wiring.

For bus A, bus B, and bus C inputs, fault contacts are set under the following conditions:

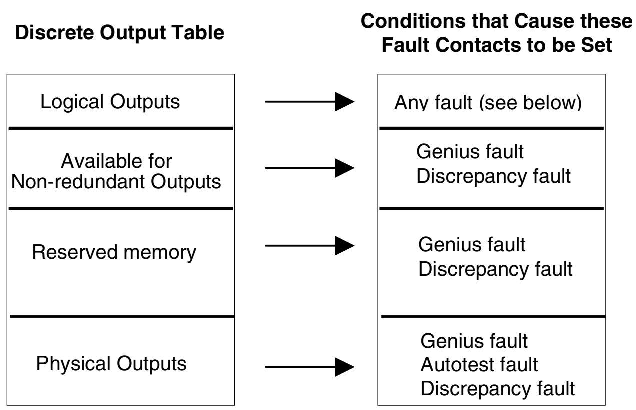
- *Autotest fault* (see above).
- *Line fault* (see above).
- *Genius faults*, including Loss of Block.
- *Discrepancy* between the raw input data, and the corresponding voted input.

Discrete Fault Contacts for GMR Redundant Outputs

For redundant discrete outputs, the fault contact is associated with the logical outputs (outputs from the application program).



These logical references are copied to the physical output references. If a fault is detected on a physical output, the fault contact associated with that output's logical reference is set. The illustration below summarizes conditions that cause discrete output fault contacts to be set for logical, physical, and non-redundant outputs.



For redundant outputs, the fault contact is set and fault messages logged for:

- Autotest faults
- Genius faults including Loss of Block, and the following additional faults:

  Short circuit
  Overtemperature
  Overload

  Failed switch: the actual output state differs from the commanded state.

  No-load: For 16-circuit blocks only, individual outputs can be configured to enable or disable reporting No-load faults. The minimum load current required for no-load reporting is 100mA, not 50mA as it is for a block that is not in a GMR group. For a 4-block group, a system output no-load fault is produced if outputs are ON; blocks A and B or blocks C and D report no-load faults.
- Discrepancy

  The blocks each report the discrepancy status for the data from each PLC, together with the PLC online/offline status.

  All PLCs periodically monitor all blocks' discrepancy status. Three discrepancy bits are maintained for each output; one for each of the PLCs. One of the bits is set if a block reports a discrepancy for any of its outputs.

Fault Contacts for Non-Redundant Outputs

For non-redundant outputs, the single fault contact is associated with the physical output. The fault contact is set under the following conditions:

- Genius faults including Loss of Block, and the following additional faults:

  Short Circuit
  Overtemperature
  Overload

  Failed switch: the actual output state differs from the commanded state.

  No Load: For 16-circuit blocks only, individual outputs can be configured to enable or disable reporting No-load faults. The minimum load current required to assure proper no-load reporting is 50mA (not 100mA, as it would be for a block in a GMR group).

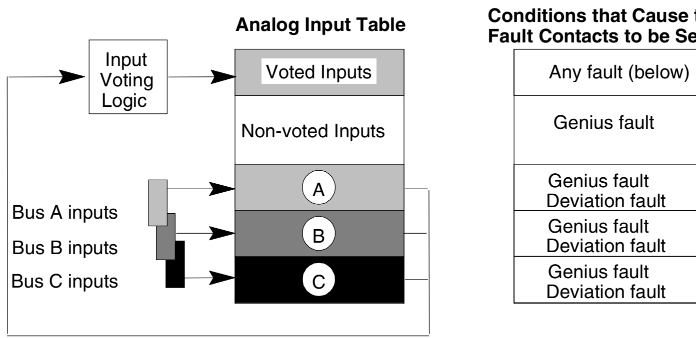
  For a single block, no-load fault reports for block outputs that are ON may be generated at any time except during a Pulse Test. For block outputs that are OFF, no-load fault reports are generated during a Pulse Test.
- Discrepancy

Using Analog Fault and Alarm Contacts

The fault, high alarm and low alarm contacts of non-voted analog inputs and outputs are not affected by GMR analog I/O processing.

Fault Contacts for Analog Inputs

As with discrete inputs, voted analog inputs have fault contacts associated with both the raw data inputs and the corresponding voted inputs. Non-voted analog inputs also have associated fault contacts.



- ***Genius faults*** include Loss of Block (or Field Control module), plus the following:

  Underrange: the input exceeds -32,767 engineering units or -4095 counts. The block transmits an underrange message and sets the value to its minimum.

  Overrange: the input exceeds +32,767 engineering units or +4095 counts. The block transmits an overrange message and sets the value to its maximum.

  Open wire: Used only for 4-20mA inputs. The fault contact is set if the input current falls below 2mA. Note that a 4 to 20 mA signal to two or more blocks must be converted to a voltage, in which case Open Wire faults are not detected.

  Wiring error

  Internal channel fault: an internal channel fault, such as the failure of the A/D converter. Block output is indeterminate.

  Channel shorted: For RTD blocks only. Block output is indeterminate.

- Analog input deviation fault: the A, B, or C input is subject to voting and is outside the deviation deadband.

Fault Contacts for Analog Outputs

For analog outputs, a fault contact is set for any Genius fault, including Loss of Block.

Alarm Contacts

> The application program can detect a high or low alarm condition on an analog (%AI or %AQ) reference using its alarm contact.

Alarm contacts indicate when an analog reference has reached one of its alarm limits. Alarm contacts are not considered to be fault contacts. Alarm contacts for a GMR system are the same as for a conventional system.

Clearing Faults Associated with Fault/No Fault Contacts

When used with a %I, %Q, %AI, or %AQ reference, a fault associated with the [FAULT] contact must be cleared to remove it from the fault table and stop the contact from passing power flow.

> Clear fault contacts by resetting them from the application program with the %M bit for I/O Reset (%M12258). *Clearing such a fault with a Hand-held Monitor does not remove it from the fault table or stop the contact passing power flow.*

Identifying Fault Locations

> To locate the system hardware location of a fault, program fault-locating references with Fault and No-Fault contacts.

The PLC does not halt execution if one of these reference faults occurs. Fault Locating References are informational only.

For a Genius device, the format of the fault-locating reference is:

M_rsbmm

r is the rack number of the bus controller from 0 to 7, **s** is its slot number, **b** is the bus number, and **mm** is the serial bus address of the affected Genius device. For example, **M_46128** represents rack 4, slot 6, bus 1, module 28. For more information about fault-locating references, please refer to the *Logicmaster 90-70 Software User's Manual.*

Checking for Discrepant Outputs

All GMR PLCs periodically monitor discrete block output voting. This monitoring detects both output discrepancies among the PLCs and lost communication between the monitored output block and the other PLCs. If a PLC is sending incorrect output data to a block, the GMR System Software logs an output discrepancy fault in the I/O Fault Table, and sets the fault contacts for that logical output.

> To check for discrepant outputs, the application program can monitor the I/O Fault Table for output discrepancy faults. In addition the program can also include the appropriate fault contacts as described previously.

Identifying Rapidly-Changing Outputs

Automatic discrepancy checking works with outputs that change state less frequently than approximately once per 10 PLC scans.

> To identify outputs for which discrepancy checking could not be completed because they changed state too rapidly, the application program can set the bit %M12266 (ENTRAN) to 1. This bit is OFF (0) by default.

When %M2266 is1, a rapidly-transitioning output discrepancy causes a message to be logged into the I/O Fault Table. The fault message indicates the rack X, slot Y, SBA x of the module where transitioning outputs caused incomplete output discrepancy processing.

Detecting I/O Forces and Overrides

Forces and overrides are not recommended in a GMR system because they can affect both autotesting and GMR voting of inputs and outputs. The GMR software does not automatically detect forces or overrides.

If forces or overrides are used in a GMR system, the program logic should include system status references to detect them *in an individual PLC*.

Detecting a Forced Genius Point in a PLC

Use %S0012 (FRC_PRE) to have the application program check for a force on a Genius point. When this bit is set (1) it indicates a force is in effect.

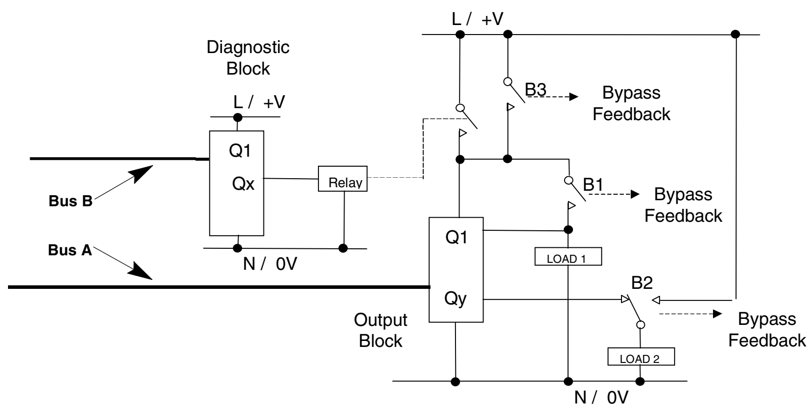
Detecting an Overridden Point in a PLC

Use %S0011 (OVR_PRE) to have the application program check for an override in %I, %Q, %M, or %G memory. When this bit is set (1) it indicates an override condition exists.

Programming for a 1oo1D Output Group

A 1oo1D Output Group consists of a discrete Output Block whose power is controlled by a Diagnostic Block on another bus. (Some individual points on the Output Block may be bypassed by providing them with a separate power source).

The GMR software automatically monitors the Output Blocks set up as 1oo1D Output Groups. If the actual state of a "guarded" point on the Output Block does not match the output state commanded by the application program, the %Q point on the Diagnostic Block that controls power to the Output Block is automatically set to 0 and an I/O fault is placed in the I/O Fault Table. In the simplified representation below, if the feedback from point %Qy does not match its commanded state, the GMR system automatically sets point %Qx on the Diagnostic Block to 0. That turns off power to all points on the block that have not been bypassed.



Note that the CPU performs this processing without checking to see if output block is logged on. This may cause spurious trips of Guard outputs to occur.

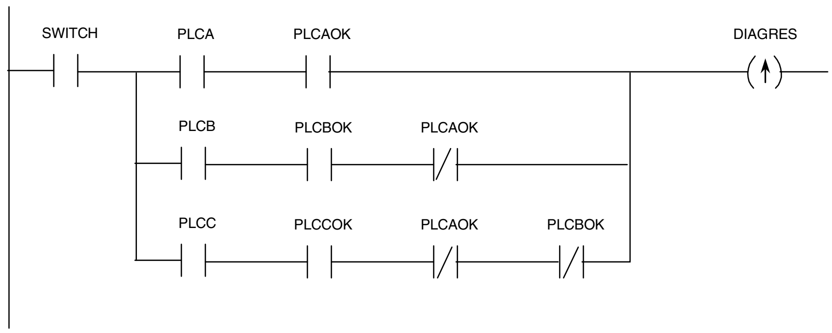
Testing Operation of Diagnostic Shutdown

To exercise the guard relay, the %Q references of the output to be guarded must be set to 0 (off). This can be done either in the program logic, or directly from the programmer.
If the outputs are not to be *de-energised*, the relay bypass (*B3* in the example above) or the individual MBB bypasses on each O/P (*B2* in the example above) must be activated.
Once the proof test has been completed, the user must perform a Diagnostic Reset (DIAGRES) to energise the guard relay. When the state of the guard relay has been manually verified, the O/P bypasses implemented can be removed.

Programming to Reset an Output Point on the Diagnostic Block

The application program must include logic to reset an output point on the Diagnostic Block after it turns off power to the Output Block.

The DIAGRES bit (%M12267) is used to reset an output point. The following simple logic in the application program can be used in each PLC:



In this example logic, SWITCH represents an operator device such as a momentary pushbutton. It could also represent a software input. When the operator presses the pushbutton, the SWITCH contact passes power flow to the right. If PLC A is OK, power flow passes to the DIAGRES positive transition coil. If PLC A is not OK, power flow passes to the contact for PLC B. If PLC B is not OK, power flow passes to PLC C.

This example logic assures that only one PLC will perform the diagnostic reset. In a three PLC system, it will always be PLC A if PLC A is available.

It is important that DIAGRES must not remain set, or be set from more than one PLC. That would prevent subsequent resets of the Diagnostic Block.

Programming Associated with I/O Shutdown

In a GMR system, the term I/O Shutdown refers to the automatic shutting down of an input or output group that has faulted during GMR Autotest. (See chapter 4 for more information about autotest failures.)

When the GMR system diagnoses a discrete I/O fault, it logs the appropriate faults in its fault tables and set the associated fault contacts. For some types of discrete I/O faults, the GMR system optionally allows a configurable 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 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 that has been configured for the input group.

Programming logic related to I/O Shutdown may include:

To be made aware of a pending I/O Shutdown, the program can monitor status bit %M12244 (IO_SD) , which indicates when any I/O Shutdown Timer has been activated.
To cancel an I/O Shutdown at any time, set bit %M12265 (SD_CAN) to 1.
The application program can do an I/O Fault Reset by setting control bit %M12258 (IORES) to 1 (on). This clears any standing faults at the block(s) and in the I/O fault table of the PLCs,
To initiate an autotest at any time, set %M12260 (ATMANIN) to 1.
To force blocks to log on and accept outputs, set bit %M12263 (FORCLOG) to 1.
Do an I/O Fault Reset by setting control bit %M12258 (IORES) to 1 (on). This clears any standing faults at the block(s) and in the I/O fault table of the PLCs,

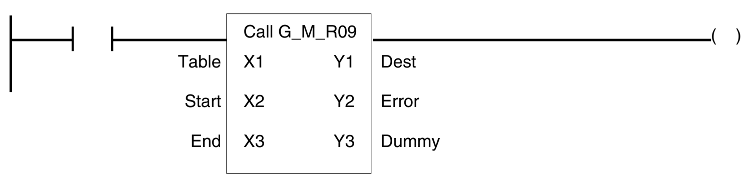
Reading Sets of Diagnostic Data

This section explains how to use a GMR program block to read a set of data about the system. Data that can be read by the program block includes:

- Discrepancy faults (for discrete inputs or outputs, analog inputs)
- Discrete input or output autotest faults
- Genius faults (for discrete inputs or outputs, analog inputs or analog outputs)
- Discrete or analog input or output point faults (Use this function to read groups of contiguous point faults. Individual point faults are accessed more conveniently using point contacts in the program, as described in this chapter).
- Discrete logon faults for an individual PLC
- Analog high or low alarms
- Input or output shutdown timers
- Configuration text

The GMR Program Block

The GMR system's application program can CALL an external Program Block named **G_M_R09.** Each call to G_M_R09 can access one type of data. The data is returned in bit format. The information is read-only; it cannot be written to.



The input and output parameters of this function are:

X1: Table	a number representing the type of data to be read, as listed in the table on the next page. For example, to read Discrete Input Discrepancy faults, enter 11.
X2: Start	the starting offset within the area of information specified in a table. For discrete point faults (input or output faults of any of the types listed), this is the actual address of the first point to be accessed. For example, to see if there was an output point fault for %Q00015, you would enter the value 15 for START.
X3: End	the end offset within the area of information specified in the table.
Y1: Destination	a location for the requested information to be placed.
Y2: Error	a location for the error code to be placed. The error code is generated only if the CALL function fails to execute successfully. Error codes are listed in this section.
Y3: Dummy	not used.

Parameters for the Call Function and Data "Table" Contents

Table	Contains	Range for Start Value	Range for End Value
11	Discrete Input Discrepancy faults	Greater than or equal to the first discrete input address for A, B, or C.	Less than the start plus the maximum discrete input address for A, B, or C.
14	Discrete Input Autotest faults	start>=1	end<=12228, end<=start
15	Discrete Input Genius faults		
16	Discrete Input Point faults *		
21	Discrete Output Discrepancy faults: PLC A		
22	Discrete Output Discrepancy faults: PLC B		
23	Discrete Output Discrepancy faults: PLC C		
24	Discrete Output Autotest faults		
25	Discrete Output Genius faults		
26	Discrete Output Point faults *		
27	Discrete Logon faults (PLC A)	First group number required	Last group number required
28	Discrete Logon faults (PLC B)		
29	Discrete Logon faults (PLC C)		
31	Analog Input Discrepancy faults	Greater than or equal to the first discrete input address for A, B, or C.	Less than the start plus the maximum discrete input address for A, B, or C.
35	Analog Input Genius faults	start>=1	end<=8192, end<=start
36	Analog Input Point faults *		
37	Analog Input Low Alarms		
38	Analog Input High Alarms		
45	Analog Output Genius faults		
46	Analog Output Point faults *		
47	Input shutdown timers (per block) Returns a single word indicating the shutdown timer value as seconds of elapsed time. A value of -1 means a fault exists but the timer has not started (the Shutdown Cancel bit is On).	High byte of start reference contains rack number (0-7) and low byte contains slot number (1-9)	High byte contains the number 1. Low byte contains the Serial Bus Address (SBA) of the block you want shutdown information from (0-28)
48	Output shutdown timers (per block) See Input shutdown timers (47) above for returned values.		
49	Input shutdown timers (per GBC) For each SBA, returns a word indicating the shutdown timer value as seconds of elapsed time. A value of -1 means a fault exists but the timer has not started (the Shutdown Cancel bit is On). A value of 0 means a block does not exist or has no associated shutdown timer. All output blocks return the value 0.	High byte of start reference contains rack number (0-7) and low byte contains slot number (1-9) where the desired Bus Controller is located.	unused
50	Output shutdown timers (per GBC) See Output shutdown timers (49) above for returned values.		
1000h	Configuration text description	unused	unused

* To read point faults, point faults must be enabled in the CPU configuration. If point faults are not enabled in the configuration, an error message will be returned.

Error Codes for the GMR Diagnostic Function Block

The following error codes may be generated by the GMR diagnostics Function Block if the Call function is used incorrectly:

Code	Meaning
10908	An attempt was made to read an I/O shutdown timer for an invalid block
10909	An attempt was made to read all I/O shutdown timers for an invalid GBC.
0900hex	User I/F - No Error
0902hex	User I/F - Incorrect GMR software version
0903hex	User I/F - Invalid table number
0904hex	User I/F - Unsupported table number
0905hex	User I/F - Invalid table offset
0906hex	User I/F - Invalid destination address
0907hex	User I/F - No Fault Contacts
0908hex	User I/F - Bad Block Location
0909hex	User I/F - Bad GBC Location
09FFhex	User I/F - Disabled

Reporting the GMR Version and Checksum to the PLC Fault Table

To report the following into the PLC Fault Table of the PLC(s) that turned it on, set control bit %M12262 (Report) to 1 (on).

- The **GMR Software Version** currently running in the PLC. Example:

  Application message (10840): GMR Ver: 4.02

- The **GMR Configuration Utility Version** used to create the G_M_R10 Program Block. Example:

  Application message (10841): Config Util Ver: 8.05

- The **GMR Configuration File** (G_M_R10 Program Block) **Checksum**. Example:

  Application message (10842): GMR config CRC:2F4E

  This checksum value can be used to verify what configuration file is running in a GMR PLC. It should be recorded for each different configuration so it can be used to determine exactly what configuration file is in a GMR PLC.

- The 40-character Configuration File Description.

This GMR control bit is typically set manually using the Logicmaster 90-70 software, although it can also be turned on by the application program if desired.

Chapter 10 Storing and Downloading GMR Programs

This section explains how to store or download programs, configurations, and data to the GMR PLCs.

- Result of Online Changes
- Storing a Program to the GMR PLCs
  - Using the Store Function
    - Storing a Program:Using the Store Function if the System is NOT Configured for Online Changes
    - Using the Store Function if the System IS Configured for Online Changes
- Using the Program Download Utility

Upgrading from an Earlier GMR Version

If you are upgrading from a previous version of GMR, please see the instructions in appendix E.

Result of Online Changes

If an online program or configuration change is made in a GMR system, it causes a checksum mismatch. The result of a checksum mismatch depends on the type of change and on whether the GMR configuration has been set to permit or to reject online changes.

Type of Mismatch or Change Detected	Configured to Allow Changes		Configured to Reject Changes	
	Changed/Started PLC	Other PLC(s)	Changed/Started PLC	Other PLC(s)
Program Checksum mismatch at startup	"Program Mismatch" message logged	"Program Mismatch" message logged	"Program Mismatch" message logged. PLC stopped	No Action
(Following PLC Fault Reset)	"Program Mismatch" message re-logged	"Program Mismatch" message re-logged	N/A - PLC is stopped	No Action
Program Checksum change while running	"Program Change" message logged	"Program Changed" message logged	"Program Changed" message logged PLC stopped	No Action
(Following PLC Fault Reset)	"Program Mismatch" message logged	"Program Mismatch" message logged	N/A - PLC is stopped	No Action
GMR Configuration Checksum mismatch at startup	"GMR Configuration Mismatch" and "Program Mismatch" messages logged. PLC stopped	No Action	"GMR Configuration Mismatch" and "Program Mismatch" messages logged. PLC stopped	No Action
(Following PLC Fault Reset)	N/A - PLC is stopped.	No Action	N/A - PLC is stopped	No Action
Configuration Checksum mismatch while running	"GMR Configuration Changed" and "Program Changed" messages logged.	"GMR Configuration Changed" and "Program Changed" messages logged.	"GMR Configuration Change" and "Program Changed" messages logged. PLC stopped	No Action
(Following PLC Fault Reset)	"GMR Configuration Mismatch"message logged.	"GMR Configuration Mismatch" message logged	N/A - PLC is stopped	No Action

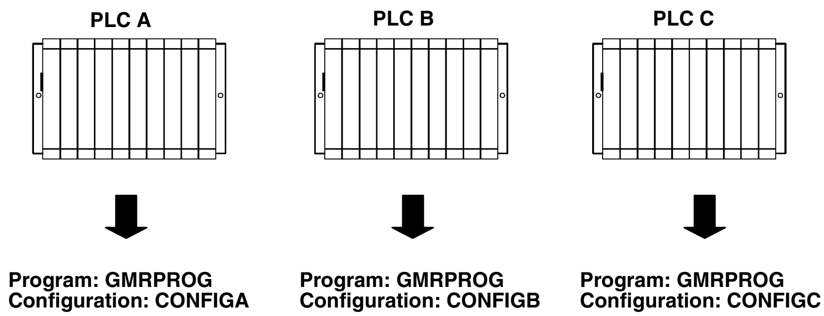
In all cases, a fault message is logged into the PLC Fault Table. If the fault condition remains after the PLC Fault is reset, the message is relogged. The message indicates which PLC has changed, or which mismatches.

A model 790 PLC must be placed in Stop mode before downloading a configuration. For a model 788 or 789 PLC, a change to the GMR Configuration takes effect when the PLC transitions from Stop to Run mode. Therefore, the PLC should be placed in Stop mode before downloading a new GMR Configuration.

Autotesting is suspended if a PLC is started up with a new configuration. After all PLCs have been given the same configuration, autotesting resumes.

Storing a Program to the GMR PLCs

Use the Store function to copy program logic, configuration data, and /or reference tables from the programmer to the PLC. All redundant PLCs in the GMR system must use the same application program. However, they use different configurations:



Supplying the configuration and program as separate files, as shown above, makes it easier to perform program updates in the future.

The method used for storing a program depends on whether the system has been configured to permit online changes.

- If online changes are NOT permitted, the process shuts down all PLCs.
- If online changes ARE permitted, a program can be stored without shutting down the PLCs. This method requires extreme caution.

It is important to match the configuration to the method (described on the following pages) you will be using. Regardless of which method you use, the system will be shut down unless the GMR configuration has online changes enabled.

Things to Consider when Storing to the PLC

The Store function copies the program, which remains unchanged in the programmer. If the PLC program name is not the same as the folder name, the Store function clears the program from the PLC. The selected data is then stored from the new program folder.

If the function is password-protected in the PLC, you must know the password in order to use this function.

Note

In the configuration software, only the configuration may be stored. No operations on program logic or tables may be performed.

Using the Store Function

To use the Store function, press **Store (F4)** from the Program Utility Functions menu. The Store Program screen appears. The screen shows the currently-selected program folder, which cannot be changed.

Three types of data can be stored from the programmer to the PLC: program logic, configuration data, and reference tables. When this screen first appears, only the program logic is set to **Y** (yes), which is the default selection. To store all of the data, change the selection for reference tables and configuration to **Y** (yes). To store only part of the data, select **N** (no) for any of the three types of data you do not want to store. When a program is being stored to a new CPU for the first time, it is most common to store all data and select **Y** (yes) for all three types.

Field	Description
Program Logic	The ladder logic program and %L and %P data.
Reference Tables	The reference tables for the program. except %L and %P data.
Configuration	The current configuration.

Note

Annotation files (nicknames, reference descriptions, and comment text) remain in the folder and are not stored to the PLC.

Logicmaster 90-70 software identifies external blocks with a unique block type when storing logic to the PLC. If the PLC rejects the external block because it is not the proper MS-DOS executable file format, the software will display an appropriate error message based on an error code that is unique to external blocks.

Use the cursor keys to select items, and type in new selections as appropriate. To restore the original selections while editing this screen, press **ALT/A.**

The information to be transferred must fit within the configured boundaries of the PLC (for example, its register memory size).

To begin storing, press the **Enter** key. The program must be complete, and must not contain errors in syntax or any instructions that are not supported by the attached PLC. If there are errors, the Store operation will be aborted.

After a successful Store, the software displays the message “Store Complete”. If a communication or disk error occurs during the Store process (indicated by a message on the screen), the selected items are cleared from the attached PLC. Correct the error and repeat the Store function.

To stop a program Store in progress, press **ALT/A** if the PLC is in **STOP** mode. If the PLC is in **RUN** mode when the Store begins, you cannot stop the Store process.

To return to the Program Utility Functions menu, press the **Escape** key.

Using the Store Function if the System is NOT Configured for Online Changes

If the GMR system is configured not to allow online changes, the PLC must be placed in Stop mode to store a program or make a change to the GMR system.

Storing a Program, Configuration, or Tables in Stop Mode

In **STOP MODE STORE**, the following can be performed:

1. You can store program logic, configuration data, and/or reference tables from the programmer to the PLC.
2. If you choose to store logic only and the PLC program name is different than the program name in the folder, the current logic in the PLC is cleared and replaced by the new logic in the current folder. The current configuration data and reference tables in the PLC are left intact.

   If you choose to store logic and configuration data and./or reference tables, the logic, configuration data, and reference tables in the PLC are cleared, and the new data is stored from the programmer to the PLC.

Storing an Identical Program Following CPU Replacement

If a PLC is to be stored with an identical program, following replacement of a faulty CPU, then only the PLC to be stored to needs to be placed in Stop mode. The other PLCs in the system can remain online, providing output control.

When the new PLC is switched to Run/Enable mode, the GMR software compares its program checksum with that of the other online PLCs while it is initializing.

Storing a Revised Program

If a PLC is to be stored with a program that is not exactly the same as the program running in the other PLCs, then all PLCs must be stopped, and the same program must be stored into each.

The GMR software CD includes a special utility that can be used to facilitate storing an updated application program in a system that will use SNP (serial network protocol) to communicate with the PLCs. This utility is described on the following pages.

Using the Store Function if the System IS Configured for Online Changes

For a system configured to allow online changes, the following sequence illustrates how an online ladder logic program change could be done in a triplex CPU System. System configuration changes are not intended to be done online. (Online ladder logic changes are intended for system debug and commissioning).

1. Using the Logicmaster 90-70 Programming Software in the Monitor mode, make a direct or multidrop connection to PLC “A”.
2. Change the Logicmaster 90-70 programmer mode to the Online mode, and change the CPU Memory Protect keyswitch to the unprotected position (the Mem Protect LED will be off). Make the run mode store (see below), single word online change, or block edit at PLC A. A “Program Changed A” message is logged into the PLC Fault Table at PLC A. “Program Changed A” is logged into the PLC Fault Table of PLC B and PLC C. If the change affects the state of any outputs, the discrepant outputs are “voted out” at the output blocks by the 2 out of 3 voting algorithm. The appropriate output discrepancy error(s), if any, are logged at all three PLCs..
3. Change the CPU Memory Protect keyswitch to the protected position (the Mem Protect LED is on).
4. Using the Logicmaster 90-70 Programing Software, make a direct or multidrop connection to PLC B.
5. Change the CPU Memory Protect keyswitch to the unprotected position. Make the same program change at PLC B. “Program Changed B” is logged into the PLC Fault Table of PLC B. If the change affects the state of any outputs, these outputs would now agree for PLC A and PLC B, and the output state(s) from PLC C are “voted out” at the output blocks by the voting algorithm. The appropriate output(s) from PLC C will now be discrepant and the appropriate discrepancy and the appropriate redundancy error(s) are logged at all three PLCs.

6. Change the CPU Memory Protect keyswitch to the protected position (the Mem Protect LED is on).
7. Using the Logicmaster 90-70 Programming Software, make a direct or multidrop connection to PLC C.
8. Change the CPU Memory Protect keyswitch to the unprotected position. Make the same program change at PLC C. “Program Changed C” is logged into the PLC Fault Table of PLC C. If the change affects the state of any outputs, these outputs would now agree for PLC A, PLC B, and PLC C, and the output state(s) should no longer be discrepant. The “Program Changed C” messages can now be cleared along with any output discrepancy errors that were logged due to the program change.
9. Change the CPU Memory Protect keyswitch back to the protected position (the Mem Protect LED is on).

Notes

After many online changes are made, fragmentation of memory may occur. That will prevent subsequent online changes from being made. To make changes, place the CPU being stored to in Stop mode and store a complete program from the programmer to the PLC. This cleans up any fragmentation that exists and enables future online changes.

If an online program change is made to a single PLC and subsequently deleted before the same change is made to the other PLCs in the system, it is possible that the program checksum will not match, even though the programs in the CPUs appear to be the same. Logicmaster 90-70 may also indicate “Logic Not Equal” when connected to a PLC in which the change/deletion was not made. To recover from this condition, a “run mode store” may be required at the PLCs in which the deletion was not made.

Storing a Program in Run Mode

In **RUN MODE STORE**, you can only store program logic under these conditions:

1. Only blocks that have been changed are stored.
2. The old program executes until the blocks are completely stored, then the new program begins executing in a “bumpless” manner.
3. The data sizes for %L and %P are based on the highest references used in each block, regardless of whether the block is called. %L and %P data is increased as these references are programmed. If a reference to %L or %P) is deleted, the new smaller size is calculated when the folder is selected.
4. Interrupt declaration changes cannot be made.
5. There must be enough PLC memory to store both old and new program blocks.
6. Timed or event-triggered programs cannot be added or deleted.
7. Control information (scheduling mode, I/O specification, etc...) for programs cannot be modified.

Downloading Programs

For a model 790 CPU, TCP/IP can be used to download programs to the PLC.

Alternatively, if the redundant PLCs are linked by an SNP network, you can use the Download utility provided on the GMR software CD when making future application program updates. The Download utility:

1. works with the Logicmaster 90 programming software.
2. stops each of the PLC CPUs, with outputs disabled.
3. stores the updated application program to each of the CPUs.

The Download utility assures more efficient, accurate downloading. However, its use is optional.

The Download utility includes three files:

- the download utility file itself, named KEY0.DEF.
- two files named UPLC and LM_KEYS.LST that can be used to edit the PLC IDs used by the download utility.

By default, the download utility requires the IDs PLCA, PLCB, and PLCC. If your PLCs use those PLC IDs, you can use the utility with modifying it. If your PLCs use other PLC IDs, you can customize the utility as described on the next page.

Using the Download Utility with the Default PLC IDs

For PLCs with the IDs PLCA, PLCB, and PLCC, the download utility can be used as is:

1. Copy the download utility file KEY0.DEF from the GMR software diskette to the folder that contains the application program. This can be done at any time.
2. When you are ready to store an updated application program to the redundant PLCs, go to the Logicmaster 90 main programming menu.
3. To begin the store operation, from the main menu screen, press the ALT and 0 keys at the same time. For each redundant PLC in sequence, the software will prompt:

   Press the Space Bar to Continue

3. When you press the Space Bar, the PLC is put into Stop mode with its outputs disabled.
4. With all PLCs stopped, the software again prompts:

   Press the Space Bar to Continue

5. For each PLC, when you press the Space Bar the utility stores the updated application program and places the PLC in Run mode with its outputs enabled.
6. After all PLCs have been restarted, the Logicmaster 90 main menu returns.

Customizing the Download Utility for Other PLC IDs

For PLCs with other PLC IDs, you need to edit the file KEY0.DEF *before adding it to the Program Folder in Logicmaster*.

1. Install the GMR software CD.
2. At the DOS prompt, log onto that drive.
3. Copy the Download utility files from the diskette to your fixed disk drive:

UPLC.EXE	Update PLC Names utility
LM_KEYS.LST	List of keynames required by the Download utility
KEY0.DEF	Download utility file

4. Log onto that fixed disk drive. At the DOS prompt, enter:
   UPLC
5. At the prompt, enter the PLC ID you want to use instead of PLCA. The name can be from 1 to 7 characters long. It can include any alphanumeric characters and the following special characters:

   -, @, _, #, $, %, <, >, =, +, &.
6. Continue and enter new names for PLCB and PLCC.
7. The software creates a new Download utility file named NEW.DEF. When it is completed, it displays:

   Processing Complete
8. Copy the new file to the Logicmaster Program Folder containing the application program. Rename the file to KEY0.DEF during the copy.

   For example:

   C: COPY NEW.DEF C:\FOLDERS\PROGRAM\KEY0.DEF
9. The edited file can now be used as described on the previous page.

Chapter 11

Installation Information for GMR

This chapter provides the specific information needed to install GMR input and output groups. It is not intended to replace the basic installation instructions for the individual PLCs, bus controllers, I/O modules and other devices in the system. Please refer to the product documentation as your first source of installation information.

This chapter describes:

- Genius bus connections
- Wiring for Discrete Input Groups
- Wiring for Analog Input Groups
- Wiring for an H-Block Output Group
- Wiring for a T-Block Output Group
- Wiring for an I-Block Output Group
- Wiring for a 1oo1D Output Group

Genius Bus Connections

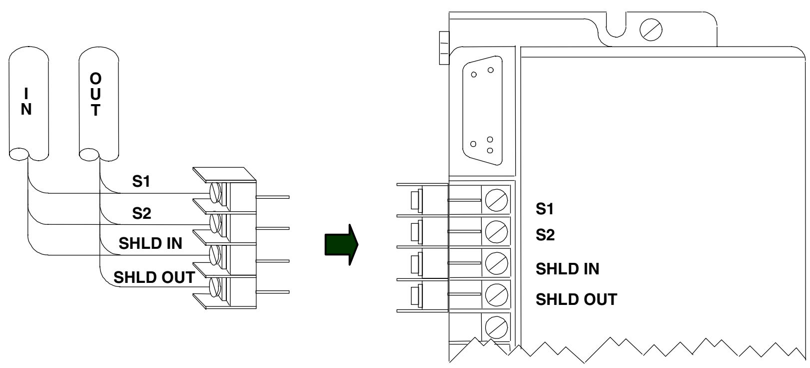
When planning and installing a Genius bus, it is extremely important to follow the guidelines given in the *Genius I/O System and Communications User's Manual*. That manual describes correct cable types, wiring guidelines, bus length, bus termination, baud rate, and bus ambient electrical information.

In GMR system, “GMR busses” can operate at any baud rate with the following restrictions:

1. All busses in a group must use the same baud rate.
2. Each individual GMR bus must have a scan time of 60 milliseconds or less.

Bus cable connections to a Genius block in a GMR system should be made in such a way that a block's terminal assembly can be removed from the bus during system operation without “breaking” the bus and disrupting communications.

To do that, the bus can be installed at each block using an intermediate connector, as shown below. The connector shown is Cooper Magnum #A107204NL, available from Kent Electronics (800-735-5426).



An alternative method, but somewhat less desirable, is to solder together the corresponding wire ends before inserting then into the block's terminals. If such soldered wires are removed while the system is operating, it is important to cover the ends of the wires with tape to prevent shorting the signal wires to one another or to ground.

Both of these installations allow a block's terminal assembly to be removed while maintaining data integrity on the bus.

When blocks are connected to the bus in this manner, field wiring to the blocks should also provide a means of disconnecting power to individual blocks.

Note that if blocks will have terminating boards attached (see chapter 12), prefabricated bus cables (part numbers IC660BLC001 or 003) should not be used.

Wiring for Discrete Input Groups

Calculating Voltage Drops on Tristate Inputs

It is important to consider the field wiring runs required for devices configured as tristate inputs. Devices that are powered by 24V DC will have a voltage-reducing component (resistor or Zener diode) inserted at the field device to provide an input threshold range for three states. The table below shows appropriate ranges.

		Range
Source Blocks	**tristate inputs**	<30% VDC
		>50% VDC < VDC+-7V
		< VDC+-4V
	Bi-state inputs	<30% VDC
		>50% VDC
Sink Blocks	**tristate inputs**	<4V
		>7V <50% VDC+
		>70% VDC+
	Bi-state inputs	<50% VDC
		>70% VDC

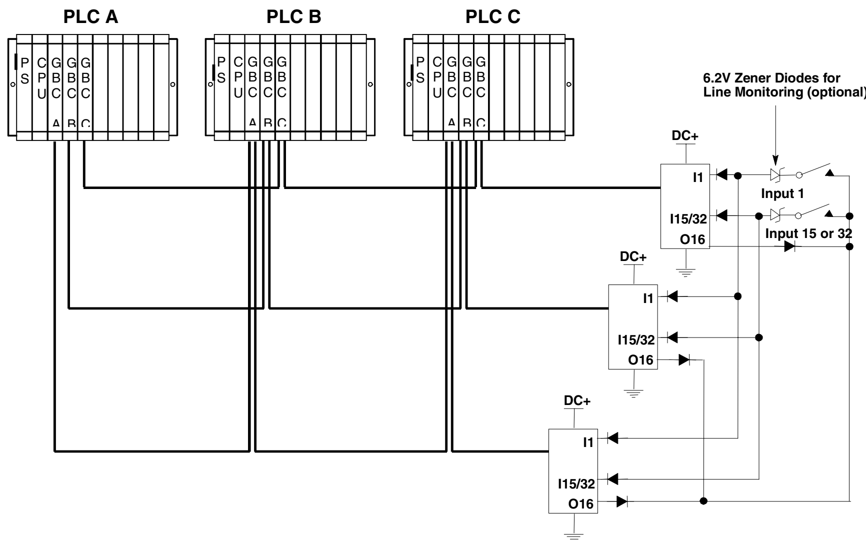
Long wiring runs can reduce the voltage at the input block terminal further, potentially to an inoperable level, depending on the length, conductor, and gauge.

Most applications do not have limitations created by these factors. However, to ensure that all input state operations are indicated correctly, calculations should include the field signal voltage, the wire resistance times the length and the voltage drop in any barriers or isolation devices, to determine the actual voltage present at the input terminal.

Additional information about input blocks is located in the *Genius I/O Discrete and Analog Blocks User's Manual* (GEK-90486-2).

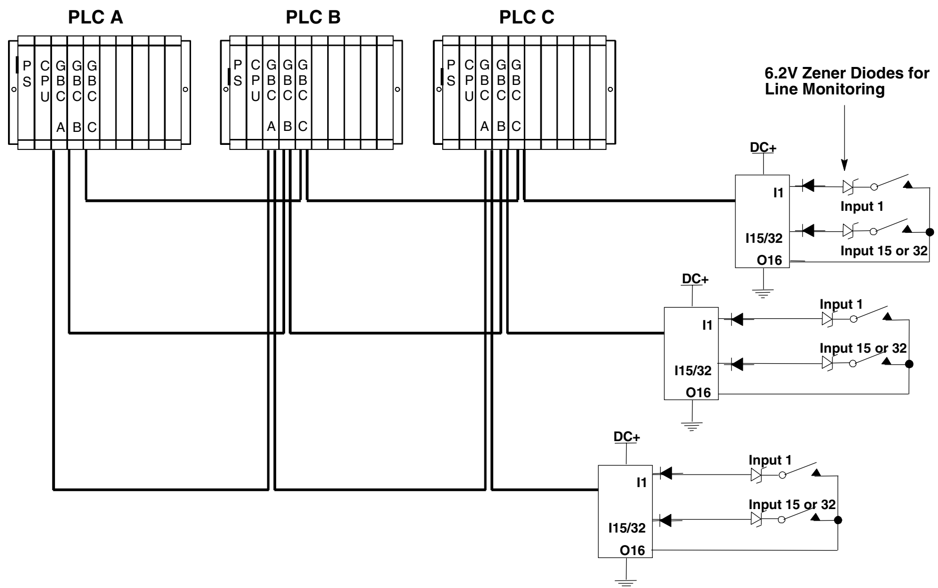
Discrete Input Groups: Single Sensor to Three Discrete DC Blocks (Triple Bus)

If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 12.



- 6.2 volt Zener diodes are used for optional line monitoring on circuits configured as tristate inputs. This option is only available with 16-circuit DC blocks.
- All blocks in an input group must have the same number of circuits (either 16 or 32).
- On either 16-circuit or 32-circuit blocks, circuit 16 is used as an output if the block group is configured for input autotesting.
- If redundant power supplies are used on the blocks, they should be diode “Ored” power supplies providing a common power source for all blocks in the group. Diode 1N4001 is suggested. Different groups may use different power sources.
- If the block group is configured for input autotesting, it must be wired appropriately, Each input that is configured (by the GMR Configuration Software) to be autotested must have its input device wired to receive power from output Q16 of the block group, as shown above. The Q16 outputs from each block are “diode-Ored” together to function as the power feed for autotested input devices. Input devices for input circuits that are not configured for autotesting should <u>not</u> be wired to the power feed output.
- Isolation diodes must also be wired as shown above for any input to be autotested. Diode 1N4001 is suggested.

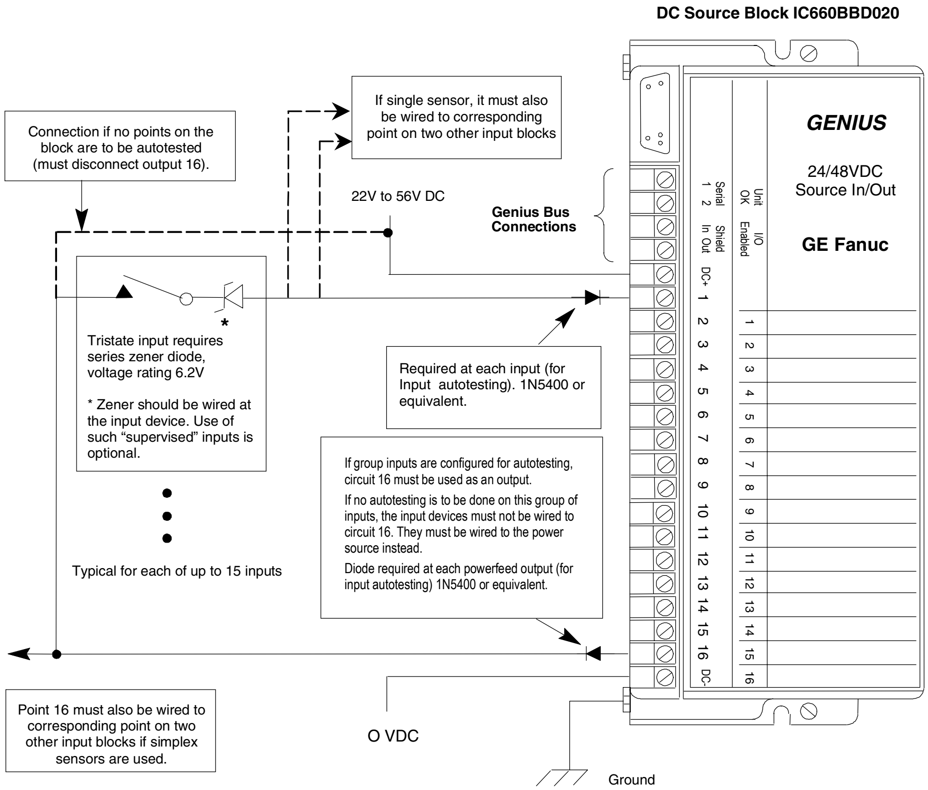
Discrete Input Groups: Three Sensors to Three Discrete DC Blocks (Triple Bus)



- 6.2 volt Zener diodes are used for optional line monitoring on circuits configured as tristate inputs. This option is only available with 16-circuit DC blocks.
- All blocks in an input group must have the same number of circuits (either 16 or 32).
- On either 16-circuit or 32-circuit blocks, circuit 16 is used as an output if the block group is configured for input autotesting.
- If the block group is configured for input autotesting, it must be wired appropriately. Each input that is configured (by the GMR Configuration Software) to be autotested must have its input device wired to receive power from output Q16 of the block group, as shown above.
- Isolation diodes must also be wired as shown above for any input to be autotested. Diode 1N4001 is suggested.

Discrete Inputs: Block Wiring for 16-Circuit DC Source Blocks

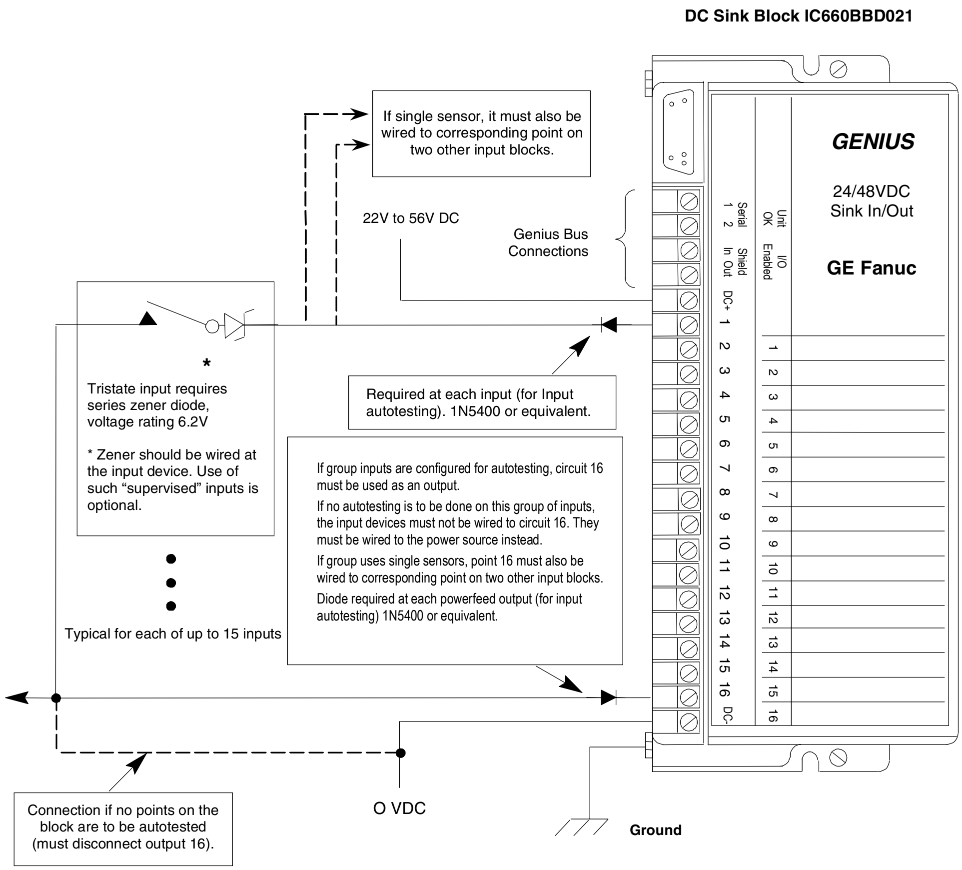
If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 12.



- In a three-block input group, each block is connected to one bus of three.
- All blocks in an input group must have the same number of circuits (either 16 or 32).
- If an input is wired for tristate operation, the circuit LED glows dimly when the input off.
- If redundant power supplies are to be used, they should be diode "Ored" power supplies providing common power to all blocks in a group. Diode 1N4001 is suggested. Different groups may use different power sources.

Discrete Inputs: Block Wiring for 16-Circuit DC Sink Blocks

If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 12.

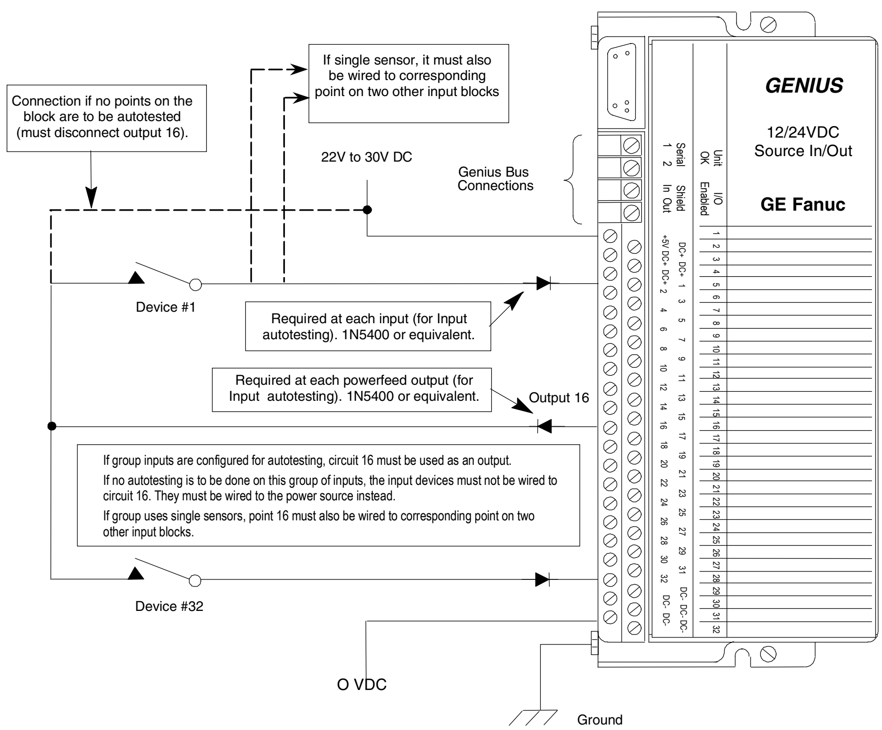


- In a three-block input group, each block is connected to one bus of three.
- If an input is wired for tristate operation, the circuit LED glows dimly when the input off.
- If redundant power supplies are to be used, they should be diode "Ored" power supplies providing common power to all blocks in a group. Diode 1N4001 is suggested. Different groups may use different power sources.

Discrete Inputs: Block Wiring for 32-Circuit DC Source Blocks

If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 12.

DC Source Block IC660BBD024

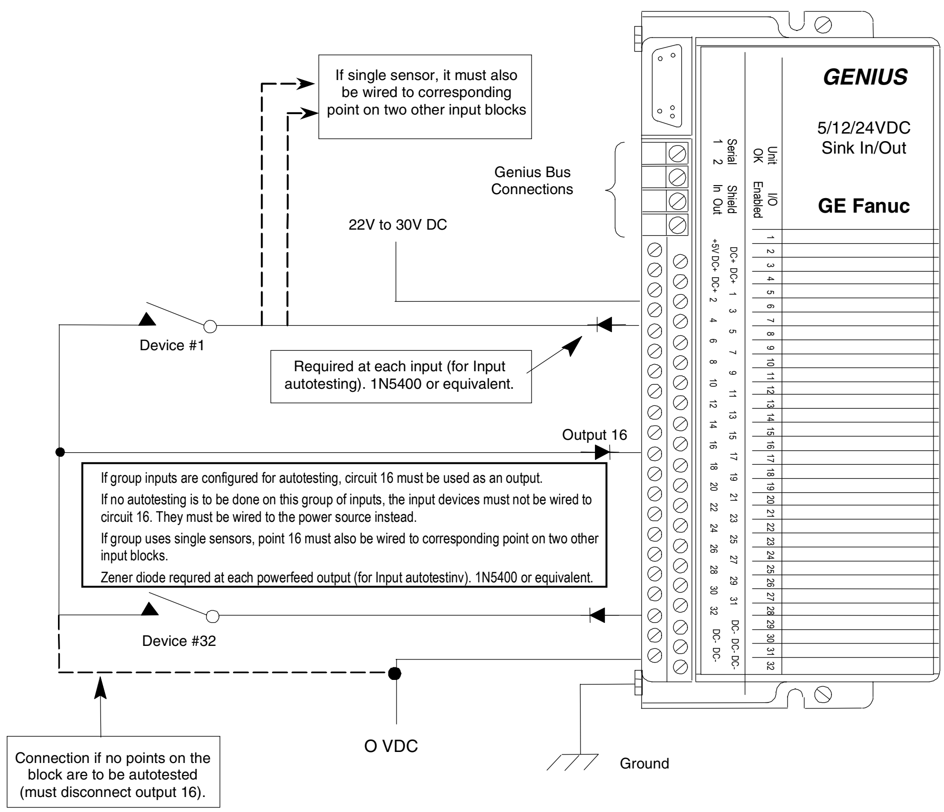


- In a three-block input group, each block is connected to one bus of three.
- All blocks in an input group must have the same number of circuits (either 16 or 32).
- If redundant power supplies are to be used, they should be diode “Ored” power supplies providing common power to all blocks in a group. Diode 1N4001 is suggested. Different groups may use different power sources.

Discrete Inputs: Block Wiring for 32-Circuit DC Sink Blocks

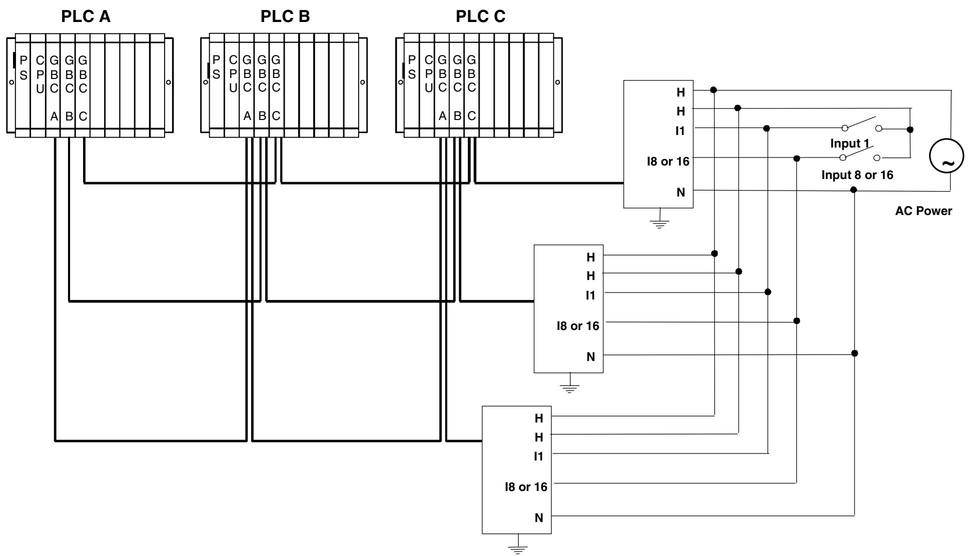
If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 12.

DC Sink Block IC660BBD025

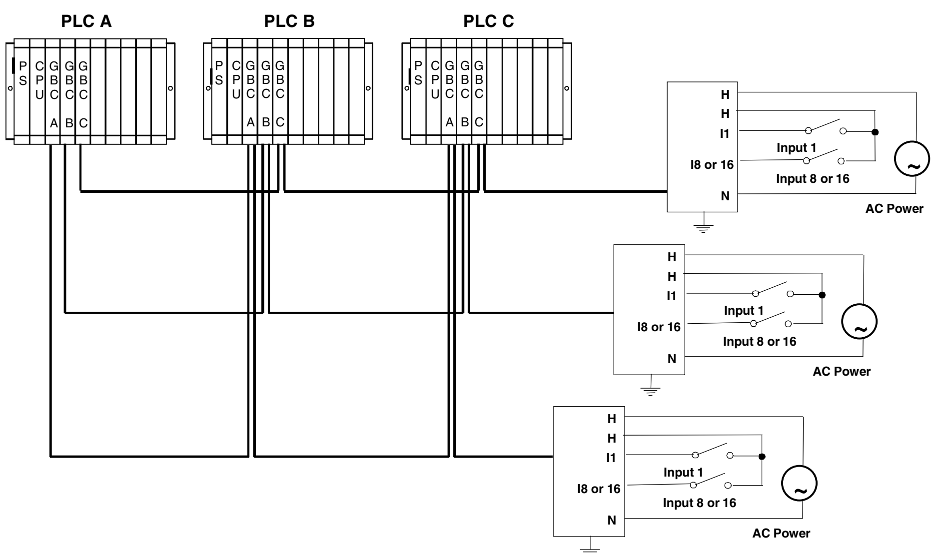


- In a three-block input group, each block is connected to one bus of three.
- All blocks in an input group must have the same number of circuits (either 16 or 32).
- If redundant power supplies are to be used, they should be diode “Ored” power supplies providing common power to all blocks in a group. Diode 1N4001 is suggested. Different groups may use different power sources.

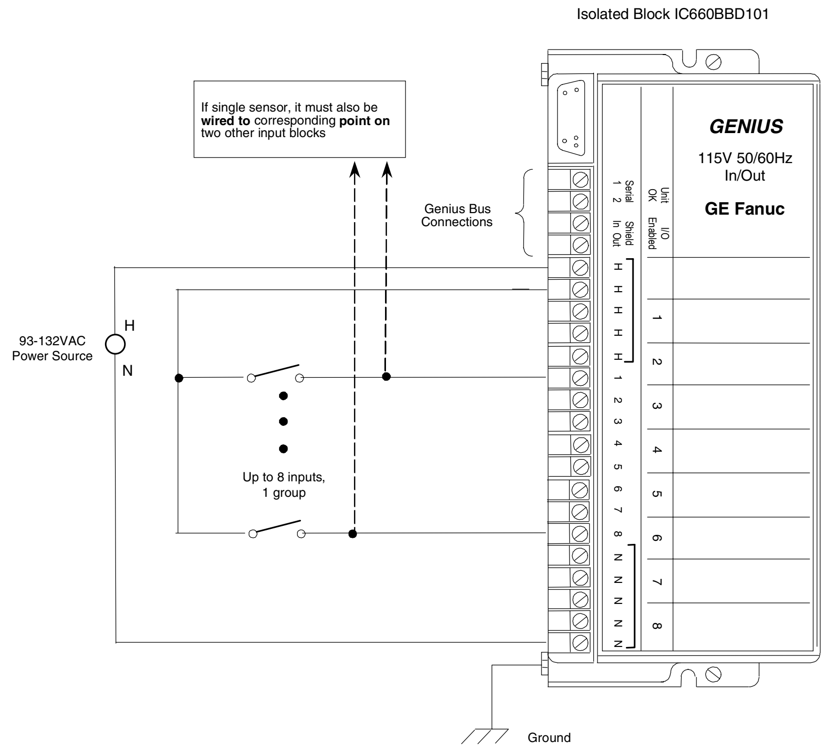
Discrete Input Groups: Single Sensor to Three Discrete AC Blocks (Triple Bus)



Discrete Input Groups: Three Sensors to Three Discrete AC Blocks (Triple Bus)

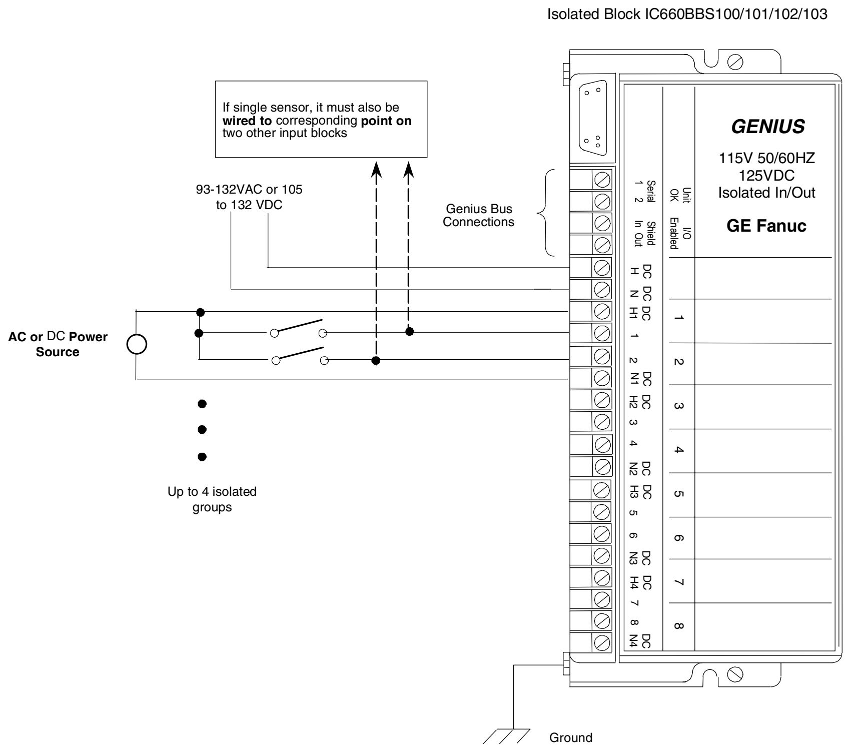


Discrete Inputs: Block Wiring for 8-Circuit Grouped AC Blocks



- In a three-block input group, each block is connected to one bus of three.
- All power connections should be made to the same 120VAC phase. All H terminals are internally bussed, as are all N terminals.
- Only one wire need be run to the field device. Depending on the physical layout and current loads, hot connections can be bussed together and made by one wire to the block or power source. Neutral connections can also be bussed together and made by one wire.
- Since block power is the same as circuit power, it is important to wire block power disconnects so that block power and input power will be removed *at the same time.*

Discrete Inputs: Block Wiring for 8-Circuit Isolated AC/DC Blocks

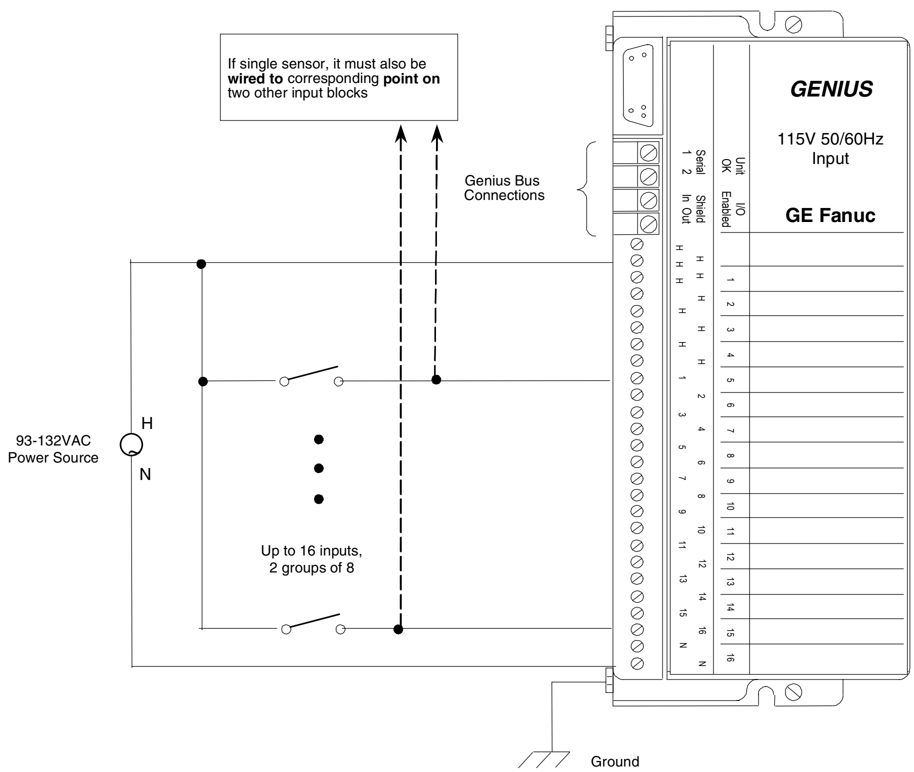


- In a three-block input group, each block is connected to one bus of three.
- Up to five separate power sources can be connected to the block. Circuit power and block power do not have to be the same type. All H terminals are internally bussed, as are all N terminals.
- If circuit power is AC, both circuits of a pair must be wired to the same AC phase. However, different pairs can be wired to different AC phases.
- If separate AC power is used for any group of circuits on a block, all power connections within the group must be wired to that same 120VAC source.
- Only one wire need be run to the field device. Depending on the physical layout and current loads, hot connections can be bussed together and made by one wire to the block or power source. Neutral connections can also be bussed together and made by one wire.

Discrete Inputs: Block Wiring for 16-Circuit AC Input Blocks

If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 12.

AC Input Block IC660BBD110



- In a three-block input group, each block is connected to one bus of three.
- All power connections to the block should be made to the same 120VAC phase. All H terminals are internally bussed, as are all N terminals. Depending on the physical layout and current loads, hot connections can be bussed together and made by one wire to the block or power source. Neutral connections can also be bussed together and made by one wire.
- Since block power is the same as circuit power, it is important to wire block power disconnects so that block power and input power will be removed *at the same time.*

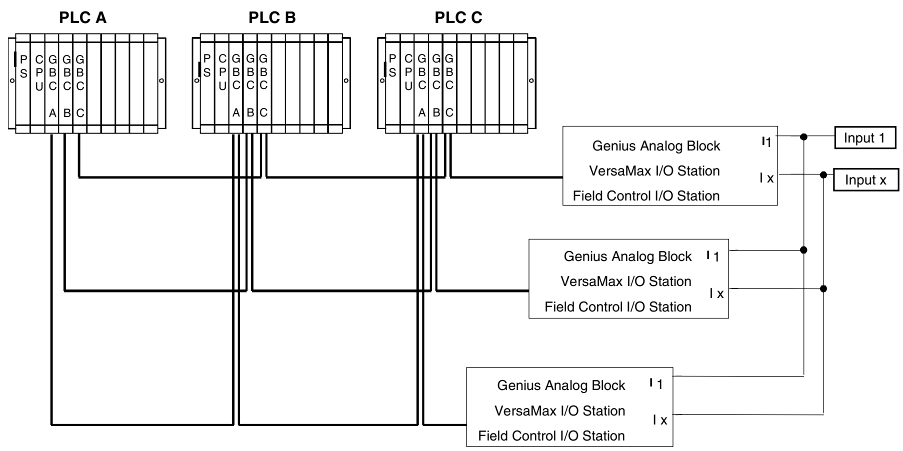
Wiring for Analog Input Groups

Analog inputs in a GMR system may be provided by voted or non-voted Genius analog blocks, VersaMax analog modules, and Field Control analog modules. VersaMax and Field Control analog modules must be located in an I/O station controlled by an intelligent interface module that exchanges I/O data on the Genius bus. A voted analog input group may include one, two or three matching analog blocks or I/O stations.

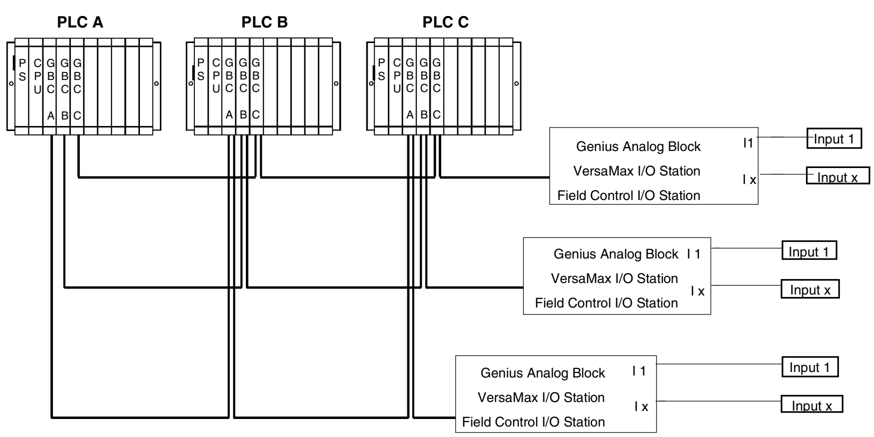
- When using either VersaMax or Field Control I/O Stations, the modules in each I/O Station in a group must be the same type and they must be installed in the same sequence in each I/O Station.
- For each voted input channel in a 3-block (or 3-I/O Station) group, either single or triple input sensors that are compatible with the input drive requirements of the input modules can be used.
- Current-loop (4-20mA) devices must be converted to voltage when a single sensor is used. For Genius I/O Blocks, the termination boards described in chapter 12 can be used to provide this conversion.

Analog Input Groups: Single Sensor to Three Analog Blocks or I/O Stations (Triple Bus)

In the diagrams below, boxes represent either matching Genius analog blocks or matching VersaMax or Field Control I/O Stations. For Genius analog blocks, termination boards can be used to connect single sensors to block groups. See chapter 12 for information.



Analog Input Groups: Three Sensors to Three Analog Blocks or I/O Stations (Triple Bus)



Wiring for an H-Block Output Group

An H-block Output Group consists of two source-type DC blocks (IC660BBD020 or IC660BBD024) and two sink-type DC blocks (IC660BBD021 or IC660BBD025). All blocks in an output group must have the same number of circuits (either 16 or 32).

Output Loads for H-Block Output Group: 16-Circuit Blocks

For blocks IC660BBD020 and IC660BBD021:

Minimum load:	100 milliamps
Maximum load:	2.0 Amps
Maximum inrush current:	10 Amps for up to 10 milliseconds
Maximum total load for block group:	15 Amps at 35 degrees C
Output Off Leakage Current:	2.0 milliamps
For Outputs to be Autotested:	
Minimum pickup time:	Greater than 20 milliseconds
Minimum dropout time:	Greater than 7.5 milliseconds

Output Autotest and Pulse Testing

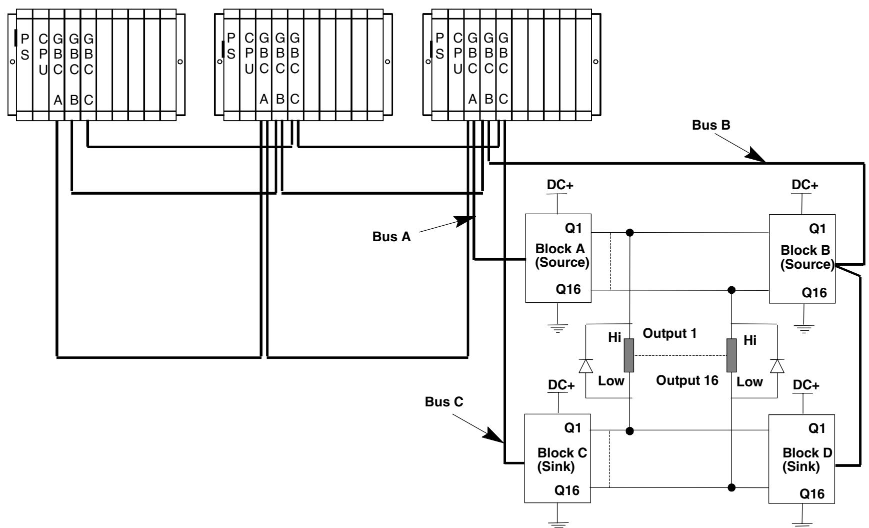
If output circuits are to be autotested, the loads will be subject to pulse testing, which is an integral part of the output autotest sequence. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load. See chapter 3 for more information.

Caution

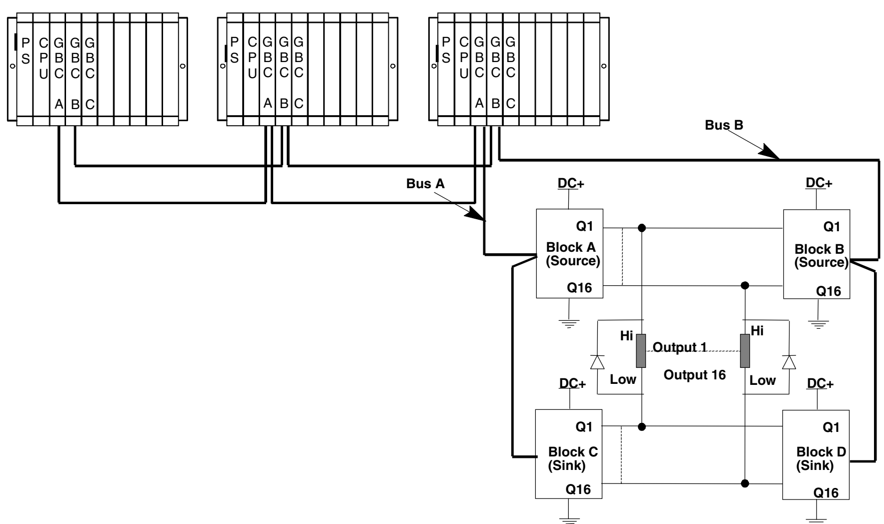
Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Bus Connections for 16-Circuit DC Blocks in an H-Block Group

An H-Block output group may be installed on either 3 busses or 2 busses, as shown below. The bus connections must match those selected in the GMR configuration for that output group. For a group connected to three busses, two of the blocks will be on the same bus.

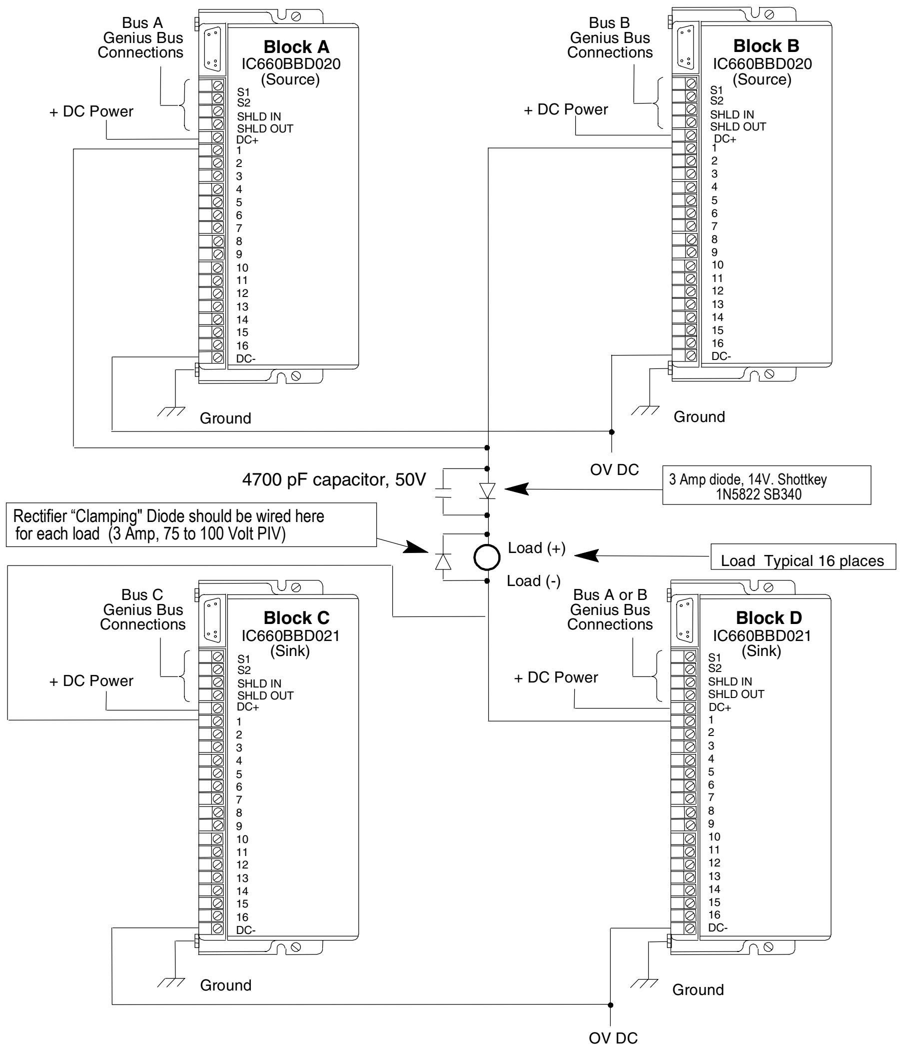


If the blocks are on two busses, two blocks will be on one bus (for example, bus A) and the other two blocks will be on another bus (for example, bus B).



Block Wiring for 16-Circuit DC Blocks in an H-Block Group

More detailed installation information is provided in the block datasheets. The labels **Block A**, **Block B**, **Block C**, and **Block D** refer to the previous system diagram.



- If redundant power supplies are to be used, they should be diode "Ored" power supplies providing common power to all blocks in a group. Different groups may use different power sources.
- Diodes and capacitors shown are not required when the termination boards described in chapter 12 are used.

Output Loads for H-Block Output Group: 32-Circuit DC Blocks

For blocks IC660BBD024 and IC660BBD025:

Minimum load:	1.0 milliamp
Maximum load:	0.5 Amp
Maximum inrush current:	4 Amps for up to 10 milliseconds
Maximum total load for block group:	16 Amps at 35 degrees C
Output Off Leakage Current:	20 microamps
For Outputs to be Autotested:	Minimum pickup time: Greater than 1 mS
	Minimum dropout time: Greater than 1 mS

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

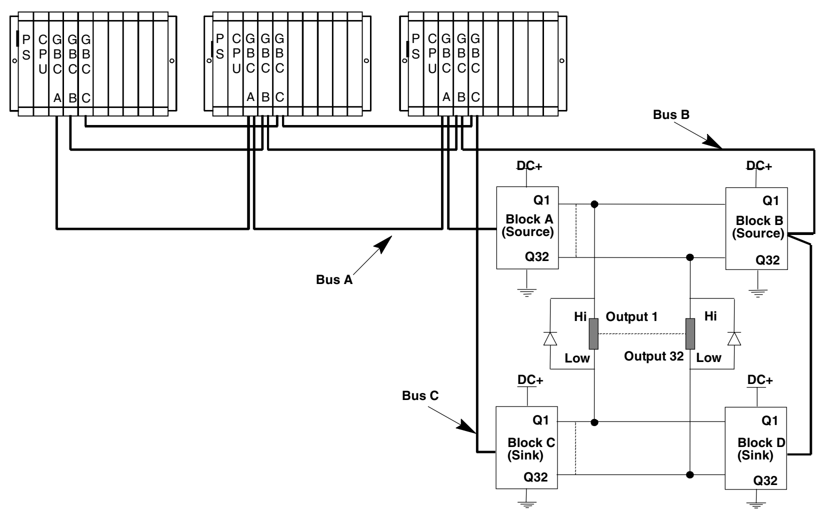
Output Autotest and Pulse Testing

If output circuits are to be autotested, the loads will be subject to pulse testing, which is an integral part of the output autotest sequence. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load. Pulse testing occurs whether the output is in the On state or in the Off state by executing one of two tests. These are the pulse ON-OFF-ON test and the pulse OFF-ON-OFF test. Outputs that are to be autotested must be able to withstand On and Off pulse times of approximately 1mS.

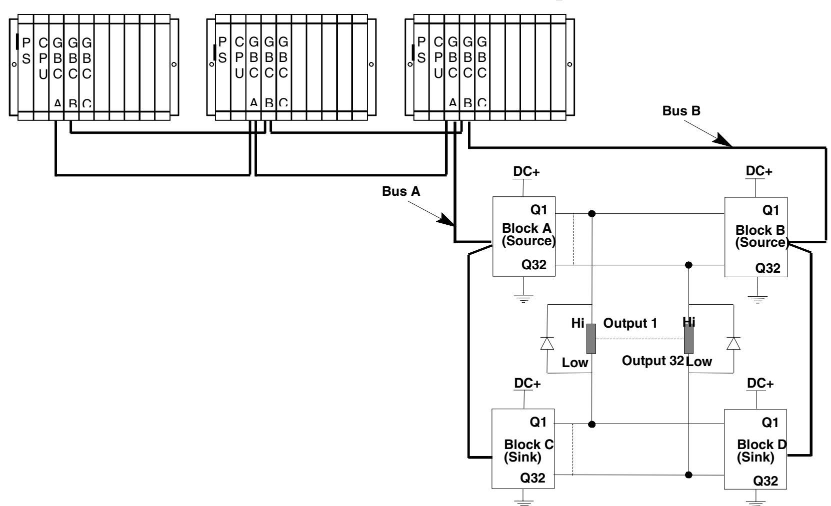
Bus Connections for 32-Circuit DC Blocks in an H-Block Group

An H-Block output group may be installed on either 3 busses or 2 busses, as shown below. The bus connections must match those selected in the GMR configuration for that output group.

For a group connected to three busses, two of the blocks will be on the same bus.



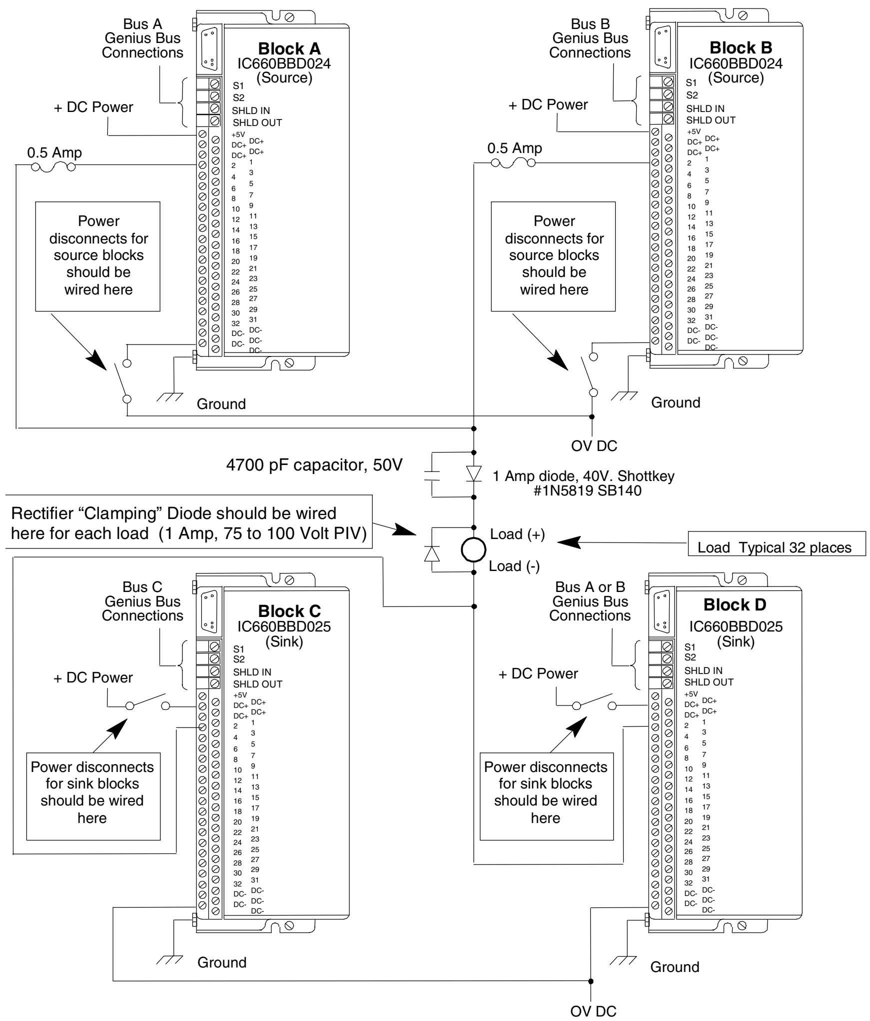
If the blocks are on two busses, two blocks will be on one bus (for example, bus A) and the other two blocks will be on another bus (for example, bus B).



Block Wiring for an H-Block Output Group: 32-Circuit DC Blocks

If you are using optional interface modules and termination boards for the input group, turn to the installation instructions in chapter 13.

More detailed installation information is provided in the block datasheets. The labels **Block A**, **Block B**, **Block C**, and **Block D** refer to the previous system diagram.



Fuses, diodes, and capacitors shown above are not required when the termination boards described in chapter 12 are used.

Power Sources and Power Disconnects for 32-Circuit DC Blocks in an H-Block Output Group

Warning

In certain cases, removing the DC power source from an output block or blocks which are part of a 32-circuit H-Block output group causes leakage currents through the output driver circuits of the powered down block(s). To ensure that these potential leakage currents do not adversely affect the output devices being controlled, these installation instructions must be followed.

A. All 4 blocks in an output group must be powered from the same common power source. If redundant power supplies are to be used they should be diode "ored" power supplies that provide a common power source for the 4 blocks in a group. Different output groups may use different power sources.

B. Power disconnects for the blocks in a group should be wired such that either a single disconnect powers down all 4 blocks simultaneously or each individual block is powered down by its own disconnect. An individual disconnect and/or fuse for each individual block provides the greatest flexibility in replacing a failed block without disturbing the controlled output devices.

C. Ideally the disconnect for a source block (IC660BBD024) should be wired in the DC- supply line and for a sink block (IC660BBD025) in the DC+ supply line.

D. A rectifier diode must be wired in parallel with each output load as shown in the diagram. This diode should have a minimum 1 Amp forward current rating and 75 volt to 100 volt PIV rating. This diode does not affect the ability of the system to do output autotesting of each output if configured to do so.

Wiring for a T-Block Output Group

A T-Block Output Group consists of two source-type DC blocks (IC660BRD020, which has 16 circuits, or IC660BBD024, which has 32 circuits). Both blocks in an output group must have the same number of circuits (either 16 or 32).

Output Loads for T-Block Output Group: 16-Circuit DC Blocks

The 16-circuit T-Block Output Group utilizes a special Genius I/O block, IC660BRD020. This block has built-in diodes to prevent feedback current from the loads powering the block itself. Block BRD020 should be used for a T-Block Output Group instead of the similar 16-circuit DC block, IC660BBD020, which does not have the feedback diodes. Specifications for block IC660BRD020 are:

Minimum load	100 milliamps
Maximum load	2.0 Amps
Maximum inrush current	10 Amps for up to 10 milliseconds
Maximum total load for block group	15 Amps at 35 degrees C
Output Off Leakage Current	2.0 milliamps
For Outputs to be Autotested	Min. pickup time: Greater than 20 mS Min. dropout time: Greater than 7.5 mS

If output circuits are to be autotested, the loads will be subject to pulse testing, which is an integral part of the output autotest sequence. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load. For more information, please turn to chapter 3.

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Often, in cases where a desired output device does not by itself meet a requirement, external components can be added to change its characteristics and allow it to operate in an output group and be autotested. Or, a diagnostic feature (such as autotest, No Load, or Overload) can be disabled to allow it to operate in a T-Block Output Group.

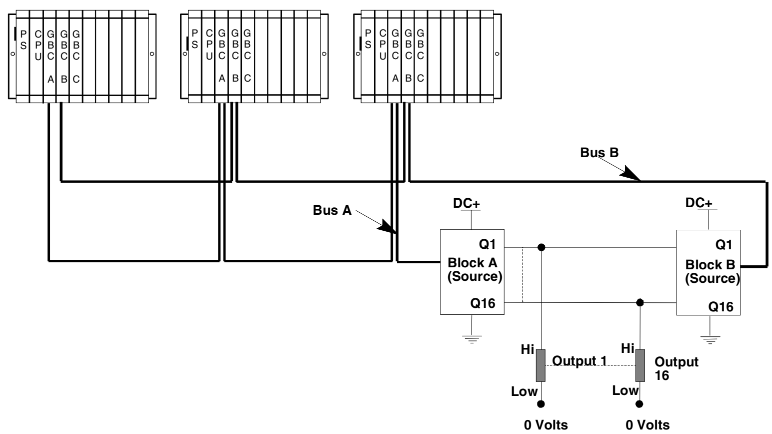
Loads Greater than 2 Amps

In a T-Block Output Group, two blocks are connected to a load in parallel. Therefore, although each block has a maximum load rating of 2.0 Amps, the two blocks in a T-Block group can control loads up to 4 Amps, <u>only while both blocks</u>

are operating. Therefore, operation of loads greater than 2 Amps cannot be guaranteed. Because it is not possible to determine how much current is supplied by each of the blocks in a T-block output group, Overload Shutdown should be disabled for loads greater than 2 Amps. In this type of installation, to assure that any load gets turned off, it is essential to supply external fusing.

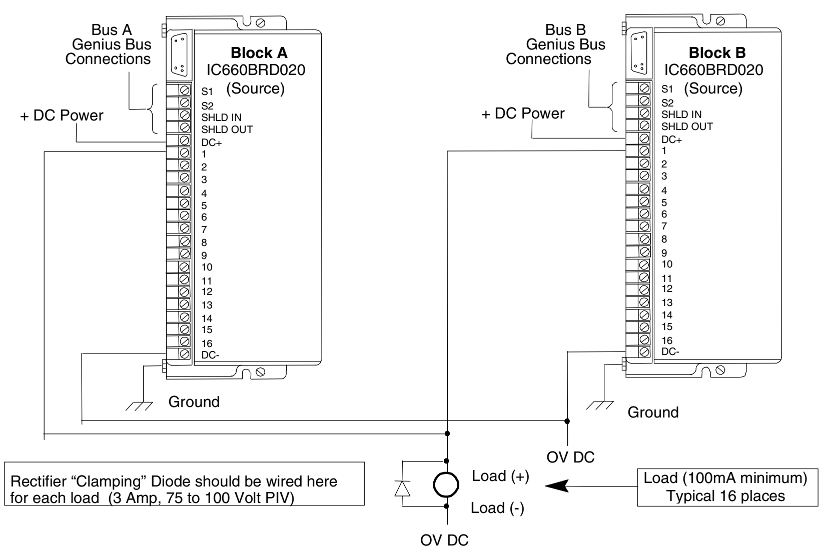
Bus Connections for 16-Circuit DC Blocks in a T-Block Group

A T-Block group must be installed on 2 busses, as shown below. The bus connections must match those selected in the GMR configuration for the group.



Block Wiring for T-Block Output Groups: 16-Circuit DC Blocks

The labels **Block A** and **Block B** refer to the diagram above. The termination boards described in chapter 12 can be used to facilitate wiring.



Output Load Considerations for T-Block Output Groups: 32-Circuit DC Blocks

For block IC660BBD024:

Minimum load:	1.0 milliamp
Maximum load:	0.5 Amp
Maximum inrush current:	4 Amps for up to 10 milliseconds
Maximum total load for block group:	16 Amps at 35 degrees C
Output Off Leakage Current:	20 microamps
For Outputs to be Autotested:	
Minimum pickup time:	Greater than 1 millisecond
Minimum dropout time:	Greater than 1 millisecond

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Output Autotest and Pulse Testing

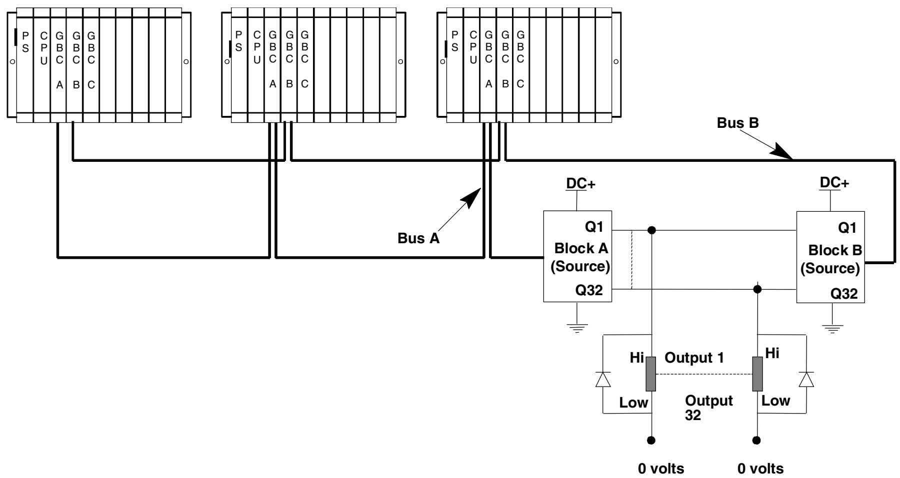
If output circuits are autotested, the loads are subject to pulse testing, which is integral to the output autotest sequence. Pulse testing verifies the ability of outputs to change state with a short pulse that is not intended to affect the actual load. Pulse testing occurs whether the output is in the On state or in the Off state by executing one of two tests. These are the pulse ON-OFF-ON test and the pulse OFF-ON-OFF test. Outputs to be autotested must be able to withstand On and Off pulse times of approximately 1 millisecond.

Load Sharing for a T-Block Output Group

In a T-Block Output Group, two current sourcing outputs are connected to a load in parallel. Therefore, it is possible for more current to be sourced from one output than the other. An individual output can source up to 0.5 Amp. With two outputs in parallel, the theoretical maximum current that can be sourced is 1 Amp if both share the load equally.

Bus Connections for 32-Circuit DC Blocks in a T-Block Group

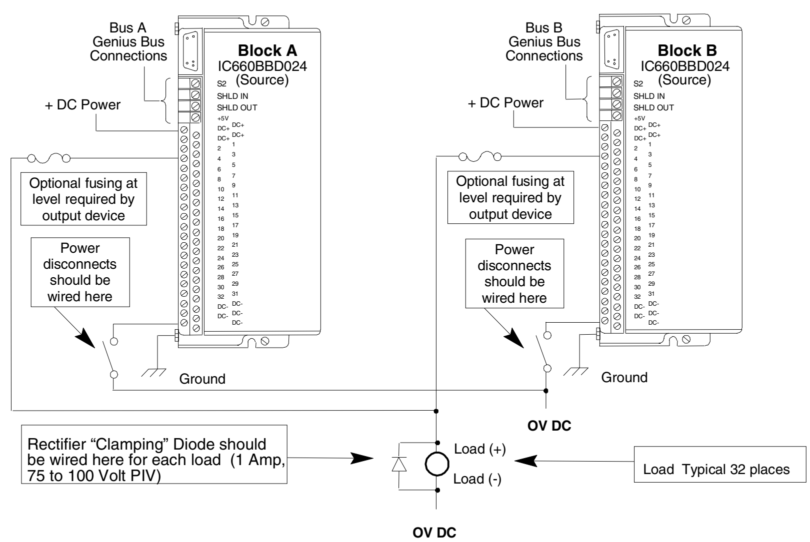
A T-Block group must be installed on 2 busses, as shown below. Bus connections must match those selected in the GMR configuration for that output group.



All blocks in an output group must have the same number of circuits (16 or 32).

Block Wiring for a T-Block Output Group: 32-Circuit DC Blocks

More detailed installation information is provided in the block datasheets. The labels **Block A** and **Block B** refer to the diagram above.



Power Sources and Power Disconnects for 32-Circuit DC Blocks in a T-Block Output Group

Warning

In certain cases, removing the DC power source from an output block or blocks which are part of a 32-circuit T-Block output group causes leakage currents through the output driver circuits of the powered down block(s). To ensure that these potential leakage currents do not adversely affect the output devices being controlled, follow these installation instructions.

A. Both blocks must be powered from the same common power source. If redundant power supplies are to be used they should be diode “ored” power supplies that provide a common power source for both blocks in the group. Other output groups may use different power sources.

B. Make power disconnects for the group such that either a single disconnect powers down both blocks simultaneously or each individual block is powered down by its own disconnect. An individual disconnect and/or fuse for each individual block provides the greatest flexibility in replacing a failed block without disturbing the controlled output devices. Ideally the disconnect for a source block (IC660BBD024) should be wired in the DC- supply line.

C. Wire a rectifier diode in parallel with each output load as shown. The diode should have a minimum 1 Amp forward current rating and 75 volt to 100 volt PIV rating. This diode does not affect the ability of the system to do output autotesting.

Wiring for an I-Block Output Group

An I-Block Output Group consists of one source-type DC block (IC660BBD020 or IC660BBD024) and one sink-type DC block (IC660BBD021 or IC660BBD025) connected to the opposite sides of the loads. All blocks in an output group must have the same number of circuits (either 16 or 32).

Output Loads for I-Block Output Group: 16-Circuit DC Blocks

For blocks IC660BBD020 and IC660BBD021:

Minimum load:	50 milliamps
Maximum load:	2.0 Amps
Maximum inrush current:	10 Amps for up to 10 milliseconds
Maximum total load for block group:	15 Amps at 35 degrees C
Output Off Leakage Current:	2.0 milliamps
For Outputs to be Autotested:	
Minimum pickup time:	Greater than 20 milliseconds
Minimum dropout time:	Greater than 7.5 milliseconds

If output circuits are to be autotested, the loads will be subject to pulse testing, which is an integral part of the output autotest sequence. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load.

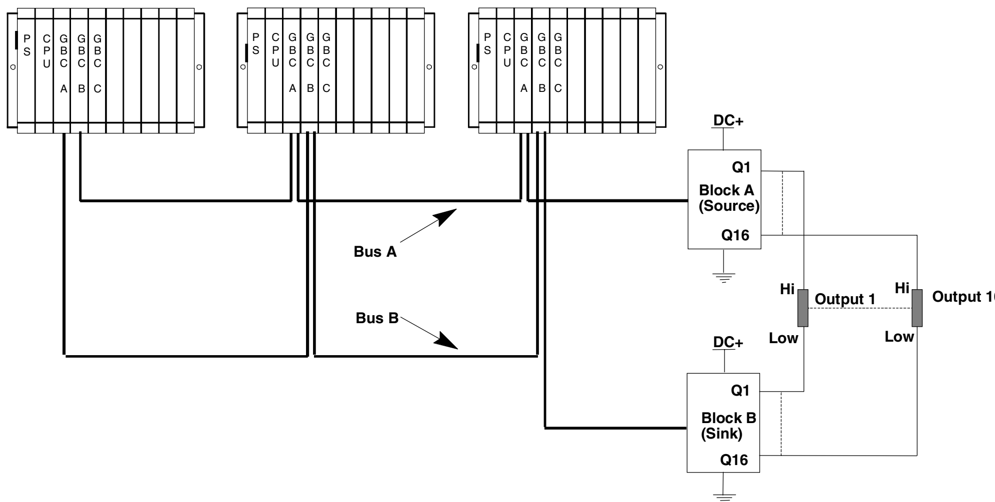
Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the I-Block Output Group. Otherwise, critical output loads could be adversely affected.

Often, in cases where a desired output device does not by itself meet a requirement, external components can be added to change its characteristics and allow it to operate in a I-Block Output Group and be autotested. Or, a diagnostic feature (such as autotest, No Load, or Overload) can be disabled to allow it to operate in a I-Block Output Group.

Bus Connections for 16-Circuit DC Blocks in an I-Block Group

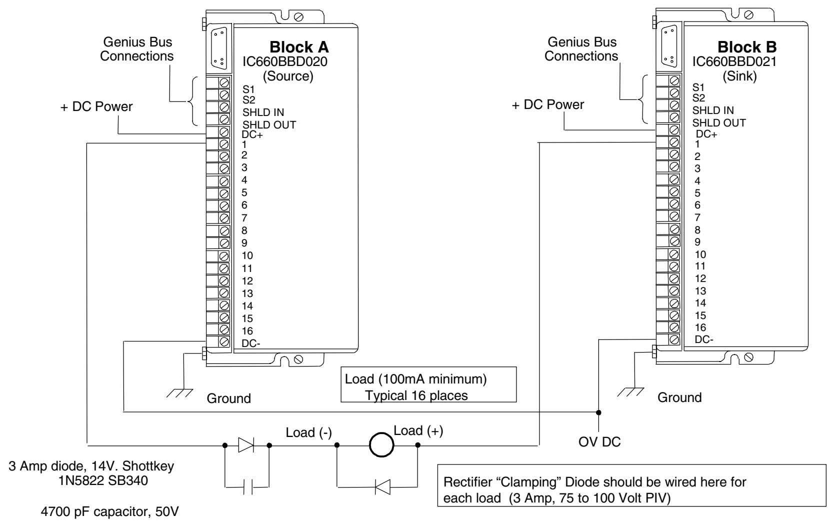
An I-Block output group must be installed on 2 busses, as shown below. The bus connections must match those selected in the GMR configuration for that output group.



All blocks in an output group must have the same number of circuits (16 or 32).

Block Wiring for an I-Block Output Group: 16-Circuit DC Blocks

More detailed installation information is provided in the block datasheets. Diodes and capacitors shown below are not required when the termination boards described in Chapter 12 are used.



If redundant power supplies are to be used, they should be diode "Ored" power supplies providing common power to both blocks in a group. Other groups may use different power sources.

Output Load Considerations for I-Block Output Groups: 32-Circuit Blocks

For blocks IC660BBD024 and IC660BBD025:

Minimum load:	1.0 milliamp
Maximum load:	0.5 Amp
Maximum inrush current:	4 Amps for up to 10 milliseconds
Maximum total load for block group:	16 Amps at 35 degrees C
Output Off Leakage Current:	20 microamps
For Outputs to be Autotested:	
Minimum pickup time:	Greater than 1 millisecond
Minimum dropout time:	Greater than 1 millisecond

Caution

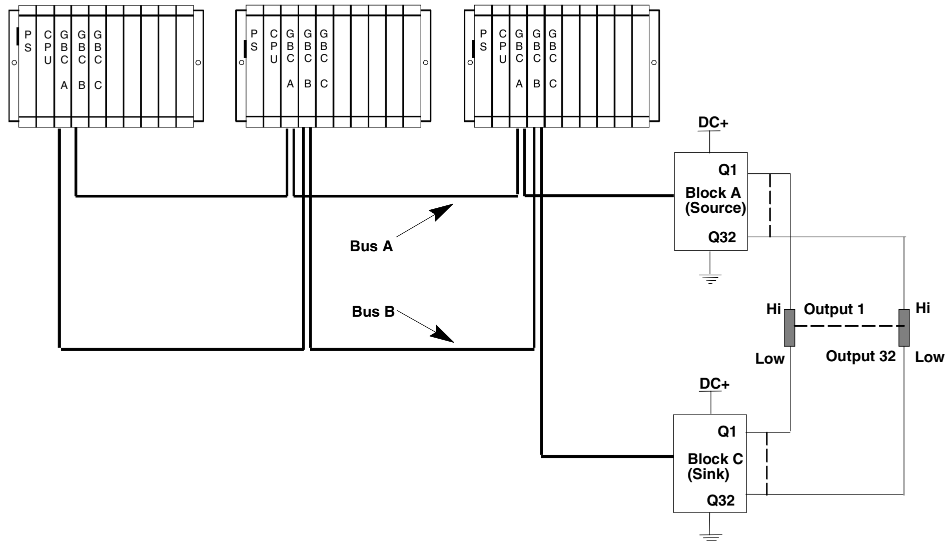
Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Output Autotest and Pulse Testing

If output circuits are to be autotested, the loads will be subject to pulse testing, which is an integral part of the output autotest sequence. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load. Pulse testing occurs whether the output is in the On state or in the Off state by executing one of two tests. These are the pulse ON-OFF-ON test and the pulse OFF-ON-OFF test. Outputs that are to be autotested must be able to withstand On and Off pulse times of approximately 1 millisecond.

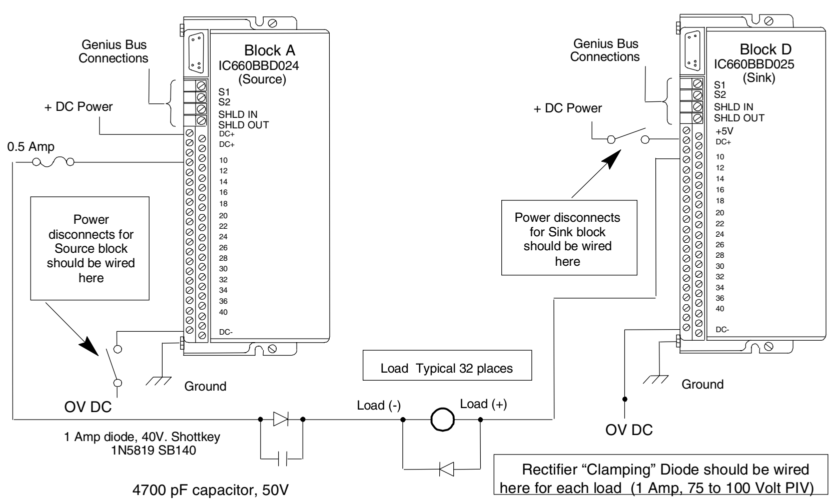
Bus Connections for 32-Circuit DC Blocks in an I -Block Group

An I-Block output group must be installed on 2 busses. The bus connections must match those selected in the GMR configuration for that output group.



Block Wiring for an I-Block Output Group: 32-Circuit Blocks

More detailed installation information is provided in the block datasheets. Fuses, diodes, and capacitors as shown below are not required when the termination boards described in Chapter 12 are used.



Power Sources and Power Disconnects for 32-Circuit DC Blocks in an I-Block Output Group

Warning

In certain cases, removing the DC power source from an output block or blocks which are part of a 32-circuit I-Block output group, causes leakage currents through the output driver circuits of the powered down block(s). To ensure that these potential leakage currents do not adversely affect the output devices being controlled, these installation instructions must be followed.

A. Both blocks in an output group must be powered from the same common power source. If redundant power supplies are to be used they should be diode “ored” power supplies that provide a common power source for both blocks in a group. Different output groups may use different power sources.

B. Power disconnects for the blocks in a group should be wired such that either a single disconnect powers down both blocks simultaneously or each individual block is powered down by its own disconnect.

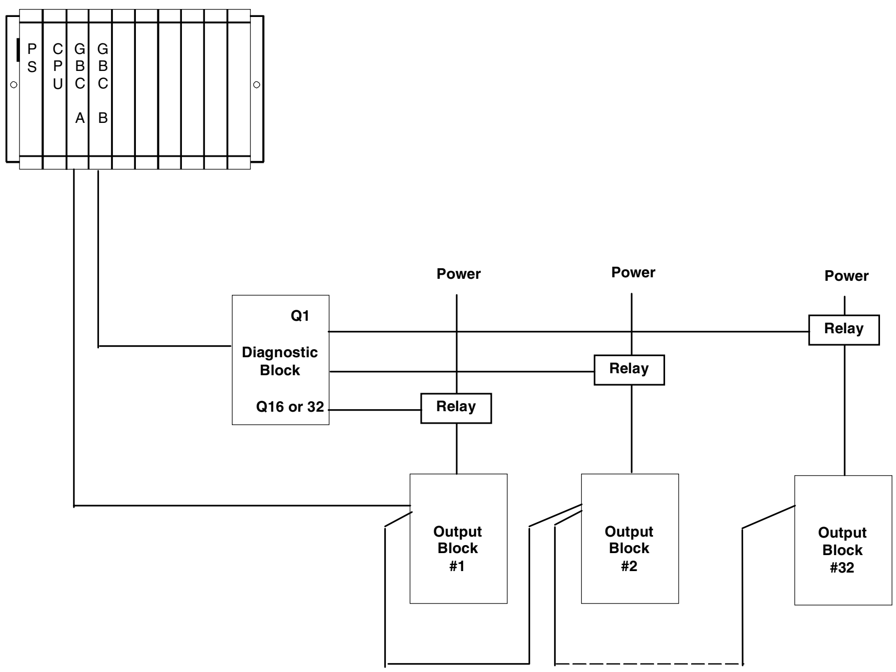
C. Ideally the disconnect for a source block (IC660BBD024) should be wired in the DC- supply line and for a sink block (IC660BBD025) in the DC+ supply line.

D. A rectifier diode must be wired in parallel with each output load as shown in the diagram. This diode should have a minimum 1 Amp forward current rating and 75 volt to 100 volt PIV rating. This diode does not affect the ability of the system to do output autotesting of each output if configured to do so.

Wiring for a 1oo1D Output Group

A 1oo1D Output Group consists of one discrete Output Block which is connected to one output point on another block. That block is referred to as the “Diagnostic Block”. The Diagnostic Block can control power into the Output Block as instructed by the GMR program logic.

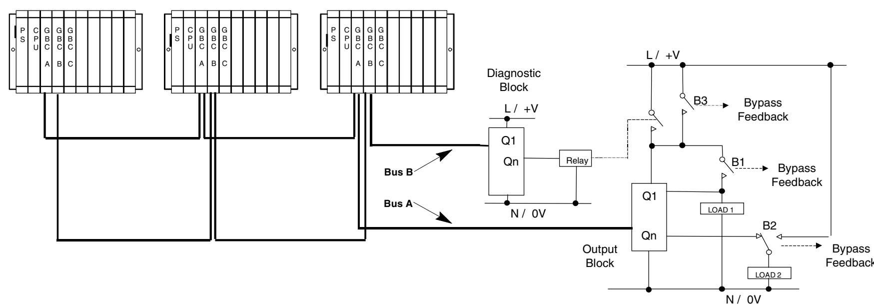
An individual Diagnostic Block can control power to many 1oo1D Output Blocks. The Output Blocks can be different types from the Diagnostic Block. They can also be different from each other.



Up to 32 Output Blocks
Each Output Block is an independent 1001D Output Group

Bus Connections for a 1oo1D Output Group

For a 1oo1D output group, the Output Block and Diagnostic Block must be installed on 2 different busses, as shown below. Bus connections must match those selected in the GMR configuration of the output group. If the same Diagnostic Block controls multiple Output Blocks, each Output Block is considered a separate 1oo1D Output Group. These separate 1oo1D Output Groups can be located on the same bus or on different busses. For example, if the Diagnostic Block is located on Bus A, the Output Blocks can be located on Bus B, Bus C, or both B and C.



Isolating the power rail used to drive the output block through a relay can effectively de-energize all output loads except any that have been bypassed by using a separate power rail. For fail-safe operation a normally energized relay with a high current rating (min. 16A) is required. The relay must conform to IEC 60255-1-00 (Electrical Relays – Part 1, All or Nothing Electrical Relays) and EN 50156-1 (Electrical Equipment for Furnaces and Ancillary Equipment – Part 1, Requirements for Application, Design and Installation).

In the example above, the output block is shown with two loads. The circuit for Load 1 shows an optional direct output bypass (*B1*) that is driven from the isolated power rail. B1 is de-activated when the diagnostic block has isolated the power.

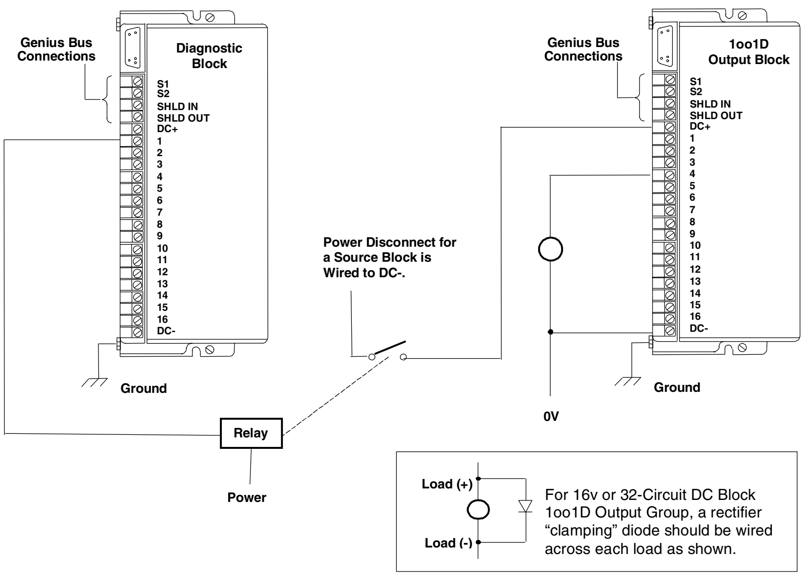
The circuit for Load 2 shows an optional changeover output bypass. It uses a Make-Before-Break switch (*B2*) that is driven from the non-isolated power rail. This bypass feature can be used when the diagnostic block has isolated the output block power, as it does not create a feedback loop through the block.

Feedback from the B1 output bypass to the PLC subsystem is needed so that the Diagnostic Block will not misinterpret the state of the output and shut down the output block when the bypass is activated. Feedback is also used to suppress Failed Switch fault reporting in DC-only blocks. This feedback must be wired into an input addressed in the non-voted section of the input table, which can be selected via the GMR Configuration Software when configuring this type of group.

The relay that controls power to the output block should be proof-tested periodically to be sure it can be driven to its safe state. In the example, when the optional relay bypass switch *B3* is closed, the output block is not de-powered during the proof test. This switch is manually closed. Because this manual control defeats the function of the Diagnostic Block, the application must provide feedback to indicate when the Diagnostic Block function has been defeated.

Block Wiring for a 1oo1D Output Group: 16/32-Circuit DC Blocks

More detailed installation information is provided in the block datasheets.



If redundant power supplies are used, they should be diode "Ored" power supplies.

Power Sources and Power Disconnects

Warning

In certain cases, removing the DC power source from the output block in a 32-circuit 1oo1D Output Group causes leakage currents through the output driver circuits of the powered down block. To ensure that these potential leakage currents do not adversely affect the output devices being controlled, these installation instructions must be followed.

A. The disconnect for a source block (IC660BBD024) should be wired in the DC- supply line.

B. A rectifier diode must be wired in parallel with each output load as shown in the diagram. For a 16-circuit Output Block, this diode should have a minimum 3 Amp forward current rating and 75 volt to 100 volt PIV rating. For a 32-circuit Output Block, this diode should have a minimum 1 Amp forward current rating and 75 volt to 100 volt PIV rating. This diode does not affect the ability of the system to do output autotesting of each output if configured to do so.

Output Load Considerations for a 1oo1D Output Group: 8-Circuit AC Output Blocks

For block IC660BBS101 or IC660BBS103 used as the output block in a 1oo1D group:

Minimum load:	IC660BBS103	AC Block Power: 25 milliamps resistive, 40mA inductive DC Block Power: 10 milliamps resistive, 10mA inductive load
	IC660BBS101	AC Block Power: 30 milliamps resistive, 100mA inductive DC Block Power: 10 milliamps resistive, 50mA inductive load
Maximum load		AC Block Power: 2.0 Amps DC Block Power: 2.0 Amps resistive (1Amp inductive)
Maximum inrush current		AC Block Power: 25 Amps (2 cycles) DC Block Power: 25 Amps (10mS peak)
Maximum total load for block:		15 Amps at 35 deg. C, 7.5 Amps at 60 deg. C
Output Leakage Current at 0V Output:	IC660BBS103	AC Block Power: 2mA DC Block Power: 2mA
	IC660BBS101	AC Block Power: 13mA DC Block Power: 2mA
For Outputs to be Autotested:		
Minimum pickup time:		Greater than 8 milliseconds (or 1/2 of line cycle)
Minimum dropout time:		Greater than 8 milliseconds (or 1/2 of line cycle)
Minimum point load for autotest:		50mA

If selected via configuration, the loads will be subject to pulse testing. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load.

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Often, in cases where a desired output device does not by itself meet a requirement, external components can be added to change its characteristics and allow it to operate in an output group and be autotested. Or, a diagnostic feature (such as autotest, No Load, or Overload) can be disabled to allow it to operate in an output group.

Output Load Considerations for a 1oo1D Output Group: 16-Circuit DC Output Block

For block IC660BBD020 or IC660BBD021 used as the output block in a 1001D group:

Minimum load:	50 milliamps
Maximum load:	2.0 Amps
Maximum inrush current:	10 Amps for up to 10 milliseconds
Maximum total load for block group:	15 Amps at 35 degrees C
Output Off Leakage Current:	2.0 milliamps
For Outputs to be Autotested:	
Minimum pickup time:	Greater than 20 milliseconds
Minimum dropout time:	Greater than 7.5 milliseconds

If selected via configuration, the loads will be subject to pulse testing. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load.

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Often, in cases where a desired output device does not by itself meet a requirement, external components can be added to change its characteristics and allow it to operate in an output group and be autotested. Or, a diagnostic feature (such as autotest, No Load, or Overload) can be disabled to allow it to operate in an output group.

Output Load Considerations for a 1oo1D Output Group: 32-Circuit DC Output Block

For block IC660BBD024 or IC660BBD025 used as the output block in a 1001D group:

Minimum load:	1.0 milliamp
Maximum load:	0.5 Amp
Maximum inrush current:	4 Amps for up to 10 milliseconds
Maximum total load for block group:	16 Amps at 35 degrees C
Output Off Leakage Current:	20 microamps
For Outputs to be Autotested:	
Minimum pickup time:	Greater than 1 millisecond
Minimum dropout time:	Greater than 1 millisecond

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the output group. Otherwise, critical output loads could be adversely affected.

Output Autotest and Pulse Testing

If selected via configuration, the loads will be subject to pulse testing. Pulse testing verifies the ability of a block's outputs to change state with a short pulse that is not intended to affect the actual load. Pulse testing occurs whether the output is in the On state or in the Off state by executing one of two tests. These are the pulse ON-OFF-ON test and the pulse OFF-ON-OFF test. Outputs that are to be autotested must be able to withstand On and Off pulse times of approximately 1 millisecond.

Chapter 12 Using Termination Boards and Interface Modules

This section describes the characteristics and installation of special termination boards and interface modules that can be used to simplify the setup of certain Genius blocks in redundant input groups and output groups.

- Overview of Termination Boards and Interface Modules
- Discrete Input Termination Boards and Interface Modules for 16-circuit DC discrete blocks IC660BBD020 and IC660BBD021.
- Discrete Input Termination Boards and Interface Modules for 32-circuit DC discrete blocks IC660BBD024 and IC660BBD025
- Analog Input Termination Boards and Interface Modules for 6-point current input analog block IC660BBD026.
- Discrete Output Termination Boards and Interface Modules for 16-circuit DC discrete blocks IC660BBD020 and IC660BBD021.
- Discrete Output Termination Boards and Interface Modules for 32-circuit DC discrete blocks IC660BBD024 and IC660BBD025.
- Installing Termination Boards and Interface Modules.

Overview

Termination boards and interface modules that facilitate the integration of certain Genius blocks into redundant groups have been developed by Silvertech Limited.

Genius Blocks for which Termination Boards and Interface Modules are Available

Termination boards and interface modules are available for the following Genius blocks:

IC660BBD020	16 Circuit Discrete Block
IC660BBD021	16 Circuit Discrete Block
IC660BBD024	32 Circuit Discrete Block
IC660BBD025	32 Circuit Discrete Block
IC660BBD026	6 Point Current Input Analog Block

The use of termination boards and interface modules is optional.

Basic Features

Discrete input termination boards and interface modules incorporate the diodes needed for input autotest. They support asynchronous input autotest. For 16-point discrete blocks IC660BBC020 and 021, they support the use of tristate inputs. The 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.

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

Discrete output termination boards and interface modules group output signals and incorporate a diode for each point to prevent reverse load leakage current. ***The 32-circuit discrete output termination board*** incorporates a self-indicating fuse, in accordance with TÜV recommendations, that is visible when the board is installed. A blown fuse is revealed by output autotest.

Interface Modules

Interface modules perform basic grouping and conditioning of I/O device signals.

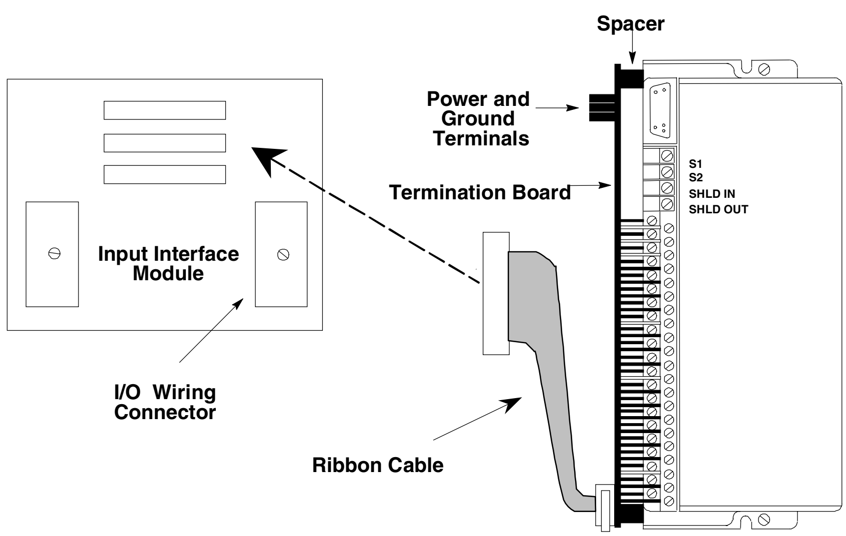
Interface modules are DIN-rail mountable, with connectors for the I/O devices and termination board wiring. 34-wire ribbon cables (the mating connector and cable are not supplied) are used to connect interface modules with termination boards. The interface module separates I/O wiring from internal panel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

Termination Boards

Termination boards interface I/O device signals to Genius blocks. They perform any additional signal conditioning that may be necessary.

Termination boards attach to the side of each Genius block in a group. The board is held in position by its connection pins that 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 and termination board with a 32 point discrete input module.



16 Point Discrete Input Termination Boards and Interface Modules

16 Point discrete input termination boards and interface modules are for use with for Genius Blocks IC660BBD020 and -021. They incorporate all the diodes needed for the input autotest feature; no other diodes are required. The termination board supports asynchronous input autotest. Input autotest can be disabled by jumpering two terminals on the termination board. All 16 points are then available as inputs.

The tristate, or supervised, input feature of 16-point blocks can be used with these termination boards.

The discrete input interface module has polarized locking two-part connectors for I/O wiring. It 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.

Specifications

Operating voltage	20V to 32V DC
Temperature range	0 to +60 degrees C
Humidity	5% to 95% non-condensing
Connectors: Interface Module	One 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 (projection from Genius block when installed)
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 inputs with autotest). Non-GMR Mode: 15/16 normally open switches with zener diodes in parallel for tristate inputs (15 inputs 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: 7mA at 24V supply Tristate, non-GMR mode: 11mA at 24V supply
Silvertech part numbers GBC1-SC-DI16 GBC1-SK-DI16 IMC3-SC-DI16 IMC3-SK-DI16 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.

32 Point Discrete Input Termination Boards and Interface Modules

32-Point Discrete Input termination boards and interface modules are available for use with Genius Blocks IC660BBD024 and -025. They incorporate all the diodes needed for the input autotest feature; no other diodes are required. The termination board includes circuitry to support asynchronous input autotest. Input autotest can be disabled by jumpering two terminals on the termination boards. All 32 points are then available as inputs.

The discrete input interface module has polarized locking two-part connectors for I/O wiring. It 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.

Specifications

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 (projection from Genius block when installed)
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 protection 31 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 board and interface module are available for use with 6-point current input Genius blocks IC660BBD026.

The termination board incorporates a high input impedance voltage-to-current converter for each point that is powered by the point power supply.

The interface module has a polarized locking two-part connector for I/O wiring. The 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.

Specifications

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 (projection from Genius block when installed)
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 ± 5%
Input Protection	Thermistor limited to less than 100mA typical
Signal Accuracy	±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.

16 Point Discrete Output Termination Boards and Interface Modules

16 point discrete output termination boards and interface modules are for use with 16-point sink and source Genius blocks IC660BBD020 and -021.

The output interface modules provide polarized locking two-part connectors for I/O wiring. The interface module groups output signals and incorporates 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 termination board operates with either sink or source blocks.

The termination boards and interface module can easily be configured for either a 4-block H-pattern or 2-block I-pattern output arrangement. Consult Silvertech Limited or your GE Fanuc sales representative for information on the 2-block T-pattern output arrangement.

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: 16 point 219mm length X 110mm width X 30mm depth: 32 point
Size: Interface Modules	145mm length X 109 mm width X 101mm depth (including mating connector, including mounting bracket)
Outputs	16 loads at 2 Amps per channel max, 15 Amps total at 35 deg. C
Load Voltage at 1A	Supply Voltage -2V typical
Minimum Load	100mA with No Load Reporting enabled
Silvertech part numbers	
GBC1-CK-DO16	Termination Board for Source or Sink block
IMC4-CK-DO16	Interface Module for 16-circuit output block group.
CBL1-CK-RRnn	34-way ribbon cable, termination board to interface module
CBL1-CK-EEnn	Field device connection cable with 2 ELCO 8016 connectors
CBL1-CK-EBnn	Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

32 Point Discrete Output Termination Boards and Interface Modules

32 point discrete output termination boards and interface modules are for use with 32-point sink and source Genius blocks IC660BBD024 and -025.

The output interface modules provide polarized locking two-part connectors for I/O wiring. The interface module groups output signals and incorporates 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 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 output autotest.

The termination boards and interface module can easily be configured for either a 4-block H-pattern or 2-block I-pattern output arrangement. Consult Silvertech Limited or your GE Fanuc sales representative for information on the 2-block T-pattern output arrangement.

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 (including mating connector, including mounting bracket)
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	Termination Board for 32-circuit Source block
GBC1-SK-DO32	Termination Board for 32-circuit Sink block
IMC4-CK-DO32	Interface Module for 32-circuit output block group.
CBL1-CK-RRnn	34-way ribbon cable, termination board to interface module
CBL1-CK-EEnn	Field device connection cable with 2 ELCO 8016 connectors
CBL1-CK-EBnn	Field device connection cable with 1 ELCO 8016 connector and stripped and tinned connectors at the other end.

Installing Termination Boards and Interface Modules

Follow the general instructions below to install optional termination boards and interface modules.

The termination board and the interface module should be located in the same enclosure.

When installing the Genius blocks, allow approximately 8cm (3 inches) between the sides of adjacent blocks to allow removal of the termination boards, and approximately 10cm (4 inches) to allow fuse replacement at a later date.

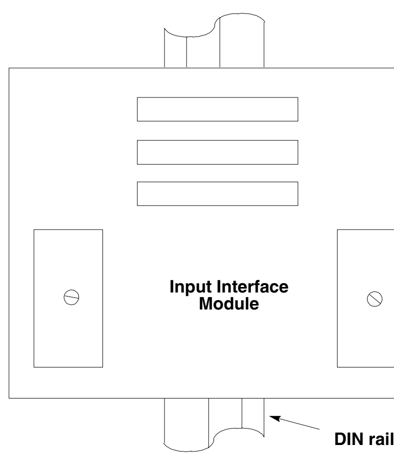
Installing an Interface Module

The interface module's mounting bracket mounts on a TS32 or TS35 or equivalent DIN rail. The rail may be raised clear of or mounted directly to the supporting plate or panel as desired.

Allow a height clearance of approximately 4 inches (100mm), for the removal of the mating ELCO 8016 series connector(s).

The interface modules incorporate one 0.25" (6.35mm) Faston tab per ELCO 8016 series connector, for the termination of I/O cable screens to a suitable ground reference potential. It is recommended that the internal panel ribbon wiring be segregated from the I/O wiring in accordance with normal engineering practice.

The illustration below represents a 32-point discrete input interface module with dual two-part field I/O connectors and three ribbon termination board connectors.



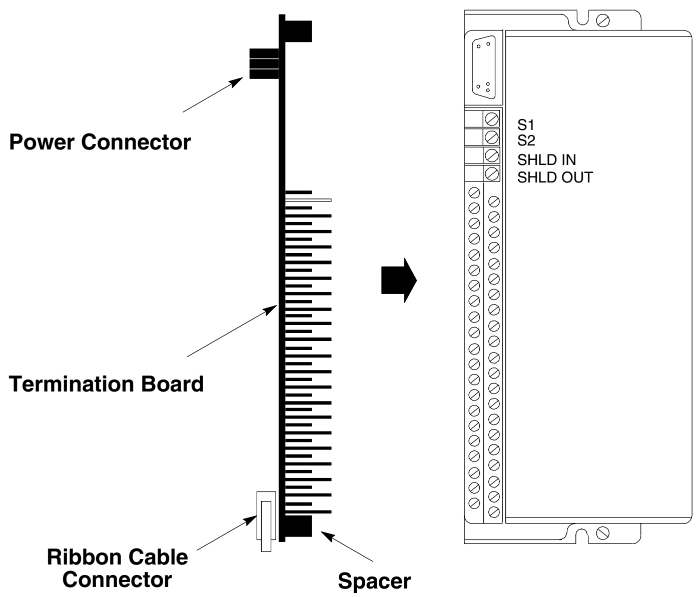
Installing a Termination Board

Mount the Genius block to the panel as described in the block's datasheet. Connect the ground wire(s) to the case of the block using the block grounding screws.

To install a termination board, loosen the block's power and I/O screw terminals. Insert the terminal board into the screw terminal apertures, ensuring that the connection pins are pushed firmly in. Tighten the screws.

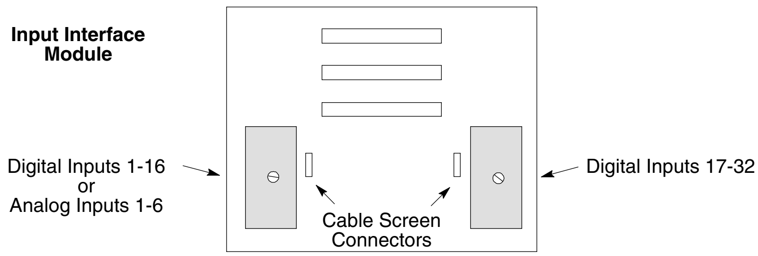
Connect the serial bus wiring to the block in the normal manner.

Termination boards are easily removed without disturbing the Genius block, by disconnecting the power wiring and ribbon cable, loosening the block's power and I/O terminal screws, withdrawing the termination board to the side, and lifting it away.



Connecting Field Wiring to an Input Interface Module

Field I/O cables (not supplied) connect to the ELCO 8016 series connectors on the input interface module. The field I/O cable screens may be terminated to ground via Faston spade connectors at the cable screen connectors as shown.



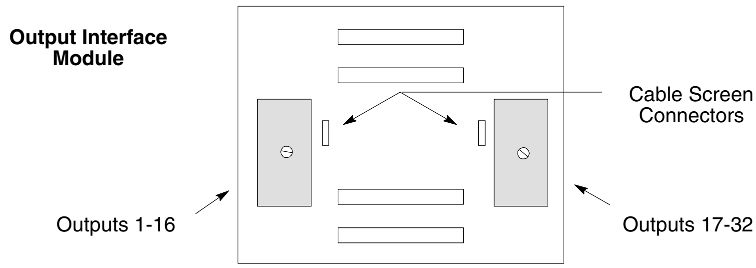
The table below lists the pin assignments for the ELCO 8016 connectors for the input interface modules.

Pin	Discrete Inputs 1-16	Discrete Inputs 17-32	Analog Inputs 1-6	Pin	Discrete Inputs 1-16	Discrete Inputs 17-32	Analog Inputs 1-6
A	Input 1 signal	Input 17 signal	Input 1 signal	X	no connection	no connection	no connection
B	Input 2 signal	Input 18 signal	Input 2 signal	Y	no connection	no connection	no connection
C	Input 3 signal	Input 19 signal	Input 3 signal	Z	cable screen	cable screen	cable screen
D	Input 4 signal	Input 20 signal	Input 4 signal	AA	Input 1 power	Input 17 power	Input 1 return
E	Input 5 signal	Input 21 signal	Input 5 signal	BB	Input 2 power	Input 18 power	Input 2 return
F	Input 6 signal	Input 22 signal	Input 6 signal	CC	Input 3 power	Input 19 power	Input 3 return
H	Input 7 signal	Input 23 signal	no connection	DD	Input 4 power	Input 20 power	Input 4 return
J	Input 8 signal	Input 24 signal	no connection	EE	Input 5 power	Input 21 power	Input 5 return
K	Input 9 signal	Input 25 signal	no connection	FF	Input 6 power	Input 22 power	Input 6 return
L	Input 10 signal	Input 26 signal	no connection	HH	Input 7 power	Input 23 power	no connection
M	Input 11 signal	Input 27 signal	no connection	JJ	Input 8 power	Input 24 power	no connection
N	Input 12 signal	Input 28 signal	no connection	KK	Input 9 power	Input 25 power	no connection
P	Input 13 signal	Input 29 signal	no connection	LL	Input 10 power	Input 26 power	no connection
R	Input 14 signal	Input 30 signal	no connection	MM	Input 11 power	Input 27 power	no connection
S	Input 15 signal	Input 31 signal	no connection	NN	Input 12 power	Input 28 power	no connection
T	Input 16 signal*	Input 32 signal	no connection	PP	Input 13 power	Input 29 power	no connection
U	no connection	no connection	no connection	RR	Input 14 power	Input 30 power	no connection
V	no connection	no connection	no connection	SS	Input 15 power	Input 31 power	no connection
W	no connection	no connection	no connection	TT	Input 16 power*	Input 32 power	no connection

* Point 16 is not available if Input Autotesting is configured for the group. To disable Input Autotest, the termination board must be jumpered as shown on page 12-14.

Connecting Field Wiring to an Output Interface Module

Field I/O cables (not supplied) connect to the ELCO 8016 series connectors on the output interface module. The field I/O cable screens may be terminated to ground via Faston spade connectors at the cable screen connectors as shown.

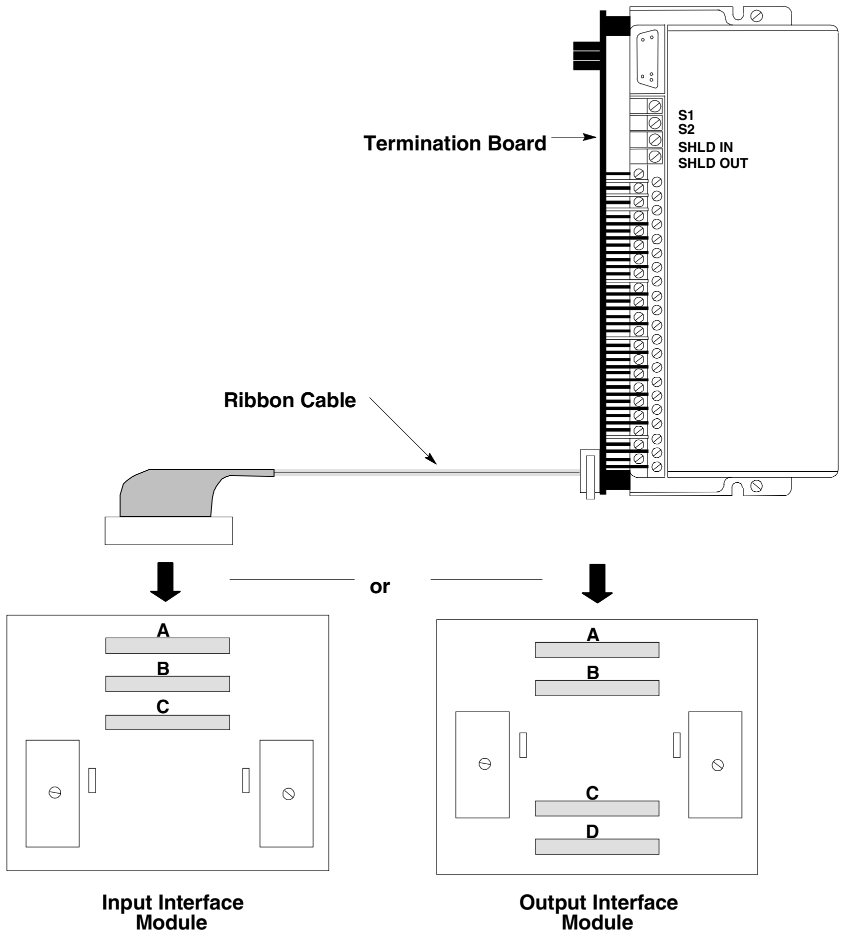


The tables below list the pin assignments for the ELCO 8016 connectors for the output interface modules.

Pin	Outputs 1-16	Outputs 17-32	Pin	Outputs 1-16	Outputs 17-32
A	Output 1 Source drive	Output 17 Source drive	X	no connection	no connection
B	Output 2 Source drive	Output 18 Source drive	Y	no connection	no connection
C	Output 3 Source drive	Output 19 Source drive	Z	cable screen	cable screen
D	Output 4 Source drive	Output 20 Source drive	AA	Output 1 Sink return	Output 17 Sink return
E	Output 5 Source drive	Output 21 Source drive	BB	Output 2 Sink return	Output 18 Sink return
F	Output 6 Source drive	Output 22 Source drive	CC	Output 3 Sink return	Output 19 Sink return
H	Output 7 Source drive	Output 23 Source drive	DD	Output 4 Sink return	Output 20 Sink return
J	Output 8 Source drive	Output 24 Source drive	EE	Output 5 Sink return	Output 21 Sink return
K	Output 9 Source drive	Output 25 Source drive	FF	Output 6 Sink return	Output 22 Sink return
L	Output 10 Source drive	Output 26 Source drive	HH	Output 7 Sink return	Output 23 Sink return
M	Output 11 Source drive	Output 27 Source drive	JJ	Output 8 Sink return	Output 24 Sink return
N	Output 12 Source drive	Output 28 Source drive	KK	Output 9 Sink return	Output 25 Sink return
P	Output 13 Source drive	Output 29 Source drive	LL	Output 10 Sink return	Output 26 Sink return
R	Output 14 Source drive	Output 30 Source drive	MM	Output 11 Sink return	Output 27 Sink return
S	Output 15 Source drive	Output 31 Source drive	NN	Output 12 Sink return	Output 28 Sink return
T	Output 16 Source drive	Output 32 Source drive	PP	Output 13 Sink return	Output 29 Sink return
U	no connection	no connection	RR	Output 14 Sink return	Output 30 Sink return
V	no connection	no connection	SS	Output 15 Sink return	Output 31 Sink return
W	no connection	no connection	TT	Output 16 Sink return	Output 32 Sink return

Connecting Terminal Boards to the Interface Module

Using 34-wire IDC ribbon cable (0.05") and bump polarized connectors, make up a cable to link each termination board in the group with the termination module. The illustration below shows connectors for an input interface module (A, B, and C) and for an output interface module (A, B, C, and D).



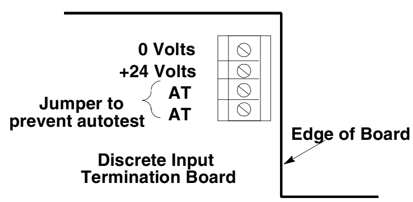
The maximum recommended length for the ribbon cable is one meter. Excessive cable length increases the possibility of picking up interference signals. The ribbon cable should remain within the enclosure.

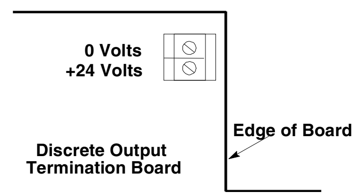
It is recommended that ribbon cable be used for internal wiring only, and that it not be used outside the panel where Genius blocks and interface modules are located.

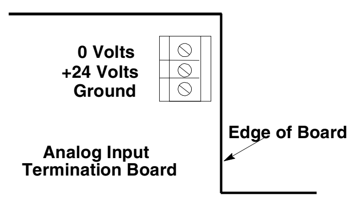
For 32-point discrete circuits a single connector is used. 16 point discrete circuits use two conductors to share the load current.

Connecting Power and Ground Wiring to a Termination Board

Connect the power wiring to the appropriate terminals on the board. Each terminal can accommodate one or more wires up to AWG #14 (avg 2.1mm^2 cross section). Wire gauges less than AWG #22 (avg 0.36mm^2 cross section) are not recommended.







The field I/O cable screens if any should be terminated to ground via pin Z on the ELCO 8016 connectors. Then the J7 and J8 (Ground) 6.3mm (1/4 inch) tabs should be connected to ground on the cubicle using 2.5mm^2 cross section (AWG #12) green-yellow wire no longer than 100mm (4 inches). A suitable DIN rail mounting earthing terminal is the Weidmüller EK4.

Wiring an Input Termination Board for Input Autotest

The Input Autotest feature is normally operative; no wiring is required to activate this feature. To disable the input autotest feature and allow point 16 to be used as an input, the termination board(s) must be jumpered as shown above.

Switching Off Blocks for Service

To temporarily remove a block from service, *first* remove the ribbon cable connector from the terminal board, then power the block down.

Chapter 13 Communications Options for a GMR System

A variety of communications options makes it possible to interface the GMR system to Distributed Control Systems (DCS), operator interfaces and workstations, host computers, and other devices that communicate using serial communications protocols.

This section is a brief overview of some of these communications options.

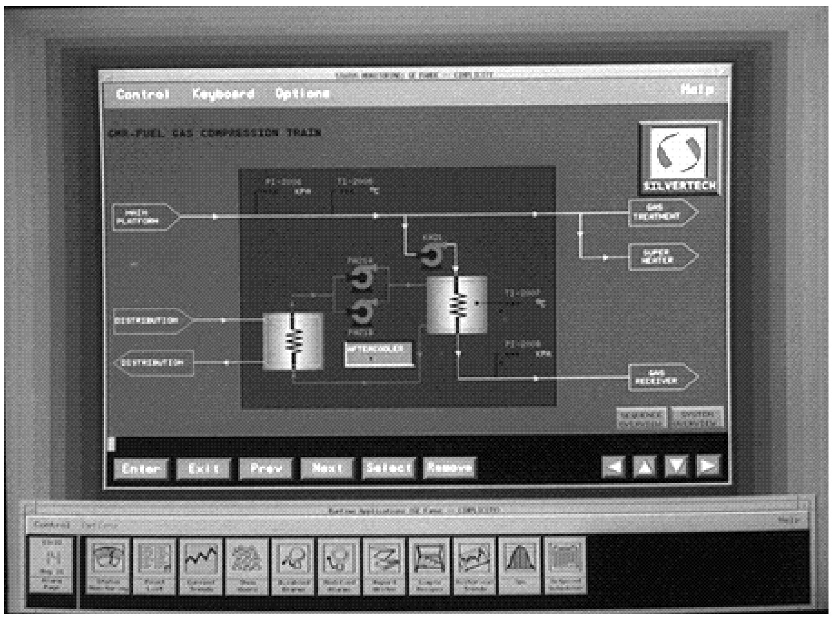
- Human–Machine Interfaces for a GMR System
- GMR with Distributed Control Systems and HMI Systems
- Communications Modules for a GMR System
- Series 90 TCP/IP Triplex

13

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



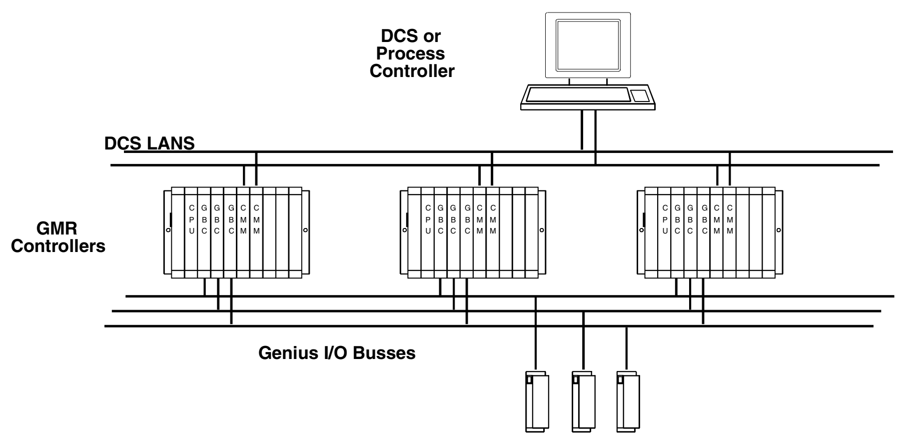
The complexity of the HMI depends on the needs of the application. A simple HMI might collect data from one GMR PLC only. A very complex HMI might collect and process data from three GMR PLCs, emulating the GMR voting process itself.

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.

GMR with Distributed Control Systems and HMI Systems

Safety systems such as GMR generally interface to a process controller or Distributed Control System. 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

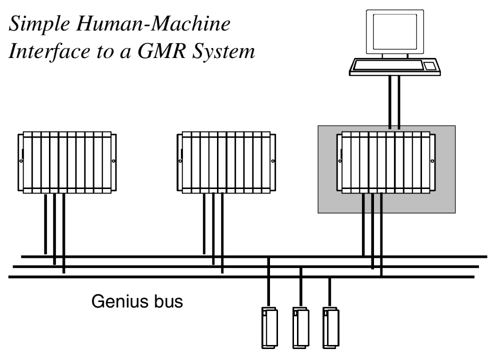


The GMR system is usually independent and isolated from the Distributed Control System, which protects its safety functions from failures of the process controller. GMR has a built-in memory protection feature that limits areas of memory that can be written to. The HMI system should alert DCS operators to fault and alarm conditions so they can take prompt corrective action.

Monitoring Data from One GMR PLC

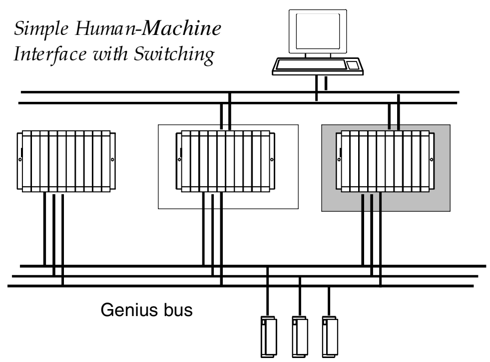
The most basic type of a HMI for a GMR system communicates with one of the GMR PLCs, monitoring data from that PLC only. In addition to basic I/O data, the HMI can monitor the status data exchanged by the GMR PLCs on the Genius bus. This type of a HMI is very easy to incorporate into a GMR system, by adding a communications module to one of the GMR PLCs. A second communications module can also be installed in the same PLC for redundancy.

Simple Human-Machine Interface to a GMR System



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 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 for redundancy.

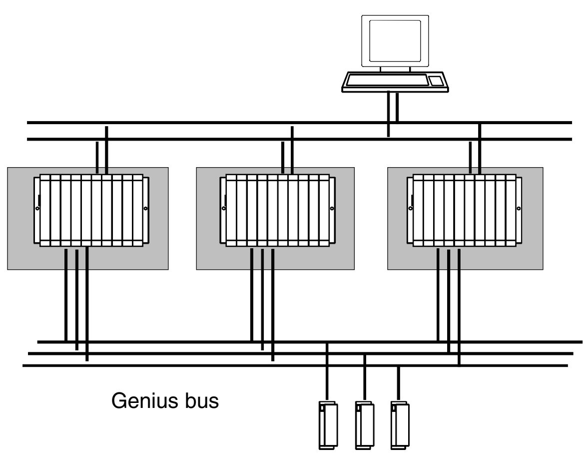


Monitoring and Data from Three GMR PLCs

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

This type of interface is able to 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 exchanged by the GMR PLCs on the Genius bus.

Human-Machine Interface for Gathering GMR PLC Data



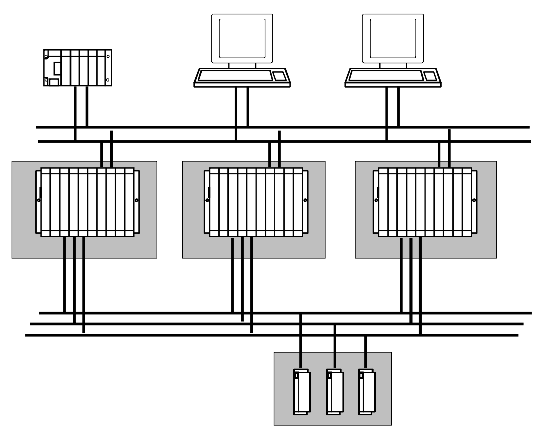
Monitoring All PLCs and Emulating the Voting Process

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



Series 90 TCP/IP Triplex

The CIMPLICITY HMI Series 90 TCP/IP Triplex enabler supports both cabling redundancy and PLC redundancy for Series 90 TCP/IP communications, and can be used in GMR applications.

The Series 90 TCP/IP Triplex enabler allows CIMPLICITY HMI to interface to up to three GMR PLCs, with up to 2 network paths per device.

With cabling redundancy, the Series 90 TCP/IP Triplex enabler communicates with the PLC using the first path while monitoring the second path. It switches automatically, without PLC intervention, to the second path if the first path fails. It continues to monitor the first path and automatically switches back to the first path on recovery. Cabling redundancy can be implemented with:

- One Ethernet LAN with two connections from each PLC to the Ethernet LAN.
- A redundant Ethernet LAN and one connection from each PLC to both of the Ethernet LANs.

With PLC redundancy, the Series 90 TCP/IP Triplex enabler communicates with one PLC, but automatically switches to another PLC if communications from the first PLC fail. It continues to monitor the PLCs and automatically switches back to a higher-ranking PLC on recovery.

The CIMPLICITY software maintains connection and status information for all the PLCs in a PLC group, but only reads data from the active master.

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. It can be used to read and write PLC data, communicate with other devices, and perform many status and control functions**.**

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.

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.

Genius Bus Controller (GBC): 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.

Sequence of Events (SOE) Recording

SOE (Sequence Of Events) Logging can be accomplished using standard documented library functions on the GMR software CD. 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.)

The SOE is a library module that is optionally included in the application program to establish Sequential Order of Events functionality. An event may be initiated by system logic, external user request, monitored system error, or any internal application program request.

The application program block stores its information in the PLC CPUs. The data and time stamps are logged along with the exact corresponding event, and may be read into a DCS, HMI, or other system asynchronously without concern for losing the sequence information.

Contact your local GE Fanuc distributor, or the GE Fanuc HOTLINE at 1-800-GE FANUC for support.

Appendix A TUV Certification

TÜV is an acronym for "Technischer Überwachungs-Verein", which has a rough translation to English of "Technical Supervisory Group". TÜV is an independent German technical inspection agency and test laboratory, widely recognized and respected for their testing and approval of electronic components and systems for use in safety critical applications.

GE Fanuc has received TÜV type approval for the GMR system, for use in safety-relevant systems where the safe state is de–energized (e.g. ESD systems) or the demand state is energized (e.g. Fire & Gas systems, Boiler Management systems). In suitable configurations, the GMR system is approved for applications from SIL 1 (Safety Integrity Level 1) through SIL 3 according to IEC 61508, or class 1 through 6 of DIN VDE 0801 standards and requirements. The type approval certificate and report at the time of printing is 968/EZ 106.00/00. Refer to the GE Fanuc website at http://www.gefanuc.com/ for the latest information on GMR type approvals.

The Genius Modular Redundancy system is a high-reliability, high-availability system. It is based on the field-proven Series 90-70 PLC and Genius I/O products. These standard off-the-shelf, general-purpose PLC products are capable of a very wide range of applications and uses. All of this general-purpose capability carries over to the GMR system.

All Series 90-70 PLC, Genius I/O, Field Control and VersaMax products can be used with a GMR system. However, not all of the available components are TÜV approved for use in the safety relevant portion of a system. All components can be used, but with the guidelines described in this appendix. The list of the certified components for use in GMR systems is maintained by GE Fanuc, and regularly verified by TÜV. It is available online at http://www.gefanuc.com/ and in the above mentioned TUV type approval certificate and report.

In addition, this appendix describes guidelines for the design, configuration, installation and use of a GMR system for which for a TÜV site application approval will be sought. Additional guidelines which are product independent and applicable to all TÜV approved safety systems can be accessed at the following TÜV web sites: http://www.isep.de/plcgen4.htm and http://www.isep.de/plclist.htm .

A TÜV site application approval consists of a review and check of the system as installed and commissioned at the final site by a TÜV site engineer. The process includes a review and check of all installed hardware, software, configuration, procedures and the specific application program to ensure conformance with the User's Manuals, the specified environmental conditions and the following guidelines.

A

TÜV Guidelines

The following guidelines are applicable once a system is commissioned and put into operation. Some of the guidelines may not be reasonable during start-up and depending on the application could possibly be disregarded until the start-up phase is completed. As an example, if it is safe during start-up for your application, the on-line programming parameter may be set to "enabled" until the start-up is complete and the system is formally commissioned, at which time the parameter would then be set to "disabled" as described below.

General System Guidelines (for all applications)

A Functional test must be performed to check for the correct design and operation of the system as a whole. This is to include the user's application program.

No change of the system software (operating system, I/O drivers, diagnostics, etc.) is allowed without TÜV approval and recommissioning.

Regulations or procedures for the use of, servicing, and repair of the system with regard to the application must be available as a part of the operational documents.

All GE Fanuc manufactured components may be used in the non-safety relevant portion of the system if appropriately de-coupled from the safety-relevant portion of the system. A list of the certified components for use in a GMR system is maintained by GE Fanuc, and regularly verified by TUV in the TUV Change Log. It can be accessed via the GE Fanuc website at: http://www.gefanuc.com/.

For the 790 model CPU, the maximum allowable ambient temperature is 40 deg. C.

Analog input blocks that are used in the safety-relevant portion of the system must be periodically (e.g. once per year) checked and verified manually by the application and verification of input signals of at least 10 equally spaced points starting at the low end of the range of the input and ending at the high end. At least two physical points of every triplex analog input must be tested in this manner. If a termination board is used for analog inputs, the termination board must be checked accordingly.

Simplex analog sensors can be connected to redundant analog inputs only if those analog inputs are de-coupled by suitable devices

When blocks IC660BBD024 and IC660BBD025 are used as part of a redundant "H" pattern output group, an appropriately sized fuse must be included in series with the load.

Note that if a power supply prior to revision IC697PWR711G is used with a 230 Volt AC power source, a surge protector/filter device is required. Any incoming over voltage transients of up to 4 Kvolts (1.2/50mS) must be limited by this device to 2.5 Kvolts (1.2/50mS) according to VDE 0160 over voltage category II. This device must be installed between the power source and the power supply. 115 Volt AC power source applications do not require a surge protector/filter device.

Each CPU module must be memory protected and the key removed.

The installation procedures in the *Series 90-70 Programmable Controller Installation Manual* (GFK-0262) and this *GMR User's Manual* (GFK-1277) are to be closely observed and complied with, especially the grounding procedures in chapter 3 of the *Series 90-70 Programmable Controller Installation Manual* (GFK-0262).

All GMR components must be installed in a panel or cabinet, which offers protection equal to or greater than specification IP54. For EMC purposes, the enclosure must provide protection equal to or greater than an enclosure having the following characteristics: Steel sides with a thickness of 0.040 inches, metal-on-metal connection around the door or the equivalent and all enclosure sides grounded to a common point with grounding straps equal to or larger than #14 AWG. Please refer to *Installation Requirements for Conformance to Standards* (GFK-1179) for additional information. The panels or cabinets must be closed during operation of the system. They may be opened only during maintenance or for short term supervised operation.

When the system is commissioned, the on-line programming option must be set to DISABLED in the configuration.

In duplex or triplex processor configurations, the simplex shutdown option must be set to be set as appropriate for the application:

- Disable simplex shutdown when it is safest to continue running and instead properly annunciate/alarm the condition of running on one processor (e.g. fire and gas application).
- Disable simplex shut down if it not safe to immediately shut down and instead perform an orderly shut down via the application program when processor redundancy no longer exists and properly annunciate/alarm the condition of running on one processor.
- Enable simplex shut down with a time that allows repair of a component, yet performs the shutdown if the repair is not made within that time.
- If safest – configure to shut down (minimum shutdown time is 60 seconds to allow for proper startup).

For applications needing to meet DIN VDE 0116 specifications, the maximum Input-to-Output response time allowed is 1.0 second. To ensure this response time is met under all circumstances, the maximum watchdog timer setting must be one of the following, whichever is smaller.
((2 * the typical scan time of the application program) - 10 milliseconds)
OR
310 milliseconds (if Genius bus baud rate = 153.6K)
250 milliseconds (if Genius bus baud rate = 76.8K)
130 milliseconds (if Genius bus baud rate = 38.4K)

The Data and System Fault actions must be set as follows: Data Fault - DIAGNOSTIC, System Fault - FATAL

All redundant I/O groups must be configured to be autotested and the autotest interval must not exceed a maximum of 480 minutes (8 hours).

The write access length parameters for %I, %AI, %Q, and %AQ must be set to 0.

If the configuration is set to allow write access, the TÜV Maintenance Override document must be complied with. This document is reprinted in this manual.

Autotesting must be set to ENABLED for all used circuits of each discrete input group.

Autotesting must be set to ENABLED for all used circuits of each discrete output group.

Vote adaptation must be set to 3-2-0 or 3-2-1-0 for all used circuits of each discrete input group depending on the redundancy level of the input group and the application.

Vote adaptation must be set to 3-2-0 or 3-2-1-0 for each analog input group depending on the redundancy level of the analog input group and the application.

The Duplex State and Default State settings for each analog input group are dependent on the application and must be set as follows:

For High Limit processing - The Duplex State must be set to High
The Default State must be set to Max.

For Low Limit processing - The Duplex State must be set to Low
The Default State must be set to Min.

For each analog input channel, the Threshold Discrepancy Percentage must be set to 0% or to a percentage value that causes a discrepancy if inputs at the low portion of a range vary by an amount more than that already allowed by the Limit percentage setting.

Configuration worksheets are available for all Genius I/O block types in the *Genius I/O Discrete and Analog Blocks User's Manual* (GEK-90486-2). Each I/O block used in the safety-relevant portion of the system must have a worksheet prepared. Each worksheet must be verified against its corresponding block on a block-by-block basis. Automated tools for this purpose, when available, should be used. The GMR configuration utility must be used to print the GMR-specific configuration data. The TÜV site engineer will use this printout to verify the configuration data with the requirements of the overall application.

Configuration Protect must be enabled in each Genius I/O block.

The Genius HHM must be configured to use serial bus address 0 (the default).

The following configuration options must be disabled and the Genius HHM keyswitch must be set to “MON” and the key removed: Change Block ID, Change Block Baud Rate, Change Block Configuration, Circuit Forcing, Clear Block Faults.

All Series 90-70 instructions can be used in the non-safety portion of the user program, but the following instructions must not be used in the safety relevant portion of the user program: VME_CFG_RD, VME_CFG_WRT, PIDISA, PIDIND, DO_IO, SUSIO, ALL SFC functions, COMMREQ, DATA_INIT_COMM, CALL SUB, CALL EXTERNAL. As the SUSIO instruction is “global” in nature (i.e. it affects all I/O), it must not be used in either the safety relevant portion or non-safety portion of the user program.

SVCREQ functions #1, #3, #4, #6, #8, #14 and #19 may not be used.

The NON-safety relevant portion of a program must be “de-coupled” or segregated from the safety relevant portion by using separate program blocks or subroutines. In addition there must be no overlap of I/O reference addresses in the two separate portions of the program. Control algorithms must NOT be in any way integrated with the safety relevant portion of the program.

C program blocks and C standalone programs are permitted for non-safety related functions, provided they are adequately decoupled from the safety related portion of the program.

No forces or overrides can be present in the system. This is checked by verifying system variables %S0012 (FRC_PRE) and %S0011 (OVR_PRE) are equal to 0. The application program must include code that issues a warning to the operator, via a redundant PLC output, if %S0012 or %S0011 are in the on state in any of the PLCs in the system.

The application program must include code that issues a warning to the operator to indicate that a fault (any fault) exists in the system, via a redundant PLC output, if system variable %SC0009 (ANY_FLT) is in the on state in any of the three PLCs.

The GMR control bits, %M12258 (IORES), %M12259 (PLCRES) and %M12264 (PLCRESG), must not be driven by the application automatically. They must be driven only under control of an operator (Operator interface or hard wired push-button inputs).

The GMR control bit, %M12261 (ATINHIB) must not be under the control of the application program. The operator must verify that this bit has not been set to the ON state by an override, in any of the CPUs, prior to system operation.

A status report must be produced by setting the GMR REPORT bit (%M12262). The resultant information must be verified against the configuration printout.

The I/O Shut Down timer must be set to a value appropriate for the application.

The Cancel I/O Shut Down control bit (%M12265 - SD_CAN) must be left in the off (0) state and must not be used in any portion of the application program.

A complete set of documentation consists of the following:

1. A printout of the GMR configuration, generated by the GMR configuration utility.

2. Configuration sheets used for all Genius blocks.

3. Configuration printouts for all used CPUs.

4. A printout of the complete ladder application program.

Inputs from other systems to any part of the safety relevant portion of the application program must be made via the safety relevant inputs of the GMR system. If a software interface, it must be made through that group of input addresses reserved for the safety relevant portion of the application. In addition, it must be verified that any non-safety inputs cannot override a demand made to an output by the safety relevant portion of the program or prevent any field input to the safety relevant portion of the program.

Manual trips and overrides must be executed exclusively during maintenance of the system. The specific requirements are described in the document "Maintenance Override" Version 2.2, Sept. 8, 1994, which is reprinted in GFK-1277.

If the Force Logon control bit is used, it must be set via a hard-wired input device. PLC force logon is to be considered a maintenance override and shall be subject to requirements described in the document "Maintenance Override" Version 2.2", Sept. 8, 1994, which is reprinted in this manual.

For safety- relevant systems where the safe state is de–energized (e.g. ESD systems)

For all safety relevant applications the safe state must be the de-energized (0) state.
The Duplex State must be set to 0 for all used circuits of each discrete input group.
The Default State must be set to 0 for all used circuits of each discrete input group.
Normal State must be set to ON for all used circuits of each discrete output group.

For safety- relevant systems where the safe state is energized (e.g. Fire & Gas systems, Boiler Management systems)

The normal state for redundant outputs must be set to OFF for normally de-energized outputs.

CPU simplex shutdown should be disabled for 3-2-1-0 operation.

If a simplex redundancy system configuration is used for applications requiring SIL2 performance then additional measures must be specified and implemented to maintain the safe state during the time that it takes to restore the system to normal operation. Due to this requirement a simplex redundancy system can only be used with applications having a high process safety time.

16 channel blocks configured for tri-state operation can be used for discrete inputs that require line monitoring and/or earth fault detection. Operation of the inputs is as follows:

BLOCK	FAULT	GMR MODE (normally on)	NON-GMR MODE (normally off)
Source	Open Wire	Off	Fault
Source	Shorted Wire	Fault	On
Source	Ground Short	Off†	Fault
Sink	Open Wire	Off	Fault
Sink	Shorted Wire	Fault	On
Sink	Ground Short	Fault	On

† Assumes a ground short to positive line interrupts power flow to the field

Additionally, or alternatively, other special measures may be applied for the detection of earth faults by for example an earth leakage detection unit. The system ground should be connected to earth unless otherwise required by the earth leakage measure.

If line monitoring is not used and no other special measures are applied then field wiring must be checked within or during the proof test.

For each discrete input used with a safety related function, the vote adapt mode (i.e. 3-2-0 or 3-2-1-0), duplex default (i.e. 0 or 1) and default state (i.e. 0 or 1) must be set according to the safe state.

For each analog input used with a safety related function, the vote adapt mode (i.e. 3-2-0 or 3-2-1-0), duplex default (i.e. high, low or average) and default state (i.e. min, max or hold) must be set according to the safe state or demand state respectively.

For discrete output groups, the normal state must be set to: -

- ON for outputs with a de-energized safe state
- OFF for outputs with an energized safe state

Critical normally de-energized outputs should be located on 16 point H-block with no load reporting enabled. Output loads that fall below the minimum required 100mA load current should include an additional resistive load in the field to fulfill the minimum load requirement.

Appendix B Maintenence Override

The information in this appendix is reprinted by permission of TUV.

Abstract

Suggestions are made about the use of maintenance override of safety relevant sensors and actuators. Ways are shown to overcome the safety problems and the inconvenience of hardwired solutions. A checklist is given.

Maintenance Override

There are basically two methods used now to check safety relevant peripherals connected to PLCs:

- Special switches connected to inputs of the PLC. These inputs are used to deactivate actuators and sensors under maintenance. The maintenance condition is handled as part of the application program of the PLC.
- During maintenance sensors and actuators are electrically switched off of the PLC and checked manually by special measures.

In some cases, e.g. where space is limited, there is the wish to integrate the maintenance console to the operator display, or to have the maintenance covered by other strategies. This introduces the third alternative for maintenance override:

- Maintenance overrides caused by serial communication to the PLC.

This possibility has to be handled with care and is introduced in this paper.

Maintenance Override Procedures

Connecting to PLC via serial lines is possible mainly in two ways:

A. The serial link is done via the MODBUS RTU protocol or other approved serial protocols. The maintenance override may not be performed by the engineering workstation or programming environment.

B. The engineering workstation or programming environment is allowed to be connected to the PLC to perform maintenance override. That requires additional safety measures inside the associated PLC to prevent a program change during maintenance intervals. These measures shall be approved, e.g. by TUV.

The following table shows common requirements. The differences between solution A and B are shown by typeface italic.

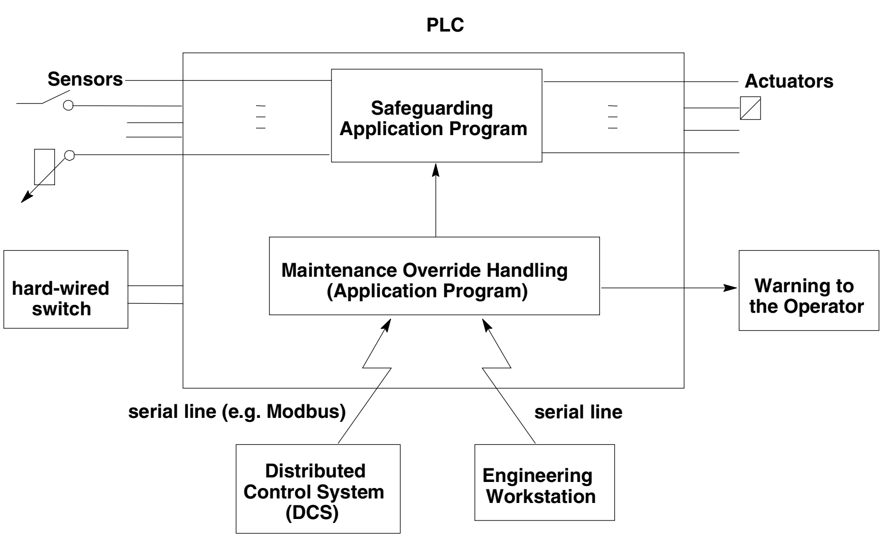
Requirements for maintenance override handling	Responsibility
Already during the software configuration of the PLC system it is determined in a table or in the application program, whether the signal is allowed to be overridden.	Project engineer and commissioner responsible for correct configuration.
The configuration may also specify by a table, whether simultaneous overriding in independent parts of the application is acceptable.	*A. Project engineer* *B. Project engineer, Type approval*
Maintenance overrides are enabled for the whole PLC or a subsystem (process unit) by the DCS or a hard-wired switch (e.g. key switch).	A. *Operator or Maintenance engineer.* B. *Type approval*
A. The override is activated via DCS. *B. The maintenance engineer activates the override via the programming environment.*	*A. Operator, Maintenance engineer* *B. Type approval, Maintenance*

As an organizational measure, the operator should confirm the override condition.	*engineer*
Direct overrides on inputs and outputs are not allowed. Overrides have to be checked and to be implemented in relation to the application. Multiple overrides in a PLC are allowed as long as only one override is used in a given safety related group. The alarm shall not be overridden.	*A. Project engineer* *B. Project engineer, Type approval*
The PLC alerts the operator, e.g. via the DCS, indicating the override condition. The operator will be warned until the override is removed.	Project engineer, Commissioner
A. The override is removed via DCS. *B. The maintenance engineer removes the override via the programming environment.*	*A. Operator, Maintenance engineer* *B. Maintenance engineer*
A. There should be a second way to remove the maintenance overrode condition. *B. If urgent, the maintenance engineer can remove the override by the hard-?wired switch.*	*A. Project engineer* *B. Maintenance engineer, Type approval*
During the time of override proper operational measures have to be implemented. The time span for overriding shall be limited to one shift (typically not longer than 8 hours), or hard-wired common maintenance override switch (MOS) lamps shall be provided on the operator console (one per PLC or per process unit).	Project engineer, Commissioner, DCS program, PLC program

Recommendations

The following recommendations are given to improve the primary safety as described by the list:

- A program in the DCS that checks regularly that no discrepancies exist between the override command signals from the DCS and the override activated signals received by the DCS from the PLC.
- The use of the maintenance override function should be documented on the DCS and on the programming environment if connected. The printout should include:
  - time stamp of begin and end.
  - ID of the person who is activating the maintenance override-maintenance engineer or operator (if the information cannot be printed, it should be entered in the work-permit).
  - tag name of the signal being overridden.
- The communication packages different from a type-approved MODBUS should include CRC, address check and check of the communication time frame.
- Lost communications should lead to a warning to the operator and maintenance engineer. After loss of communication a time-delayed removal of the override should occur after a warning to the operator.



Version History

This version 2.2 supersedes the version 2.1 from 24. Jun 1994

Appendix C Reliability Data

Calculation of system reliability and availability as well as safety function PFD and spurious trip rates requires module specific reliability data. GE Fanuc has a well-established procedure for determining module reliability data. This data is available on request from GE Fanuc.

GE Fanuc calculates failure rate based on modules returned in warranty. Factory tests are performed on returned modules. The results place returned modules in one of three categories:

- No Defect
- Customer Induced Failure
- Proven Product Failure

Only proven product failures are included in the failure rate calculation. Modules not tested are assumed to have the same ratio of proven defects as those for which test results are available.

Calculation of the number of in-warranty operating hours for a given module type is based on a model that predicts the fraction of shipped modules operating as a function of the number of months since the module was shipped.

The model was developed through field experience and makes the following assumptions:

- 90% of total months shipments are used
  - 5% of shipments cover warranty returns
  - 5% of shipments never go into use (User stock, etc)
- 693 hours per operation month (95% of time)
- Processes
  - CPU/Memory continuous cycling
  - I/O holding or cycling

MTBF calculations are based on one year (12 months) accumulated run hours and warranty returns for a corresponding 12-month period. To gain statistical validity, each module type must have accumulated a minimum of 500,000 run hours during this 12-month period before a reliable prediction will be made. MTBF and reliability are not calculated for modules with less than 500k run hours.

Appendix D

PLC Fault Table Messages for GMR

Clearing the Fault Tables

Caution

Do not use the Logicmaster F9 key to clear the Fault Tables.
Fault Table Clearing from the Logicmaster software can be prevented by keeping it in Monitor mode.

Although the Fault Tables seem to operate as they would in a non-GMR system, they are actually controlled by the GMR software,. In a GMR application, the fault tables must be monitored and cleared from the application program logic.

Use these %M references to clear the PLC Fault Tables:

- To clear the PLC Fault Table in a single PLC, set reference %M12259 to 1 for at least one PLC sweep.
- To clear the PLC Fault Table in all PLCs, set reference %M12264 to 1 for at least one PLC sweep.
- To clear the I/O Fault Table and corresponding fault contacts in all PLCs, set reference %M12258 to 1 for at least one PLC sweep.
- Monitor %M12238 (IORESIP) to determine when an I/O Fault Table reset is complete.

PLC Fault Table Messages for GMR

The following tables lists PLC Fault Table messages for GMR. If you need additional help, call GE Fanuc Technical Service at 1-800-828-5747.

Code	Message	Cause	Possible Corrective Action
nnnn	GMRx Rs Ss Pp FLT	The GMRx module has logged a fault against the bus controller in rack r, slot s, with priority p. The following priority numbers apply: 20 Master O/P Disc 22 Master I/P A/T 24 Master O/P A/T 25 Master A/T Recovery 28 Non-master O/P A/T 29 Non-master I/P A/T and O/P Disc 30 Fault Processing 35 Force Logon Processing 40 Initialization	*Verifiy correct Genius Bus Controller and and I/O Device configuration and firmware revision levels.* *Contact GE Fanuc Technical Support.*
100	No CPU Clock	There is no CPU clock present	*Contact GE Fanuc Technical Support.*
100	No PLC Clock	There is no PLC clock present	
101	Illegal state step	Internal GMR error: invalid step	
101	Illegal trans code	Internal GMR error: invalid transition code	
101	Bad trans x from wwww	Internal GMR error: attempted transition to invalid step	
10001	Heap allocation failed	The memory heap allocation was not successful	
10002	Copying diag data to %R1	The diagnostic data is being copied into %R1	
100+GBC ID	CFPT, 0 attempts wwww	Number of attempts exhausted while trying to send a COMREQ	*Verifiy correct Genius Bus Controller Configuration.*
10009	GMRx ornge GBC g req	Out of range Bus Controller (g) was requested by GMRx module	*Verifiy correct Genius Bus Controller Configuration.*
10009	GMRx bad GBC g req	Unconfigured Bus Controller (g) was requested by GMRx module	
10010	GMRx ornge GBC g rel	Out of range Bus Controller (g) was released by the GMRx module	
10010	GMRx bad GBC g rel	Unconfigured Bus Controller (g) was released by the GMRx module	
10011	GMRx ornge GBC g flt	Out of Range Bus Controller (g) was faulted by the GMRx module	
10011	GMRx bad GBC g flt	Unconfigured Bus Controller (s) was faulted by the GMRx module	

Code	Message	Cause	Possible Corrective Action
10101	Unauthorized GMR Access	Initialization module was invoked with incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
10102	Incorrect GMR Version	Initialization module was called with incorrect version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10103	GMR Software Exception	An invalid call number was detected	*Contact GE Fanuc Technical Support.*
10104	Invalid GMR Pointer	Initialization module was invoked with invalid pointer for diagnostics area	
10109	Prog Checksum Timeout	PLC didn't calculate the program checksum within 10 seconds	*Increase the number of words to be check-summed per sweep in CPU configuration parameters using LM90.*
10110	Invalid Bus Address	Initialization detected bus addresses not equal to 29, 30, or 31	*In the LM90 h/w configuration files, correct the Genius Bus Controller Serial Bus Addresses (SBAs) to be 31 for PLC A, 30 for PLC B and 29 for PLC C.*
10111	Sync Not Possible	Synchronization cannot be performed	*Check for proper Genius Global Data configuration and general Genius Bus Controller configuration, installation and bus wiring.*
10113	Sync, %M Miscompare	Sync detected miscompare	*Consider adding the %M bits selected for the initialization data to the global data that is continuously synchronized between PLCs. Check for other errors such as output discrepancies that could be causing %M init data to be different in one PLC.*
10114	Coldstart	GMR is performing cold start	*None Required -This is an informational message.*
10115	Warmstart	GMR is performing a warm start	
10116	Cannot get all GBCs	Cannot acquire all GBCs during initialization	*Verify that the GBC configurations in the LM90 h/w configuration correspond to the GBC configurations in the GMR configuration data file. Contact GE Fanuc Technical Support.*
10117	Cannot do VME Write	The VME Write to 7F3h was unsuccessful	
10119	Invalid Switch Case	An invalid case condition was detected during a switch	*Contact GE Fanuc Technical Support.*
10120	Failed Disable Ops	The Disable Outputs command (COMREQ) failed to complete successfully	
10121	Failed Enable Ops	The Enable Outputs command (COMREQ) failed to complete successfully	
10122	Failed Set GMR Mode	The Set GMR Mode command (COMREQ) failed to complete successfully	
10123	Failed DG Dgrams	The Clear Datagrams Dequeue command (COMREQ) failed to complete successfully	
10124	Failed Read Address	The Read Bus Address command (COMREQ) failed to complete successfully	

Code	Message	Cause	Possible Corrective Action
10129	Num dequeues = n	N dequeue entries were dequeued at startup	*Informative message indicating PLC was powered up (but not running) in a system with other PLCs which were already running.*
10130	Program mismatch A/B	PLCs A and B program mismatch, C is not online	*Informative message if programs are intended to be different or if changing programs with long delay between one CPU and next. Otherwise update programs by storing them to the PLCs with LM90.*
10131	Program mismatch B/C	PLCs B and C program mismatch, A is not online	
10132	Program mismatch A/C	PLCs A and C program mismatch, B is not online	
10133	Program mismatch A/B&C	PLC A program mismatch with B and C	
10134	Program mismatch B/A&C	PLC B program mismatch with A and C	
10135	Program mismatch C/A&B	PLC C program mismatch with A and B	
10136	Program mismatch A/B/C	All three PLCs mismatch	
10137	Program changed A	PLC A program changed	*During intentional program changes, this is an informational message.*
10138	Program changed B	PLC B program changed	
10139	Program changed C	PLC C program changed	
10140	Config mismatch A/B	PLCs A&B config mismatch, C not online	*Attempted to start a PLC but the GMR configuration is not the same in each PLC. (You cannot make a GMR configuration changs to the system without stopping all PLCs in the system).*
10141	Config mismatch B/C	PLCs B and C config mismatch, A is not online	*During intentional configuration changes, this is an informational message. Attempted to start a PLC but the GMR configuration is not the same in each PLC. (You cannot make a GMR configuration change to the system without stopping all PLCs in the system).*
10142	Config mismatch A/C	PLCs A and C config mismatch, B is not online	
10143	Config mismatch A/B&C	PLC A config mismatch with B and C	
10144	Config mismatch B/A&C	PLC B config mismatch with A and C	
10145	Config mismatch C/A&B	PLC C config mismatch with A and B	*Attempted to start a PLC but the GMR configuration is not the same in each PLC. (You cannot make a GMR configuration change to the system without stopping all PLCs in the system).*
10146	Config mismatch A/B/C	All three PLCs mismatch	
10147	Config changed A	PLC A config changed	*During intentional configuration changes, this is an informational message*
10148	Config changed B	PLC B config changed	
10149	Config changed C	PLC C config changed	
10201	Unauthorized GMR Access	Inter-PLC Comms module was invoked with incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
10202	Incorrect GMR Version	Inter-PLC Comms module has incorrect GMR version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10203	GMR Software Exception	Inter-PLC Comms module was called with invalid call number	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
10204	Invalid GMR Pointer	Inter-PLC Comms module was called with invalid data pointer	*Contact GE Fanuc Technical Support.*

Code	Message	Cause	Possible Corrective Action
10211	Comms Fail PLC A bus a	Communications with PLC A has failed on bus a	*Check that the indicated PLC (A, B, or C) is powered and running. Check fault tables for any Genius Bus Controller faults. Check that the status indicators for the "bus a" GBCs indicate it is healthy. Verify correct physical Genius Bus wiring for the bus configured as "bus a". Next check for correct Global data configuration for "bus a" in all PLCs.*
10212	Comms Fail PLC B bus a	Communications with PLC B has failed on bus a	
10213	Comms Fail PLC C bus a	Communications with PLC C has failed on bus a	
10221	Comms Fail PLC A bus b	Communications with PLC A has failed on bus b	*Check that the indicated PLC (A, B, or C) is powered and running. Check fault tables for any Genius Bus Controller faults. Check that the status indicators for the "bus b" GBCs indicate it is healthy. Verify correct physical Genius Bus wiring for the bus configured as "bus b". Next check for correct Global data configuration for "bus b" in all PLCs.*
10222	Comms Fail PLC B bus b	Communications with PLC B has failed on bus b	
10223	Comms Fail PLC C bus b	Communications with PLC C has failed on bus b	
10241	Big err rate, PLC A on a	PLC detected a high data CRC failure rate communicating with PLC A on bus a	*Check fault tables for any other Genius Bus Controller faults. Check that the status indicators for the GBCs on the specified bus (bus a or bus b) indicate that each one is healthy. Verify correct physical Genius Bus wiring and routing for the bus configured as specified (bus a or bus b). Next check for correct Global data configuration or conflicts for that bus in all PLCs.*
10242	Big err rate, PLC A on b	PLC detected a high data CRC failure rate communicating with PLC A on bus b	
10243	Big err rate, PLC B on a	PLC detected a high data CRC failure rate communicating with PLC B on bus a	
10244	Big err rate, PLC B on b	PLC detected a high data CRC failure rate communicating with PLC B on bus b	
10245	Big err rate, PLC C on a	PLC detected a high data CRC failure rate communicating with PLC C on bus a	
10246	Big err rate, PLC C on b	PLC detected a high data CRC failure rate communicating with PLC C on bus b	
10251	Invalid Switch Case	GMR2 software detected an illegal internal condition	*Contact GE Fanuc Technical Support.*
10301	Unauthorized GMR access	Fault Processor Module was invoked with incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
10302	Incorrect version number	Fault Processor Module was invoked with incorrect version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10303	Invalid call number	Call number was invalid	*Contact GE Fanuc Technical Support.*
10305	Invalid GMR Pointer	The supplied diagnostics pointer is out of range for the required memory type	
10306	Invalid Block Size	Incorrect block size was specified	
10307	Invalid Digital Address	Incorrect address of digital I/O was specified	
10308	Invalid Analog Address	Incorrect address of analog I/O was specified	
10309	Invalid Block Type	Block type currently unsupported	
10310	Invalid Config r.s.l.d	An attempt was made to log a fault against a block with an invalid configuration	*Verify that all configuration parameters for the actual block at rack r, slot s, SBA d, match the corresponding configuration parameters in the GMR configuration.*

Code	Message	Cause	Possible Corrective Action
10311	GMR3 Rr Ss comreq Fail	A COMREQ sent by GMR to a bus controller in rack r slot s has failed	*Check for any other Genius Bus Controller faults in the fault tables and verify that the status indicators for the GBC in rack r, slot s, indicate it is healthy.*
10312	GMR S/W Except. %L	%L range error	*Contact GE Fanuc Technical Support*
10313	Value out of range	Calculated value is out of range	
10314	Force Logon	Force Logon has taken place	*Informative message indicating that a Force Logon has taken place. (See Force logon description elsewhere in this manual)*
10322	IO Reset Seq Timeout	I/O reset timed out in step 2	*Contact GE Fanuc Technical Support*
10323	IO Reset Seq Timeout	I/O reset timed out in step 4	
10324	IO Reset Seq Timeout	I/O reset timed out in step 6	
10328	IO Reset Seq Timeout	I/O reset timed out in step 8	
10330	IO Reset Seq Timeout	I/O reset timed out in step 10	
10601	Unauthorized GMR Access	I/O Module was invoked with the incorrect password	*Verify that the application program has no calls to GMR program blocks (except G_M_R09).*
10602	Invalid GMR Version	I/O Module S/W version does not match expected version	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10603	Invalid GMR call number	I/O Module was invoked with incorrect call number	*Verify that the application program has no calls to GMR program blocks (except G_M_R09).*
10604	GMR S/W Except, %L	I/O Module was invoked with out of range input parameters	*Contact GE Fanuc Technical Support.*
10607	Invalid Switch Case	No cases satisfied by switch condition	
10608	Diagnostic S/D	The input feedback from an output circuit on an output block of a 1oo1D group did not match the output's commanded state.	*Output circuit failure or an output bypass switch is causing the incorrect output state. Return the bypass switch to its normal position or replace the failed I/O block.*
10701	Unauthorized GMR Access	GMR7 was invoked with the incorrect password	*Verify that the application program has no calls to GMR program blocks (except G_M_R09).*
10702	Incorrect GMR Version	The GMR7 version number does not match the GMR system version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10703	GMR Software Exception	An invalid call number was detected.	*Verify that the application program has no calls to GMR program Blocks (Except G_M_R09).*
10704	Invalid GMR Pointer	The error code pointer was out of bounds	*Contact GE Fanuc Technical Support.*
10705	Discrep NAK PLC A	PLC A failed to acknowledge discrepancy results	
10706	Discrep NAK PLC B	PLC B failed to acknowledge discrepancy results	
10707	Discrep NAK PLC C	PLC C failed to acknowledge discrepancy results	
10708	Disc results read fault	The PLC was unable to read output discrepancy results data from the master PLC	
10709	CR fail x.y.l.z f/s	A COMREQ with function code f and subfunction code S failed when sent to the device at rack x, slot y, SBA z.	

Code	Message	Cause	Possible Corrective Action
10710	Trans x.y.l.z cccccccc	Output discrepancy processing could not be completed for the channels marked in c on the device at rack x, slot y, SBA z, due to transitioning outputs	*Informative message that indicates the identified Output(s) are changing state too rapidly to properly complete output discrepancy processing. This message is normally suppressed unless %M12266 (ENTRAN) "Enable Transition" is enabled .*
10711	Null timeout from PLC A	A timeout occurred while waiting for PLC A to transmit a null test number	*Contact GE Fanuc Technical Support*
10712	Null timeout from PLC B	A timeout occurred while waiting for PLC B to transmit a null test number	
10713	Null timeout from PLC C	A timeout occurred while waiting for PLC C to transmit a null test number	
10801	Unauthorized GMR Access	GMR Configuration Module was invoked with incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
10802	GMR S/W Except Null FH	GMR Configuration Module failed to load fault handler	*Contact GE Fanuc Technical Support.*
10802	GMR S/W Except I/O FH	GMR Configuration Module encountered an error loading the fault handler	
10803	GMR S/W Except call no	GMR Configuration Module detected call number exception	
10804	ADL rack r slot s flt	GMR Configuration Module failed to build active device list	
10805	GMR S/W Except %L	GMR Configuration Module detected invalid diagnostic or error references	
10806	GMR Invalid switch	GMR Configuration Module detected invalid switch case	
10810	GMR config util invalid	GMR Config Module detected incompatibility with configuration utility	*Verify that the correct version of the GMR configuration s/w is being used with this GMR system s/w. Try re-generating the configuration data from a valid ".gcf" file into the program folder.*
10811	GMR cfg err GBCxx	GMR Configuration Module detected invalid GBC record xx in the config data	*Verify that the GMR and Logicmaster 90-70 Configurations are correct, then try re-generating the configuration data from a valid ".gcf" file into the program folder.*
10812	GMR cfg err GBCxx I/O yy	GMR Configuration Module detected invalid GBC record yy in GBC record xx of the config data	
10813	GMR cfg err CPU type	GMR Configuration Module detected incompatible CPU type in the config data	
10814	GMR cfg err no of PLCs	GMR Configuration Module detected more than 3 PLCs in the config data	
10815	GMR cfg err W/dog timer	GMR Configuration Module detected invalid watchdog time in the config data	
10817	GMR cfg err %R usage	GMR Configuration Module detected insufficient %R registers	
10818	GMR cfg err %AI Usage	GMR Configuration Module detected insufficient PLC Analog Inputs	

Code	Message	Cause	Possible Corrective Action
10819	GMR cfg err comreq %R	GMR Configuration Module detected invalid positioning of the comreq status %R area	*Try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support.*
10820	GMR cfg err Tx global	GMR Configuration Module detected invalid positioning of the Tx global comms %R area	
10821	GMR cfg err Rx global	GMR Configuration Module detected invalid positioning of the Rx global comms %R area	
10822	GMR cfg err I/O > max	GMR Configuration Module detected that the maximum I/O points has been exceeded	*Check that the number of I/O points is within the maximum boundaries in the configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support.*
10823	GMR cfg err voted DIN	GMR Configuration Module detected that the maximum number of voted digital inputs has been exceeded	*Check that the number of voted digital inputs is within the maximum boundaries and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support.*
10824	GMR cfg err voted AIN	GMR Configuration Module detected that the maximum number of voted analog inputs is exceeded	*Check that the number of voted analog inputs is within the maximum boundaries and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support.*
10825	GMR cfg err redund O/P	GMR Configuration Module detected that the maximum number of redundant outputs is exceeded	*Check that the number of redundant outputs is within the maximum boundaries and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support.*
10826	GMR cfg err alpha rack	GMR Configuration Module detected that alpha inter-PLC GBC is in an invalid rack	*Verify GMR and Logicmaster GBC configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support.*
10827	GMR cfg err alpha slot	GMR Configuration Module detected that alpha inter-PLC is in an invalid slot	
10828	GMR cfg err beta rack	GMR Configuration Module detected that beta inter-PLC is in an invalid rack	
10829	GMR cfg err beta slot	GMR Configuration Module detected that beta inter-PLC is in an invalid slot	
10830	GMR cfg err %M sync	GMR Configuration Module detected invalid positioning of the %M sync area	*Try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10831	GMR cfg err %R sync	GMR Configuration Module detected invalid positioning of the %R sync area	
10832	GMR cfg err %R temp	GMR Configuration Module detected invalid positioning of the %R temp %M sync area	
10833	GMR cfg err %R A/T int	GMR Configuration Module detected invalid positioning of the %R autotest interval pointer	
10834	GMR cfg err ssu flt act	GMR Configuration Module detected invalid system startup fault action	
10835	GMR cfg err syc flt act	GMR Configuration Module detected invalid startup sync fault action	

Code	Message	Cause	Possible Corrective Action
10837	GMR cfg err no of GBCs	GMR Configuration Module detected invalid number of GBCs	*Verify GMR and Logicmaster GBC configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10840	GMR version MM.mmE	GMR software version number	*This is a normal informative message generated by using the control bit %M12262 (REPORT) "Report GMR version/status".*
10841	Cfg util ver MM.mmE	GMR config utility version number	
10842	GMR config crc 0xXXXX	Config config CRC value	
10843	XXXXXXXXXXXXXXXXXXXX	First 20 characters of config description	
10844	XXXXXXXXXXXXXXXXXXXX	Remaining characters of description	
10850	Invalid Dig I/P data	Invalid data detected in voted digital input record	*Verify correct voted digital input group configurations in GMR configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10851	Invalid NV Dig I/P data	Invalid data detected in nonvoted digital input record	*Verify correct nonvoted digital input group configurations in GMR configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10852	Invalid Ana I/P data	Invalid data detected in voted analog input record	*Verify correct voted analog input group configurations in GMR configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10853	Invalid NV Ana I/P data	Invalid data detected in nonvoted analog input record	*Verify correct nonvoted digital input group configurations in GMR configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10860	GMR cfg err %R Write	%R register external device write access range is invalid	*Verify correct write access configuration in GMR configuration and try re-generating the configuration data from a valid ".gcf" file into the program folder. Contact GE Fanuc Technical Support*
10861	GMR cfg err %AI Write	%AI register external device write access range is invalid	
10862	GMR cfg err %AQ Write	%AQ register external device write access range is invalid	
10863	GMR cfg err %I Write	%I register external device write access range is invalid	
10864	GMR cfg err %Q Write	%Q register external device write access range is invalid	
10865	GMR cfg err %T Write	%T register external device write access range is invalid	
10866	GMR cfg err %M Write	%M register external device write access range is invalid	
10867	GMR cfg err %G Write	%G register external device write access range is invalid	
10870	Shutdown in hh mm ss	System simplex shutdown in hh hours, mm minutes and ss seconds	*Informative message – indicating system has degraded to running on one PLC and per the GMR configuration will shut down in hh hours, mm minutes and ss seconds.*
10871	Shutdown Cancelled	System simplex shutdown cancelled	*Informative message – indicating system is again running on more that one PLC.*

Code	Message	Cause	Possible Corrective Action
10872	System Shutdown	System has shut down	*Informative message – indicating system had degraded to running on one PLC and per the GMR configuration has shut down after the configured simplex timeout time has expired.*
10880	Invalid G_M_R__PB	G_M_R__ ladder block is incompatible with GMR modules	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10902	User_IF-GMR version	Module version number does not match the GMR system version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
10903	User_IF-Invalid Table	Module was called with extended mode table number when the module was in normal mode	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09). Contact GE Fanuc Technical Support.*
10903	Bad Table c (h)	Module was called with an invalid table number (c=requested table in decimal, h=requested table in hexadecimal)	*See "Reading GMR Diagnostics" using G_M_R09 in this user's manual for instructions.*
10905	User_IF-Invalid Range	Start or end address parameter is out of range for the specified table type	
10906	User_IF-Table Space	Destination parameter is out of range for the destination type of memory	
10907	No fault contacts	An attempt was made to read fault contact data, but no fault contacts were configured	
10908	Bad blk loc r.s.b.d.	An attempt was made to read an I/O shutdown timer for an invalid block Generated by GMR_09.	
10909	Bad GBC Loc r.s.	An attempt was made to read all I/O shutdown timers for an invalid GBC. Generated by GMR_09.	
10910	GMR9 Disabled	GMR9 was called when it was disabled	*Contact GE Fanuc Technical Support*
11001	Null GMR Configuration	A Null GMR configuration has been detected	*This is the condition of a new GMR program folder which has not yet had a valid GMR configuration generated into the GMR system software from the GMR configuration s/w.*
11101	Unauthorized GMR Access	GMR Configuration Module was invoked with incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
11102	GMR S/W Except. %L	%L parameter out of range	*Contact GE Fanuc Technical Support*
11201	Unauthorized GMR Access	GMR Configuration Module was invoked with the incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
11202	GMR S/W Except %L	%L parameter out of range	*Contact GE Fanuc Technical Support*
11401	Unauthorized GMR Access	GMR14 was invoked with the incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
11402	Incorrect GMR Version	GMR14 version does not match the GMR system version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
11403	GMR Software Exception	Invalid call number was detected	*Contact GE Fanuc Technical Support*
11404	Invalid GMR Pointer	The error code pointer was out of bounds	

Code	Message	Cause	Possible Corrective Action
11410	GMR1-IS x at y	GMR1-state-machine went to step x (illegal). Step no. at offset y in GMR1 diagnostics	Contact GE Fanuc Technical Support
11411	GMR1-ST x at y	GMR1 state mach. exceeded allowed time in step x. Step no. at offset y in GMR1 diagnostics	
11412	GMR1-IW x	GMR1 has output an illegal waycode of x	
11413	GMR1-tmplt too small	GMR14 has detected an internal error condition	
11415	GMR2-IS x at y	GMR2-state-machine went to step x (illegal). Step no. at offset y in GMR2 diagnostics	
11416	GMR2-ST x at y	GMR2 state mach. exceeded allowed time in step x. Step no. at offset y in GMR2 diagnostics	
11417	GMR2-IW x	GMR2 has output an illegal waycode of x	
11418	GMR2-tmplt too small	GMR14 has detected an internal error condition	
11420	GMR3-IS x at y	GMR3-state-machine went to step x (illegal). Step no. at offset y in GMR3 diagnostics	
11421	GMR3-ST x at y	GMR3 state mach. exceeded allowed time in step x. Step no. at offset y in GMR3 diagnostics	
11422	GMR3-IW x	GMR3 has output an illegal waycode of x	
11423	GMR3-tmplt too small	GMR14 has detected an internal error condition	
11430	GMR6-IS x at y	GMR6-state-machine went to step x (illegal). Step no. at offset y in GMR6 diagnostics	
11431	GMR6-ST x at y	GMR6 state mach. exceeded allowed time in step x. Step no. at offset y in GMR6 diagnostics	
11432	GMR6-IW x	GMR6 has output an illegal waycode of x	
11433	GMR6-tmplt too small	GMR14 has detected an internal error condition	
11435	GMR7-IS x at y	GMR7-state-machine went to step x (illegal). Step no. at offset y in GMR7 diagnostics	
11436	GMR7-ST x at y	GMR7 state mach. exceeded allowed time in step x. Step no. at offset y in GMR7 diagnostics	
11437	GMR7-IW x	GMR7 has output an illegal waycode of x	
11438	GMR7-tmplt too small	GMR14 has detected an internal error condition	
11440	GMR8-IS x at y	GMR8-state-machine went to step x (illegal). Step no. at offset y in GMR8 diagnostics	
11441	GMR8-ST x at y	GMR8 state mach. exceeded allowed time in step x. Step no. at offset y in GMR8 diagnostics	
11442	GMR8-IW x	GMR8 has output an illegal waycode of x	
11443	GMR8-tmplt too small	GMR14 has detected an internal error condition	
11445	GMR11-IS x at y	GMR11-state-machine went to step x (illegal). Step no. at offset y in GMR11 diagnostics	
11446	GMR11-ST x at y	GMR11 state mach. exceeded allowed time in step x. Step no. at offset y in GMR11 diagnostics	
11447	GMR11-IW x	GMR11 has output an illegal waycode of x	
11448	GMR11-tmplt too small	GMR14 has detected an internal error condition	
11450	GMR12-IS x at y	GMR12-state-machine went to step x (illegal). Step no. at offset y in GMR12 diagnostics	
11451	GMR12-ST x at y	GMR12 state mach. exceeded allowed time in step x. Step no. at offset y in GMR12 diagnostics	
11452	GMR12-IW x	GMR12 has output an illegal waycode of x	
11453	GMR12-tmplt too small	GMR14 has detected an internal error condition	
11455	GMR15-IS x at y	GMR15-state-machine went to step x (illegal). Step no. at offset y in GMR15 diagnostics	

Code	Message	Cause	Possible Corrective Action
11456	GMR15-ST x at y	GMR15 state mach. exceeded allowed time in step x. Step no. at offset y in GMR15 diagnostics	*Contact GE Fanuc Technical Support*
11457	GMR15-IW x	GMR15 has output an illegal waycode of x	
11458	GMR15-tmplt too small	GMR14 has detected an internal error condition	
11501	Unauthorized GMR Access	GMR15 was invoked with incorrect password	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
11502	Incorrect GMR Version	GMR15 version number does not match the GMR system version number	*Verify that all GMR System Software program blocks are of the same version. Could be caused by an incomplete update of the system software from one version to another.*
11503	GMR Software Exception	An invalid call number was detected	*Verify that the user application program has no calls to GMR program blocks (except G_M_R09).*
11504	Invalid GMR Pointer	The error code pointer was out of bounds	*Contact GE Fanuc Technical Support.*
11505	More than 1 Master	GMR15 detected that more than 1 PLC was operating as master	*Verify correct Genius Global Data configuration for alpha and beta GBCs. Also verify GBC status LEDs show a healthy GBC and bus. Verify proper wiring for complete alpha and beta buses.*
11506	Invalid Switch Case	GMR detected an illegal internal condition	*Contact GE Fanuc Technical Support*
11511	DQ x.y.1.z -> d/f/s	The PLC expected to dequeue an input autotest results datagram from the device at rack x, slot y, SBA (serial bus address) z. Instead, an invalid datagram was dequeued with function code f and subfunction code s from SBA (bus address) d	
11511	CQ x.y.1.z -> d/f/s	The PLC expected no datagram to be in the queue for the device at rack x, slot y, serial bus address z. Instead, an invalid datagram was found with function code f, and subfunction code s, from serial bus address d	
11513	Xtalk results read flt	Non-master could not read input autotest results from master PLC	*Verify correct Genius Global Data configuration for alpha and beta GBCs. Also verify GBC status LEDs show a healthy GBC and bus. Verify proper wiring for complete alpha and beta buses.*
11530	I/O S/D r.s.b.d	I/O Shutdown on the specified block	*Informative message that is generated when a fault that causes an I/O shutdown occurs. The I/O shutdown occurred on an I/O block at rack r, slot s, SBA d. See "I/O Shutdown" section in this user's manual.*
11530	I/O S/D cancel r.s.b.d	I/O Shutdown cancelled on the specified block	*Informative message that indicates a pending I/O shutdown was cancelled on an I/O block at rack r, slot s, SBA d. This can be accomplished by using the control bit %M12265 (SD_CAN) "Cancel I/O Shutdown". See "I/O Shutdown" section in this user's manual.*
11530	I/O S/D 8hrs r.s.b.d	I/O Shutdown in 8 hours on the specified block	*Informative warning message that is generated when a fault that causes an I/O shutdown occurs. The pending I/O shutdown will occur on an I/O block at rack r, slot s, SBA d. See "I/O Shutdown" section in this user's manual.*
11530	I/O S/D 1hr r.s.b.d	I/O Shutdown in 1 hour on the specified block	
1rsdd	I/P A/T res timeout	A/T results for SBA dd on GBC at rack r slot s	*Contact GE Fanuc Technical Support*

Appendix E — Upgrading a Previous Version of the GMR Software

This section explains how to upgrade an existing GMR application to use the GMR phase 4 software. There are instructions for:

- Upgrading a 788 or 789 CPU using a previous GMR version to the new GMR version
- Upgrading a 790 CPU using a previous GMR version to the new GMR version
- Upgrading a 788/789 CPU already using the new GMR software to a 790 CPU using the new GMR software.

The preferred method is:

Copying your own logic to a copy of the new GMR

Instructions are also included for:

Copying the new GMR software into an existing folder.

Preferred Method: Adding Your Program Logic to the New GMR Folder

1. Make a copy of the GMR logic folder:

A. Using the Logicmaster 9070 Programmer software, create a new logic folder. For example: GMRPROG.

B. Copy the appropriate version (see below) of the GMR folder from the GMR CD:

- (386 version): If you are upgrading a model 788/789 CPU to the new GMR without also upgrading the CPU type.
- (486 version) : If you are upgrading a model 788 or 798 CPU to a 790.
- (486 version): If you are upgrading a model 790 CPU to the new software.

2. Copy the variable declarations from the main block to a side file:

A. Using Shift F1, view the _MAIN block of the program.

B. Cursor to the Variable Declarations and zoom in using F10.

C. Activate the Region selections (F9).

D. Activate Select with F1, then press the ‘End’ key to navigate to the end of the list (all variables in the main block should now be selected).

E. F5 is the Write selection and will bring up a prompt for the name of a side file. For example: GMRVARS. Type in the name and press Enter.

3. Copy the existing program logic to library or side files to add to the new folder:

A. Select the folder (eg: MYPROG) with your existing logic.

B. If your logic contains program blocks, you can export them using the library functions. These can then be pulled into the new folder in a subsequent step.

C. Sections of logic that are not in program blocks can be written to side files and subsequently included in the new folder (remember to copy your variable nicknames as well as logic from the _MAIN block):

- From the Program view, Shift F1 and place the cursor on starting rung of section to be copied.
- Activate the Region selections, F9.
- Move the cursor to final rung of section to be copied.
- Press F5 to Write.
- Enter the name of side file, such as MYCODE1 or MYVARS. Press the Enter key.

4. Update the GMR Configuration folder if necessary:

If the folder was created by version 7.01 of the GMR software, skip this step and go to Step 5. If the folder was created by a version of the GMR software prior to 7.01, you will need to:

A. Use a copy of version 7.01 of the GMR Configuration Utility.

B. If you wish to back up your current folder, do so now.

C. Open your *.sav file with GMR Configuration Utility 7.01.

D. Create a runtime configuration (alt-o, c).

E. Exit the Configuration Utility (7.01).

5. Import the Configuration:

A. Start the new GMR Configuration Utility (version 8.xx).

B. Import the configuration from the existing folder. This may be a good time to enter a new System description.

C. To upgrade a 788 or 789 CPU to a 790 application only, open the configuration from your folder (MYPROG). Generate a printout of your configuration, and keep it nearby for reference.

   Open a second instance of the GMR Configuration Utility and create a **new configuration for a 790 model.** Using a series of copy and paste steps, copy all GBC and IO groups from the 788/789 configuration to the new one created for a 790 model.

   Using the printout from the original configuration, visually inspect the new configuration for accuracy.

D. Save the configuration (Note: This version of the Configuration Utility uses .gcf files instead of .sav files). You can save the configuration with a descriptive name (eg: GMRPROG) to the new folder. Unless a different location is specified, the Configuration utility defaults to the folder where the GMR Configuration software resides on the hard drive.

6. Now create a runtime configuration in the folder (eg: GMRPROG).

A. From the menu bar, select Tools -> Create Runtime Configuration.

B. From the file selection window, go to the MYPROG folder and click OK.

For a CPU788/789, this step creates a program block named G_M_R10. (See chapter 7 for information about adding G__M_R10 using the Librarian function of the Logicmaster software).

For a CPM790, this step embeds the GMR configuration into the G_M_R_.STA file for use by the GMR application during runtime.

7. Include user blocks and side files (including those with variable nicknames) into new GMRPROG folder. Import program blocks, using Shift-F6, F3.

8. Update variable labels in the _MAIN block

A. Delete any GMR Reserved for Future Use variables from the main block.

B. Include the GMRVARS side files.

Alternate Method – Adding New GMR software to an Existing Folder

This section gives steps to update an existing 788/789 CPU application and to update an existing 790 CPU application. Do not use this method if you are updating an existing788/789 application AND upgrading the CPU type to 790. In that case, use the previously-described Preferred Method instead.

1. Export GMR blocks from the new GMR folder to the Logicmaster library

It is not necessary to copy the GMR distribution folder, because you are not going to modify it. However, if you prefer to work with a copy, you can do so and delete it when no longer needed.

A. From the Logicmaster 9070 programmer, select the GMR distribution folder or the copy.

B. For a CPU model 790 only, export the G_M_R09 block.

For a CPU model 788 or 789 only, export all blocks with names beginning "G_M_R" from the folder to the library.

2. Save variable nicknames from the new GMR folder to a side file.

A. Using Shift F1, view the _MAIN block of the program.

B. Cursor to the Variable Declarations and zoom in using F10.

C. Activate the Region selections (F9).

D. Activate Select with F1, then press the 'End' key to navigate to the end of the list (all variables in the main block should now be selected).

E. F5 is the Write selection and will bring up a prompt for the name of a side file. Type in the name (for example: GMRVARS) and press Enter.

3. Import GMR block(s) from the library

A. Select the folder with your logic (for example: MYPROG)

B. When updating an existing CPU model 790 application only, import the G_M_R09 program block from the library (if prompted to replace existing block, answer Yes).

C. When updating an existing CPU model 788 or 789 application only, import the G_M_Rxx program blocks from the library in ascending numerical order (if prompted to replace existing blocks, answer Yes).

4. (For updating existing CPU model 790 only): copy the G_M_R_.Sta file

Copy the G_M_R_.STA file from the distribution folder to the folder with your application program logic. You can use the Windows Explorer. To avoid a sharing violation, ESC out of the folder to the main menu of Logicmaster until you have completed this step.

5. Update the GMR Configuration folder if necessary

If you are using a GMR configuration folder that was created with version 7.01 of the GMR software, skip this step.

If the folder was created by a version of the GMR software prior to 7.01, you will need to:

A. Use a copy of version 7.01 of the GMR Configuration Utility.

B. If you wish to back up your current folder, do so now.

C. Open your *.sav file with GMR Configuration Utility 7.01.

D. Create a runtime configuration (alt-o, c).

E. Exit the Configuration Utility (7.01).

6. (for updating an existing CPU 788/789 application only) Update the G_M_R10 file in the current folder.

A. Start the new GMR Configuration Utility (version 8.xx).

B. Import the configuration from your folder (eg: MYPROG). This may be a good time to enter a new System description.

C. Save this configuration (Note: In the new Configuration Utility, .gcf files have replaced the .sav files). You could save this with a descriptive name to the new folder (eg: GMRPROG). However, unless specified the Configurator defaults to the folder where the GMR Configuration program resides on your hard drive.

7. Create the runtime configuration.

A. From the menu bar, select Tools -> Create Runtime Configuration.

B. From the file selection window, navigate to the MYPROG folder and click OK.

For a 788/789 CPU, this step updates the G-M_R10 file in the current folder.

For a 790 CPU, this step embeds the GMR configuration information into the G_M_R_.STA file for use byu the GMR application during runtime.

8. In the user folder, delete any GMR Reserved for Future Use variables from the main block

9. In the user folder, include side file GMRVARS with variables for main block

Appendix F

PFD Calculations

The following assumptions have been used for the basis of calculating the Probability to Fail on Demand as determined in *IEC61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems*.

To avoid excessive number of configurations, the PFD calculations have been made by computing individual sub-system PFD based on the worst case channel/path reliability figures within the sub-system for the specified configuration. By combining the PFD results of these sub-systems, the PFD of a safety function can be computed.

Standard Parameters

Parameter	Value	Comment
Proof Test Period, T_1	6 months	Industry accepted value
Mean Time To Repair, MTTR	8 hours	Repair within shift
Diagnostic Coverage, DC	90%	All GE Fanuc units incorporate extensive internal diagnostic.
Fraction of failures with common cause, β	1%	Common cause design failures have been minimized through mature design and long service combined with a high degree of segregation between paths and modules.
Average probability of failure per hour, λ	Module Specific	Contact GE Fanuc for module reliability data
Probability of dangerous failure per hour, λ_D	see calculation	Value depends on Architecture
Probability of undetected dangerous failure per hour, λ_{DU}	see calculation	Value depends on Architecture
Probability of detected dangerous failure per hour, λ_{DD}	see calculation	Value depends on Architecture
Device equivalent mean down time, t_{DE}	see calculation	Value depends on Architecture
System equivalent mean down time, t_{SE}	see calculation	Value depends on Architecture
Average probability of failure on demand, PFD_{AVG}	see calculation	Value depends on Architecture

The formulas for calculating the PFD for various architectures have been taken or are based on those in IEC61508 as follows;

$$\lambda_D = \lambda_{DU} + \lambda_{DD} = \frac{\lambda}{2} \qquad \lambda_{DU} = \frac{\lambda}{2}(1-DC) \qquad \lambda_{DD} = \frac{\lambda}{2}DC$$

PFD Formula 1oo1

$$t_{DE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{2} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D}MTTR$$

$$PFD_{AVG} = (\lambda_{DD} + \lambda_{DU})t_{DE}$$

PFD Formula 1oo2

$$t_{DE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{2} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D}MTTR$$

$$t_{SE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{3} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D}MTTR$$

$$PFD_{AVG} = 2((1-2\beta)\lambda_{DD} + (1-2\beta)\lambda_{DU})^2 t_{DE}t_{SE} + \beta\lambda_{DD}MTTR + 2\beta\lambda_{DU}\left(\frac{T_1}{2} + MTTR\right)$$

PFD Formula 2oo2

$$t_{DE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{2} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D}MTTR$$

$$PFD_{AVG} = 2\lambda_D t_{DE}$$

PFD Formula 1oo2d

$$t_{DE}' = \frac{\lambda_{DU}\left(\frac{T_1}{2} + MTTR\right) + (\lambda_{DD} + \lambda_{SD})MTTR}{\lambda_{DU} + \lambda_{DD} + \lambda_{SU}}$$

$$t_{DE}' = \frac{\lambda_{DU}\left(\frac{T_1}{3} + MTTR\right) + (\lambda_{DD} + \lambda_{SD})MTTR}{\lambda_{DU} + \lambda_{DD} + \lambda_{SD}}$$

$$PFD_{AVG} = 2(1-2\beta)\lambda_{DU}((1-2\beta)\lambda_{DU} + (1-\beta)\lambda_{DD} + \lambda_{SD})t_{DE}'t_{SE}' + \beta\lambda_{DD}MTTR + 2\beta\lambda_{DU}\left(\frac{T_1}{2} + MTTR\right)$$

PFD Formula 2oo3

$$t_{DE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{2} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D} MTTR$$

$$t_{SE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{3} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D} MTTR$$

$$PFD_{AVG} = 2(1-2\beta)\lambda_{DU}\left((1-2\beta)\lambda_{DU} + (1-\beta)\lambda_{DD} + \lambda_{SD}\right)t_{DE}'t_{SE}' + \beta\lambda_{DD} MTTR + 2\beta\lambda_{DU}\left(\frac{T_1}{2} + MTTR\right)$$

Genius Input PFD

The worst case PFD for various Genius input configurations per channel are shown below. The calculations assume the probability of failure of the I/O power supply is at least a magnitude better than path for the arrangement under consideration.

Configuration	PFD (Per Channel)	Comment
Simplex	6.81×10^{-05}	
Duplex (1oo2d)	1.34×10^{-06}	
Duplex (1oo2)	1.35×10^{-06}	
Triplex	1.36×10^{-06}	

Series 90-70 Logic Unit PFD

The worst case PFD for Series 90-70 Logic Units are shown below. The calculations assume that only 10% of rack PSU failures are “fail to danger”.

Configuration	PFD (Per Path)	Comment
Simplex	7.11×10^{-04}	Configuration is 9 Slot Rack, PSU, CPU and Simplex GBC. Voting occurs in output block
SimplexD	8.24×10^{-04}	Configuration is 9 Slot Rack, PSU, CPU and Duplex GBC. Voting occurs in output block
Duplex (1oo2d)	1.63×10^{-05}	Configuration is 9 Slot Rack, PSU, CPU and Duplex GBC. Voting occurs in output block
Duplex (1oo2)	1.71×10^{-05}	Configuration is 9 Slot Rack, PSU, CPU and Duplex GBC. Voting occurs in output block
Triplex	2.19×10^{-05}	Configuration is 9 Slot Rack, PSU, CPU and Triplex GBC. Voting occurs in output block

Genius Output PFD

The worst case PFD for various Genius output groups are shown below. The calculations assume the probability of failure of the I/O power supply is at least a magnitude better than path for the arrangement under consideration.

Configuration	PFD (per channel)	Comment
Simplex	6.81×10^{-05}	
1oo1d	1.34×10^{-06}	Calculated per 1oo2
I-Block	1.34×10^{-06}	Calculated per 1oo2
H-Block	1.35×10^{-06}	Calculated per 1oo2d

PFD Summary

The following table provides a range of typical Fire and Gas subsystem configurations and indicates the worst-case safety function PFD for each of these subsystems for the electronic control system only. It is intended to provide a quick-check/cross-reference for system designers.

Note that only the Logic Unit PFD is additive to the total PFD of each safety function under consideration. The input and output PFD has to be re-calculated including the field devices and associated control modules/barriers with due consideration for environmental factors.

Genius Input		90-70 Logic Unit		Genius Output	
Configuration	PFD	Configuration	PFD	Configuration	PFD
Simplex	6.81×10^{-05}	Simplex	7.11×10^{-04}	Simplex	6.81×10^{-05}
Simplex	6.81×10^{-05}	Duplex (1oo2)	1.63×10^{-05}	Simplex	6.81×10^{-05}
Simplex	6.81×10^{-05}	Duplex (1oo2d)	1.71×10^{-05}	Simplex	6.81×10^{-05}
Simplex	6.81×10^{-05}	Triplex (2oo3)	2.19×10^{-05}	Simplex	6.81×10^{-05}
Simplex	6.81×10^{-05}	SimplexD	8.24×10^{-04}	I-Block/1oo1d	1.34×10^{-06}
Duplex (1oo2d)	1.34×10^{-06}	SimplexD	8.24×10^{-04}	I-Block/1oo1d	1.34×10^{-06}
Duplex (1oo2d)	1.34×10^{-06}	Duplex (1oo2d)	1.63×10^{-05}	I-Block/1oo1d	1.34×10^{-06}
Duplex (1oo2d)	1.34×10^{-06}	Duplex (1oo2d)	1.63×10^{-05}	H-block	1.35×10^{-06}
Simplex	6.81×10^{-05}	SimplexD	8.24×10^{-04}	I-Block/1oo1d	1.34×10^{-06}
Duplex (1oo2)	1.35×10^{-06}	SimplexD	8.24×10^{-04}	I-Block/1oo1d	1.34×10^{-06}
Duplex (1oo2)	1.35×10^{-06}	Duplex (1oo2)	1.71×10^{-05}	I-Block/1oo1d	1.34×10^{-06}
Duplex (1oo2)	1.35×10^{-06}	Duplex (1oo2)	1.71×10^{-05}	H-Block	1.35×10^{-06}
Triplex (2oo3)	1.36×10^{-06}	Triplex (2oo3)	2.19×10^{-05}	I-Block/1oo1d	1.34×10^{-06}
Triplex (2oo3)	1.36×10^{-06}	Triplex (2oo3)	2.19×10^{-05}	H-Block	1.35×10^{-06}

Appendix G

Glossary of GMR Terms

This section explains some of the terms used in this manual.

1v1 <or> 1oo1 Voting:

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

2v2 <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.

1v2 <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 data 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 data 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:

The 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 that 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 HMI (Human-Machine Interface) hardware and software 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, and if they are the only CPU(s) in a system (that is, no other CPUs are currently on-line), the startup sequence for diagnostic and error detection that allows the system to transition from offline to operational for all activated components is called a Cold Start.

Configuration:

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

Configuration Software

The Logicmaster 90™ configuration software and GMR configuration software are 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 potential 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, or between device on a LAN.

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 can be up to 128 8-bit bytes (64 words) in length.

De-energize–to–Trip:

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

Degradation Path:

The method of ignoring failures. It can be applied to keep an area of a fault-tolerant system operational when some part of it has become inoperable or incorrect. For TMR system components, this may be 3-2-1-X or 3-2-X, selectable. For dual system components, this may be 2-1-X or 2-X selectable. (Where X = the preferred default safe state, i.e. On or Off for a discrete input or output, or the default value for an analog channel).

Detected Failure:

An apparent (not covert) failure. The failure is detectable because it causes an apparent change of operation request. For a system, this failure may result in the safe state being achieved, although not by system request.

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:

In a voting system: a disagreement between one of two (for dual components) or one of three (for triplicated components) corresponding voted states (for discrete) or out of preset range voted values (for analog).

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 user 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, 1oo2D, 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 applications such as Fire and Gas supression 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 Communications, 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 communication error detection. GMR CPUs can exchange data with other system devices via TCP/IP protocol on an ethernet system.

Ethernet module:

A Series 90-70™ module that resides in a system CPU rack or its expansion racks. The module provides TCP/IP protocol capability.

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 Degradation:

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

3– 2 – 1* – X <or> 3 – 2 – X

For dual system components, the two available degradation modes that may be selected are:

2 - 1 - X <or> 2 - X

For simplex system components, the only degradation mode which is possible is:

1 - X

The method of fault degradation is selected during GMR configuration of each group. When the fault degradation path reaches X, outputs default to individually-selected safe states. *Note: TÜV limits use of 1oo1 mode to a selectable 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.

Fault Contacts:

See Alarm and Fault Contacts

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:

A 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 may be configured in a triple modular redundant (TMR), 2oo2, 1oo2, 1oo2D, or 1oo1D scaleable architecture configuration. This means that the system has support 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" 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 Fail Safe 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 for robust 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. This 32-bit backplane support is a non-proprietary open hardware form factor used in the Series 90-70 system.

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 HMI 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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