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GE Fanuc Automation

Programmable Control Products

Genius™ Modular Redundancy Flexible Triple Modular Redundant (TMR) System User's Manual

GFK-0787B

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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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Preface

This manual is a reference to planning, configuring and programming a Series 90™-70 PLC system that utilizes Genius Modular Redundancy (GMR).

The information in this manual is intended to supplement the basic system installation, programming, and configuration instructions located in the manuals listed on the next page.

Content of this Manual

Chapter 1. Introduction: describes the concept of GMR, and gives an overview of system components, configuration, and programming.

Chapter 2. Input Subsystem: provides information about the inputs to a GMR system.

Chapter 3. Output Subsystem: describes GMR output groups, output handling, manual output controls, and load sharing.

Chapter 4. PLC Operation: describes system startup, the CPU sweep in a GMR system, PLC operation, I/O processing, and communications between redundant PLCs

Chapter 5. Diagnostics: chapter 5 describes the various types of diagnostics available in a GMR system.

Chapter 6. Configuration: describes configuration for a Series 90-70/Genius GMR system.

Chapter 7. Programming Information: describes the application program interface to the GMR software.

Chapter 8. Installation Information: provides supplementary installation information for GMR.

Appendix A. TÜV Certification: describes restrictions placed on the design, configuration, installation and use of a GMR system that will be applied in an Emergency Shut Down (ESD) application, for which for a TÜV site application approval will be sought.

Appendix B. Maintenance Override: The information in this appendix is reprinted by permission of TÜV. 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.

Changes for this Version of the Manual

This manual describes a group of features and product enhancements that are collectively referred to as "GMR Phase II":

- Programming can now be done online. This capability is intended for use during debug and commissioning.
- 32-circuit DC Genius I/O blocks can now be used in "H-pattern" output subsystems.

- The GMR configuration software now allows selection of memory addresses for external write access. Serial and network communication ports are restricted; the Genius bus is not. A GMR Genius bus must *not* be used for communications.
- Input autotest is enhanced. External isolation diodes are required.
- The method used for input voting adaptation can now be configured to suit the application.
- New diagnostics including parity checks and checksums are provided.
- Fault text displayed by the Logicmaster software is improved.

Related Publications

For more information, refer to these publications:

Genius I/O System User's Manual (GEK-90486-1). Reference manual for system designers, programmers, and others involved in integrating Genius I/O products in a PLC or host computer environment. This book provides a system overview, and describes the types of systems that can be created using Genius products. Datagrams, Global Data, and data formats are defined.

Genius Discrete and Analog Blocks User's Manual (GEK-90486-2). Reference manual for system designers, operators, maintenance personnel, and others using Genius discrete and analog I/O blocks. This book contains a detailed description, specifications, installation instructions, and configuration instructions for all currently–available discrete and analog blocks.

Series 90™ -70 PLC Installation and Operation Manual (GFK-0262). This book describes the modules of a Series 90–70 PLC system, and explains system setup and operation.

Logicmaster90™ -70 User's Manual (GFK-0263). Reference manual for system operators and others using the Logicmaster 90–70 software to program, configure, monitor, or control a Series 90–70 PLC and/or a remote drop.

Logicmaster 90 Software Reference Manual (GFK-0265). Reference manual which describes program structure and defines program instructions for the Series 90–70 PLC.

Series 90-70 Bus Controller User's Manual (GFK–0398). Reference manual for the Bus Controller, which interfaces a Genius bus to a Series 90-70 PLC. This book describes the installation and operation of the Bus Controller. It also contains the programming information needed to interface Genius I/O devices to a Series 90-70 PLC.

We Welcome Your Comments and Suggestions

At GE Fanuc automation, we strive to produce quality technical documentation. After you have used this manual, please take a few moments to complete and return the Reader's Comment Card located on the next page.

Jeanne L. Grimsby

Senior Technical Writer

Contents

Chapter 1 Introduction

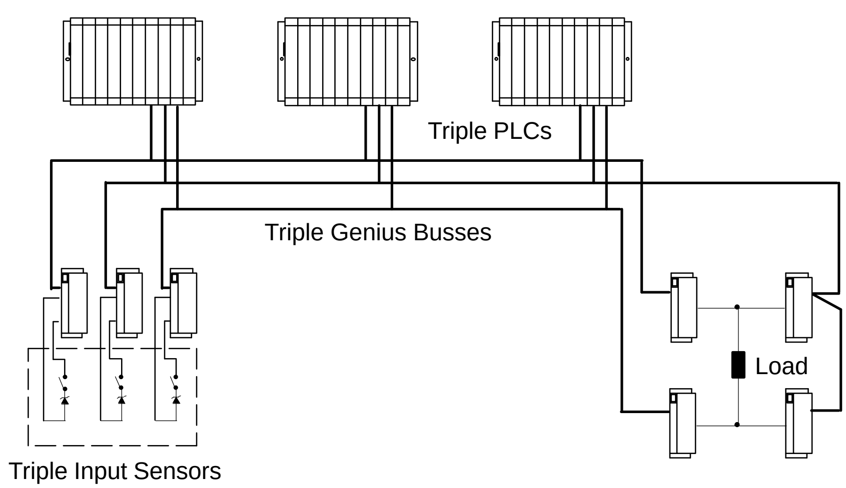
Genius Modular Redundancy (GMR™) has been developed by GE Fanuc Automation and Silvertech Limited of the United Kingdom. Silvertech has many years experience applying GE Fanuc products to high-integrity safety system applications such as Emergency Shutdown and Fire & Gas Detection in the petrochemical / oil and gas industries. They have captured this expertise in the GMR system software.

GMR is a high-reliability, high-availability redundancy system that provides a scalable solution for many types of redundancy applications, including critical TMR (Triple Modular Redundancy) applications.

TÜV has certified GMR for classification to these requirements: triplex Class 5, duplex Class 4 and 5, and simplex Class 4 according to the DIN V19250/DIN V VDE 081 standards. For use of the GMR system in a TÜV approved safety critical installation, refer to information in Appendix A.

The GMR system is based on standard, off-the-shelf hardware. It utilizes field-proven Series 90-70 PLC and Genius I/O products. Enhancements have been incorporated into the standard PLC CPU, bus controller, and several Genius I/O blocks specifically for use in GMR systems. These enhanced products, together with GMR system software, provide input voting by the PLCs, output voting, support for both discrete and analog I/O, automatic testing of discrete inputs and outputs, and extensive fault-monitoring capabilities for the application program.

A basic GMR system consists of groups of Genius blocks 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 is provided by the Genius bus.



GMR provides great configuration flexibility. A system can include 1, 2, or 3 PLCs. There can be just one I/O subsystem, as represented above, or more than one. Each I/O subsystem can include 1, 2, or 3 busses. A bus can serve up to a total of 32 devices (I/O blocks, PLCs, and a Hand-held Monitor). The system can include both non-redundant I/O blocks and individual non-redundant points on redundant blocks.

Components of a GMR System

GMR Software

GMR software version 2.06 (catalog number IC641SWP714B) provided on diskette consists of:

- Easy-to-use GMR configuration software.
- GMR system software, which automatically processes, monitors, and tests redundant I/O.
- A download utility for updating programs in systems with SNP multidrop communications.

Series 90-70 PLCs

Two models of the Series 90-70 PLC CPU support GMR, CPU 788 and CPU 789. If the GMR system includes either two or three PLC CPUs, they must be the same model. Each PLC requires one to three Bus Controllers per bus. Minimum suffixes for GMR version 2.06 are:

CPUs and Bus Controllers	Catalog Number	Minimum Suffix
Series 90-70 PLC CPU	IC697CPU788 IC697CPU789	DA DA
Series 90-70 PLC CPU Memory	IC697BEM735	D
Series 90-70 Bus Controller	IC697BEM731	N

Genius I/O Blocks

- The following standard Genius blocks are supported by the GMR system. These blocks contain GMR modifications for version 2.06 beginning with the "minimum suffix" listed:

Block Type	Catalog Number	Minimum Suffix
24/48VDC 16-Circuit Source block	IC660BBD020	M
24/48VDC16-Circuit Sink block	IC660BBD021	M
12/24VDC32-Circuit Source block	IC660BBD024	N
5/12/24VDC32-Circuit Sink block	IC660BBD025	N
Analog,RTD, and Thermocouple blocks		no specific suffix required

- Other types of Genius blocks can be used as non-redundant blocks in the same system.

Additional Items

- **"SPECIAL SAFETY SYSTEM"** red I/O block labels (package of 20 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 4.02 or later.
- **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.)

Incompatible Products

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

Series 90-70 PLCs

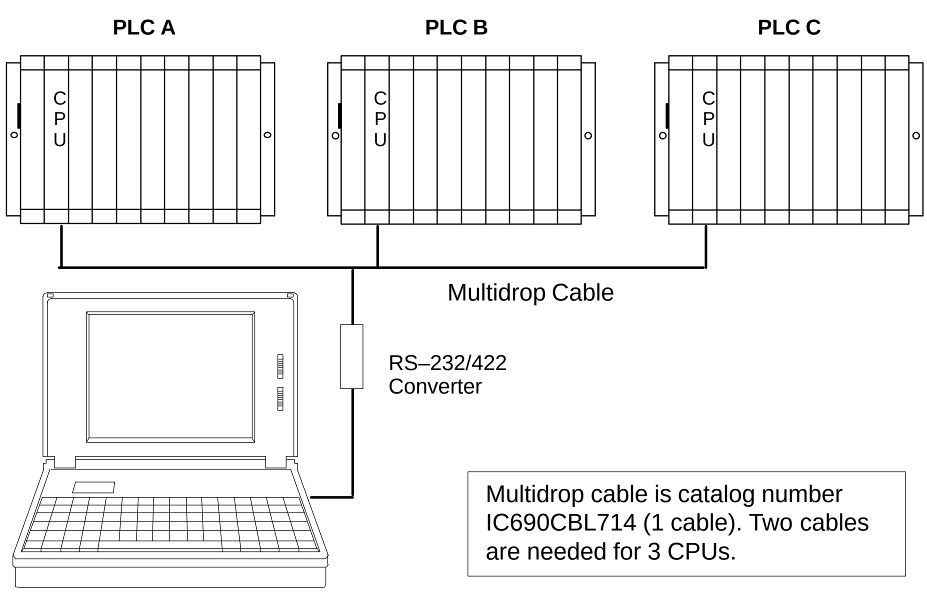
A GMR system normally consists of one to three identical CPUs running identical application software. Each CPU is connected to the same input and output subsystems.

Each CPU receives all inputs and performs voting for discrete inputs and mid-value selection for analog inputs. Each CPU computes the required outputs as a function of the inputs and the application program logic.

Inter-processor Communications

The PLCs exchange initialization data at startup, then operate asynchronously. They communicate regularly using Global Data. Each Genius bus scan, each PLC broadcasts up to 64 words of Global Data. This includes 8 words of system information. An additional 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.

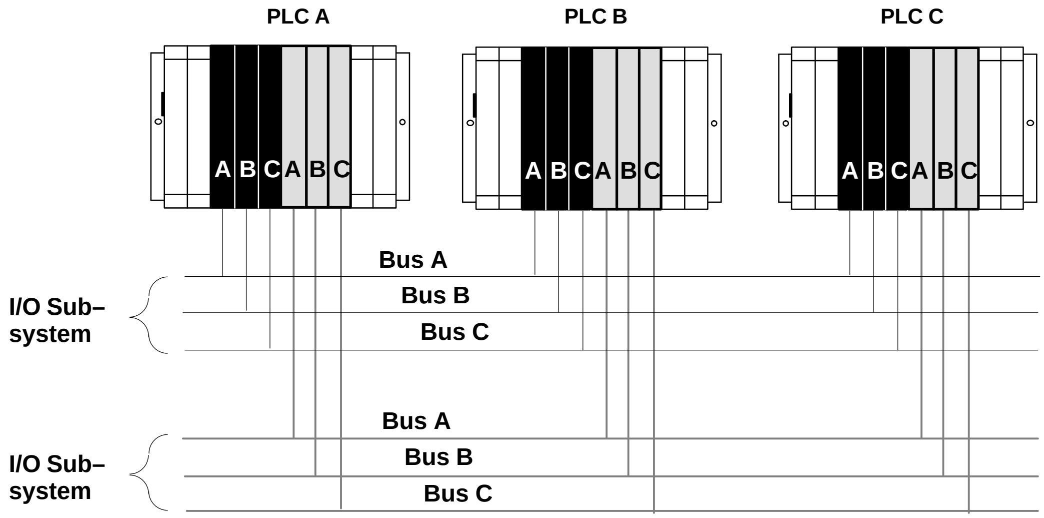
The PLCs may also be joined in a multidrop Series Ninety Protocol (SNP) network. A host computer on the network can be used for gathering data from the system. In addition, the SNP network permits convenient program updates using the Logicmaster 90 programming software and the Program Download utility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



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.

Busses and Bus Controllers

In a GMR system, there can be one to three bus controllers per bus, per PLC. Larger systems may require more than one I/O subsystem. For example, the GMR system represented below has two I/O subsystems 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.

Additional Bus Controllers for Communications

The Genius busses that support GMR input/output groups are also used for internal communications between PLCs, as explained on the previous page. They 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 autotesting in a GMR system, the Genius bus scan time should not be be more than 60mS.

Operation Overview

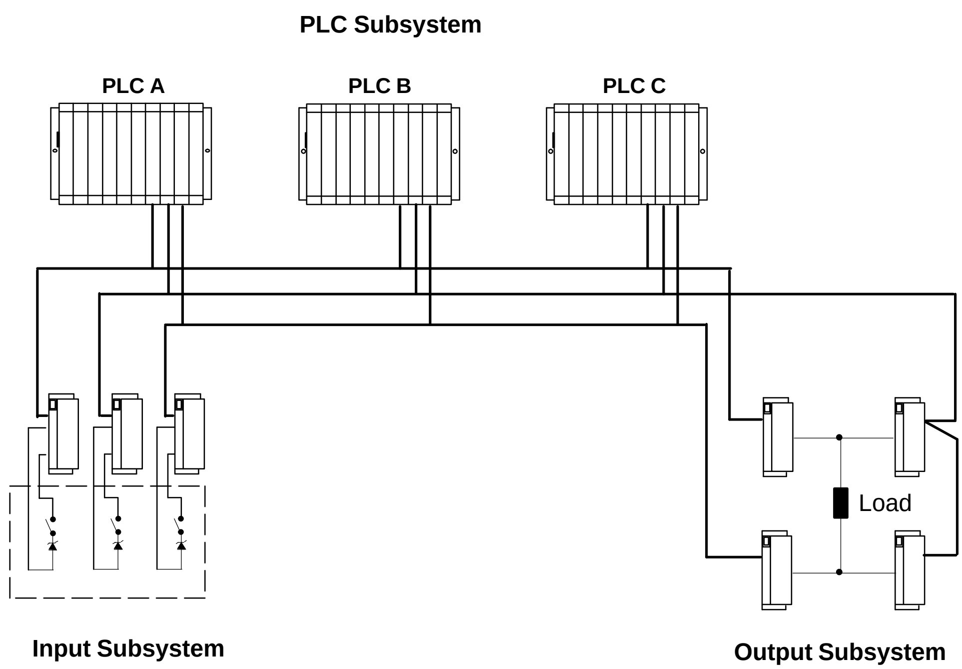
Genius Modular Redundancy has been developed for use in systems that have static or nearly static I/O under normal operating conditions. The system may have:

- 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:

- high degree of self-test and monitoring with diagnostics
- fault tolerance.
- support for centralized or fully distributed systems.
- Scalable voting: 2-out-of-3, 2-out-of-2, 1-out-of-2, or simplex.

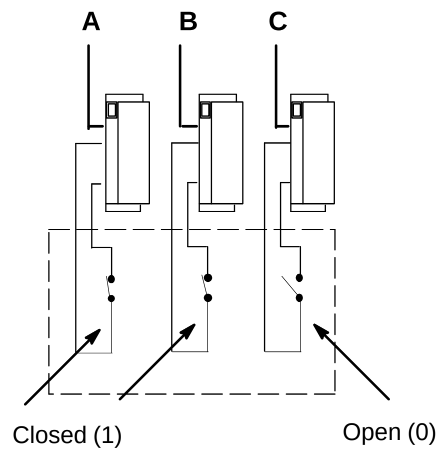
The example that follows illustrates how the GMR input subsystem, PLC subsystem, and output subsystem combine to provide a high-availability, high-reliability system.



Input Subsystem

In a GMR system, the basic elements of an input subsystem are single or triple sensors connected to triple Genius blocks. Each block is on a different communications bus (shown below as A, B, and C).

For this example, there are triple input sensors which are normally-on. However, one of these input sensors is off:

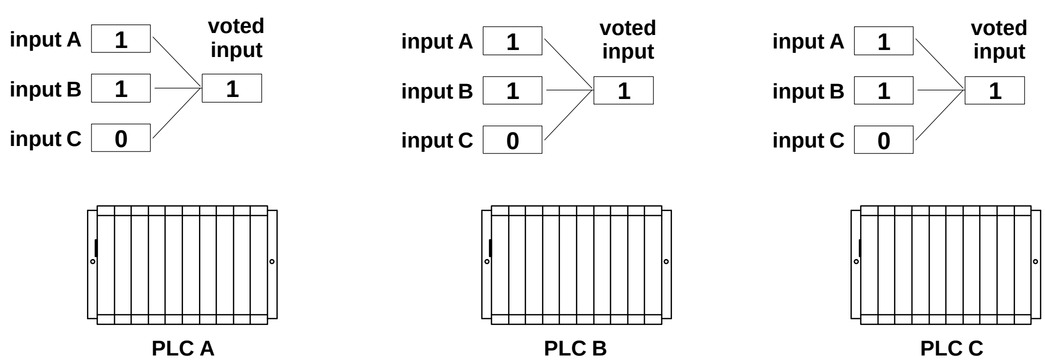


Each PLC in the example system votes on the input data received from these three sensors as summarized below. For a more detailed description of input processing, see chapter 2.

PLC Subsystem: Voting on Input Data

The example system uses three PLCs. Each PLC receives corresponding inputs from all three blocks in the input group.

The GMR software in each PLC automatically votes on the input data and provides the voted input to the application program (the program can also access the unvoted input data). Each of these example voted inputs represents the *same* input sensors.

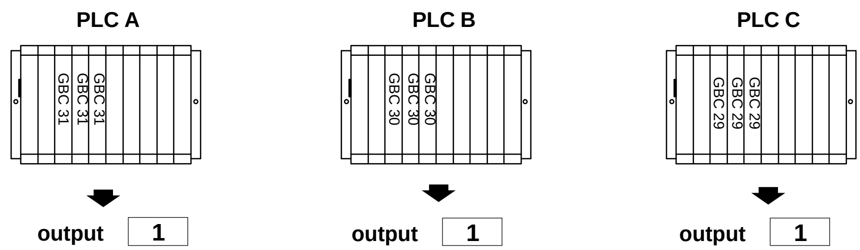


If an input is faulty, the PLC(s) follow a configurable, predetermined voting scheme based on the remaining input data.

PLC Subsystem: Providing Output Data

Running the same application program, each PLC (referred to here by Genius Bus Controller (GBC) serial bus addresses: 31, 30, and 29) processes the voted input data and produces appropriate outputs. Because each of the three PLCs is running the same program, they produce three copies of the same output data.

Each PLC then sends this triplicated output data on the bus.

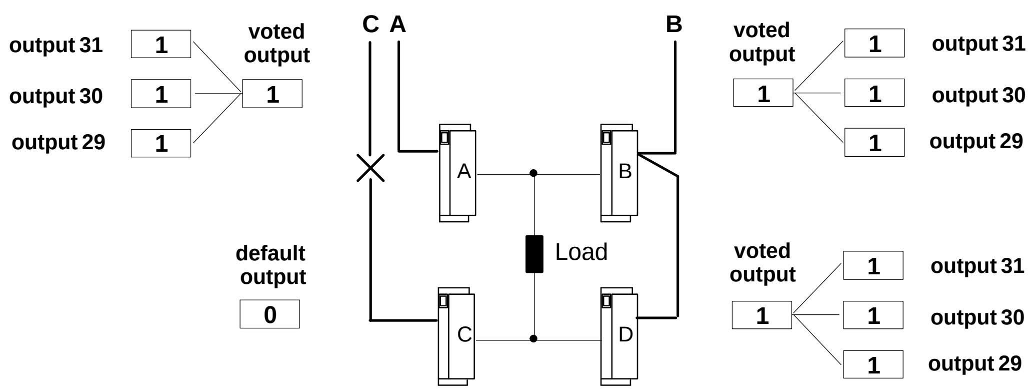


Output Subsystem

The basic element of an output subsystem is the output group. Each block in the group has the same reference address in the application program, so each block receives the same output data.

The output group votes on the three outputs and uses the result as the physical output.

In this example, communications are lost on bus C. Upon losing communications, the block on bus C follows its configuration instructions, which are to default its outputs to 0. However, the remaining blocks in the group continue to receive valid output data from all three PLCs over busses A and B, and the actual state of the output load is controlled properly. The loss of block or loss of bus diagnostic would be recorded, providing an aid to troubleshooting and annunciating the problem.



In a 4-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 the three separate processors.

Automatic System Test

Optional autotest routines test the complete system from input modules through to output modules, including failures in the I/O wiring. Autotesting does not affect the normal state of field devices.

Genius I/O Blocks

Inputs and outputs in a GMR system are provided by Genius I/O blocks. Some types of Genius blocks are now enhanced for GMR operation. In addition, these and other types of blocks can be included in a GMR system as “non-voted” blocks. Non-voted blocks are individual blocks that are present on GMR busses in the system; they are not part of any GMR input group or output group. They are included in the GMR configuration and they may be autotested.

Discrete Blocks

All types of discrete blocks can be used as non-voted blocks in a GMR system.

The discrete blocks listed on page 1-2 are standard Genius blocks that are now enhanced to include GMR functions. These blocks can be used in either GMR or non-GMR systems. *When configured for GMR operation (only)*, they perform output voting, support GMR autotesting, and provide diagnostic reports to up to three PLCs. In addition, certain of their operating parameters are changed when they are in GMR mode.

Analog, RTD, and Thermocouple Blocks

Analog blocks can be included in the GMR configuration and used in GMR input groups, as either voted or non-voted inputs. However, analog blocks in GMR input groups are *not* autotested by the GMR software.

Analog blocks do not provide output voting, so they cannot be used in GMR output block groups. However, they can be used as non-voted blocks in a GMR system, and support standard Hot Standby Redundancy.

Analog, RTD, and Thermocouple blocks operate the same way in either GMR or non-GMR systems. No specific versions of these blocks are required for GMR use.

I/O Block Summary

The following table summarizes how different types of blocks can be used in a GMR system.

Basic Block Types	Can be GMR Input Block	Can be GMR Output Block	Can be “non-voted” GMR block	Can be Autotested	Can be non-GMR block
24/48VDC 16-Circuit Source block 24/48VDC 16-Circuit Sink block 12/24VDC 32-Circuit Source block 5/12/24VDC 32-Circuit Sink block	yes	yes	yes	yes	yes
Any other discrete block	no	no	yes	no	yes
Analog, RTD, and Thermocouple blocks	yes	no	yes	no	yes
High-speed Counter block	no	no	no	no	yes
Power Trac block	no	no	no	no	yes

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 or model 789. 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.

CPU Model	Total Discrete Physical I/O	Maximum Number of Voted Inputs	Maximum Number of Voted Outputs	Maximum Total Voted I//O
788	352	112	80	100
798	12288	2048	2048	4096

Non-GMR I/O: Non-GMR I/O is I/O that is not included in the GMR configuration. The amount of non-GMR I/O that can be used depends on the amount of GMR I/O present and the CPU memory capacity. The tables below show how much memory is available for non-GMR I/O (main part of tables) for given numbers of GMR inputs and GMR outputs. In the equations, the GMR Inputs and GMR Outputs are the actual number of I/O configured with the programming software.

Number of Non-GMR I/O Available for the 788 CPU

Number of Voted GMR Inputs	Number of Redundant GMR Outputs						
	0	**16**	**32**	**48**	**64**	**80**	**96**
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						

Number of Non-GMR I/O Available for the 789 CPU

These numbers are determined by the limits of physical I/O based on the Logicmaster configuration and table size limitations based on the manner in which GMR maps I/O into multiple locations in the I/O tables (this is explained in chapter 4).

Number of Voted GMR Inputs	Number of Redundant GMR Outputs								
	0	**256**	**512**	**768**	**1024**	**1280**	**1536**	**1792**	**2048**
0	12288	11264	10240	9216	8192	7168	6144	5120	4096
256	11264	10496	9472	8448	7424	6400	5376	4352	3328
512	10240	9728	8704	7680	6656	5632	4608	3584	2560
768	9216	8960	7936	6912	5888	4864	3840	2816	1792
1024	8192	7936	7168	6144	5120	4096	3072	2048	1024
1280	7168	6912	6400	5376	4352	3328	2304	1280	256
1536	6144	5888	5632	4608	3584	2560	1536	512	
1792	5120	4864	4608	3840	2816	1792	768		
2048	4096	3840	3584	3072	2048	1024			

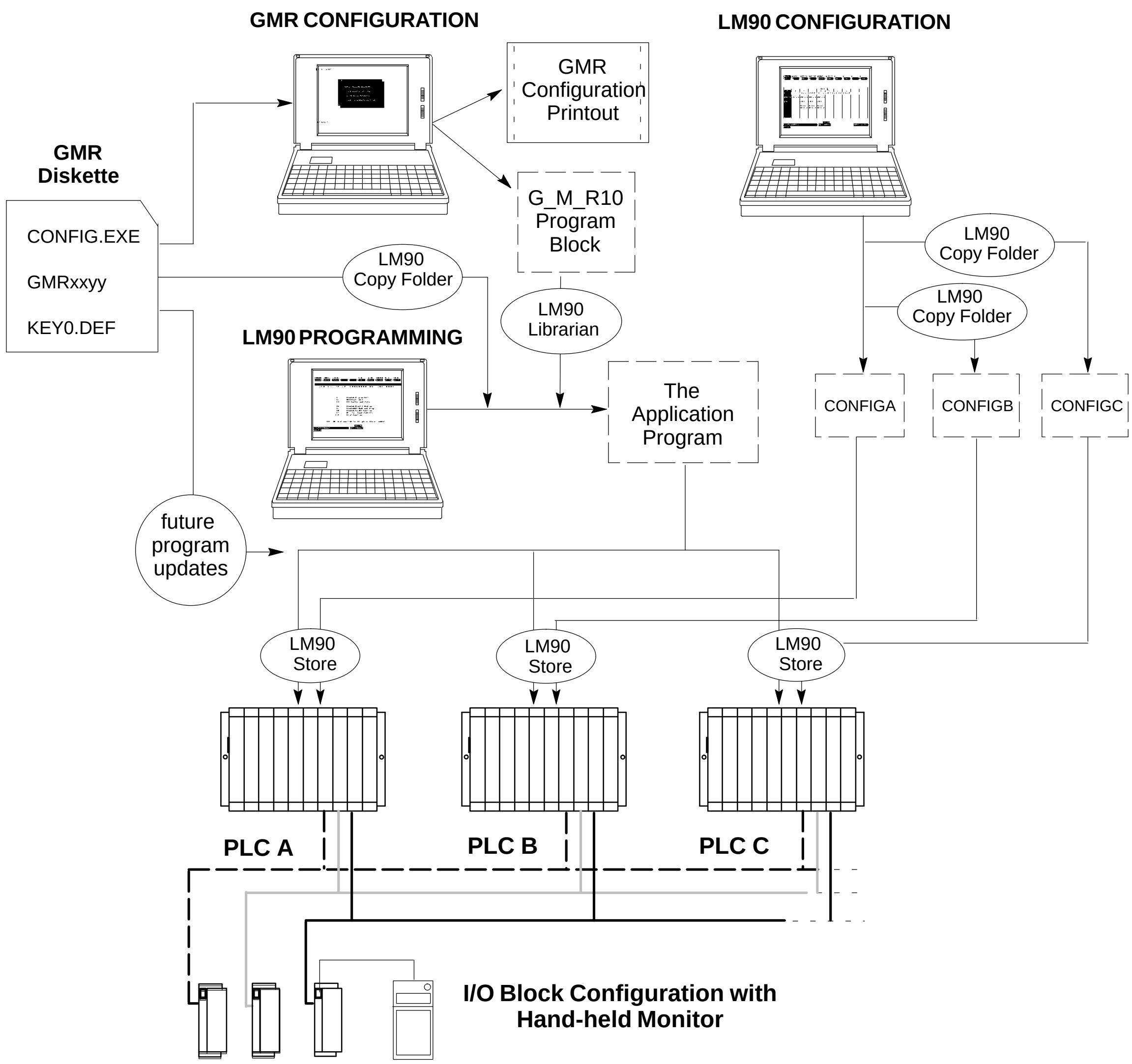
Configuration and Programming

The GMR Software

The GMR software consists of:

- The GMR configuration software file, CONFIG.EXE. This file, which runs under DOS, is used to enter the system parameters that will be used by the GMR system software. When the GMR configuration is completed, it produces a Program Block named G_M_R10.
- A directory named GMRxxyy containing the GMR system software files, to which the application program will be added. In the directory name GMRxxyy, xx is two digits representing the major revision level of the GMR software. The last two digits (yy) represent the minor software revision level.
- A "teach" file named KEY0.DEF for use in future application program updates.

Subsequent chapters of this book explain configuration steps and programming guidelines for a GMR system. The basic steps are illustrated below.



The Basic Steps of Configuration and Programming

1. **Use the GMR configuration software to complete the GMR configuration. There is only one <u>GMR configuration</u> needed for the system.** GMR configuration sets up the parameters that will be used by the system, *including reference addresses*. The GMR configuration software produces:
   - A printout of the GMR Configuration.
   - A program block named G_M_R10. This is later added to the application program.
2. **Using the LM90 configuration software, create a Logicmaster configuration for each PLC. The easiest way to do that is to:**

   A. Create a Program Folder for PLC A. With the GMR configuration printout as a reference, complete its Logicmaster configuration.

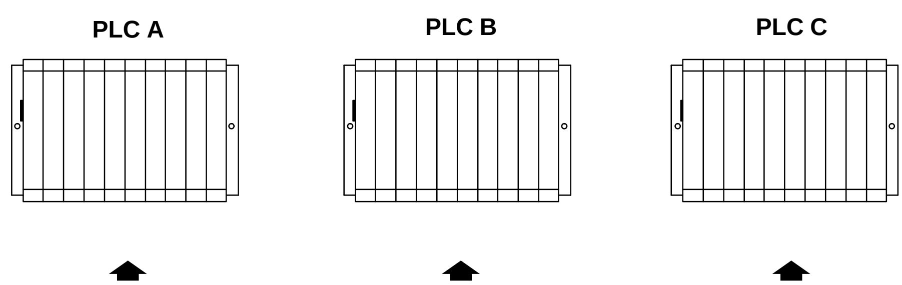
   B. Use the Copy Folder feature of the Logicmaster 90 programming software to copy the configuration of PLC A to additional folders for PLC B and PLC C.

   C. Edit the configurations for PLC B and PLC C as necessary.
3. **Using a Hand-held Monitor, complete the Genius block configuration. Genius block configuration sets up the operating characteristics of each block in the GMR system.**
4. **Using the Logicmaster 90 programming software, create the application program.** While there can be up to three PLCs in a GMR system, each of which has a slightly different configuration, there is normally only one application program.

   A. Using Logicmaster 90, copy the folder named GMRxxyy (for example, GMR0101) from the GMR software diskette to a program folder with your application program name (such as GMRPROG).

   B. Using Logicmaster 90, add program block G_M_R10 (created with the configuration utility) to the application program folder.

   C. Create or add the application program logic in this folder.
5. **After completing the application program and the configuration(s), store them to the PLCs.** As explained above, all redundant PLCs in the GMR system normally use the same application program, but different configurations:



Program: GMRPROG
Configuration: CONFIGA

Program: GMRPROG
Configuration: CONFIGB

Program: GMRPROG
Configuration: CONFIGC

Supplying the configuration and program as separate files, as shown, makes it easier to perform program updates in the future.

The GMR Configuration Software allows the system to be set up for online program changes. Online changes are intended for system debug and commissioning.

Chapter 2 — Input Subsystem

This chapter provides information about the inputs to a GMR system.

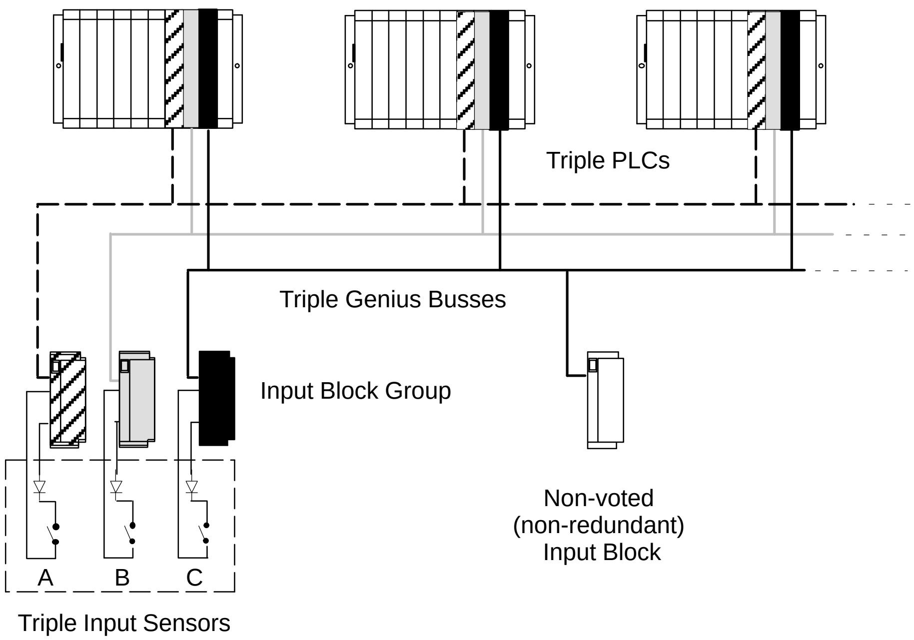
- Overview
- GMR Input Groups
- Non-Voted I/O in the Input Subsystem
- Discrete Inputs
  - Types of Blocks in the Input Subsystem
  - Discrete Input Processing
  - Discrepancy Reporting for GMR Inputs
  - Input Autotest for GMR Inputs
  - Line Monitoring for Discrete Inputs
  - Manual Input Controls
- Analog Inputs
  - Voted Analog Inputs
  - Analog Discrepancy Reporting
  - Non-Voted Analog Inputs in GMR Input Groups
  - Non-GMR Analog Blocks

Overview

The input subsystem is the part of a GMR system that gathers input data. It may consist of:

- GMR Input groups of 1 to 3 discrete or analog blocks
- Individual non-voted discrete and analog blocks

The following illustration represents basic elements of an input subsystem.



GMR blocks are arranged in "groups" of 1, 2, or 3 blocks. Within a group, all the blocks must be the same type. The input group shown above consists of three Genius blocks. Each has its own input sensors monitoring the same parts of the application process. Each block sends the input data from its sensors to three Series 90-70 PLCs. For simplification, the illustration only shows one input circuit on each block. However, each group can serve multiple GMR inputs. In addition, circuits that are not needed for GMR inputs can be used for non-voted inputs *or outputs*.

Genius blocks broadcast their inputs. So each block's input data is received by all PLCs on the bus. The GMR system software in each PLC then performs input voting and provides the results to its application program. If all input data is not available, the software follows a configured voting adaptation scheme. Details of both discrete and analog input voting are in the PLC chapter.

In addition to the diagnostics capabilities of the Series 90-70 PLC and Genius I/O blocks, the GMR system provides autotesting and discrepancy reporting for GMR inputs.

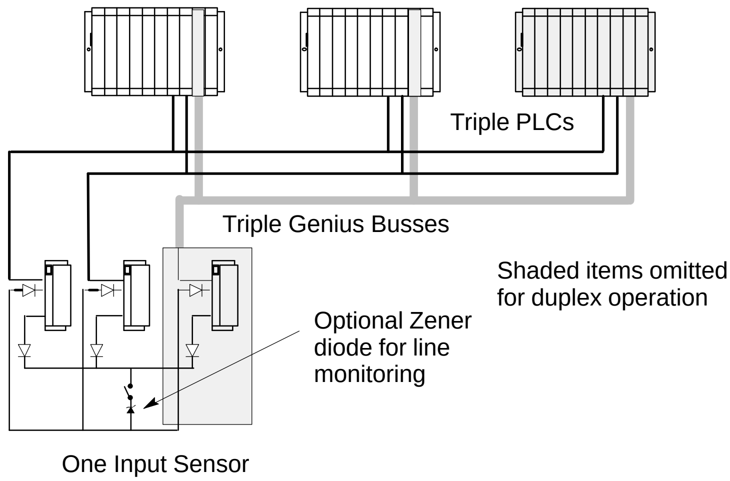
Genius blocks configured for GMR operation automatically generate three copies of their standard Genius fault report messages. They send one copy to the PLC Bus Controller configured with serial bus address 31, one to 30, and one to 29. So all of the GMR PLCs are able to monitor the blocks for Genius diagnostics.

GMR Input Groups

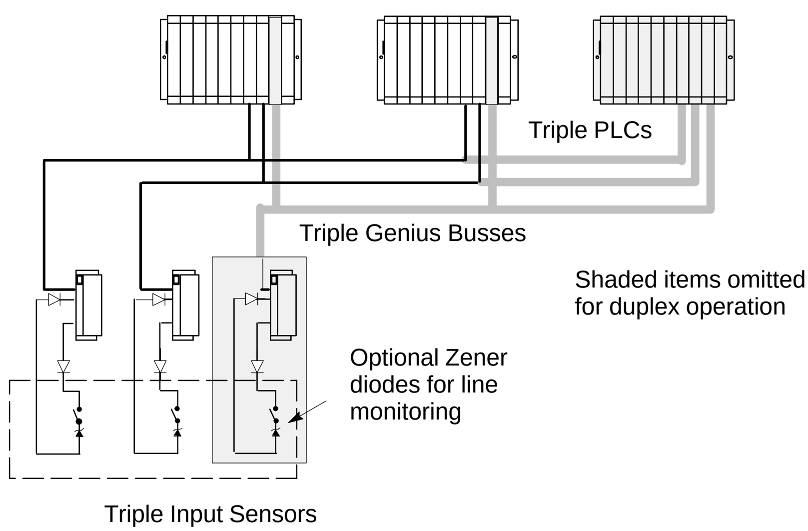
The configuration can include as many as 128 16-circuit voted discrete and 256 four-input analog input groups. (The actual I/O capacity of the system depends on the CPU type. See page 1-9).

In an system that has normally-energized discrete inputs, the following combinations of sensors and Genius inputs can be used with Genius Modular Redundancy.

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



- **three sensors to three Genius inputs, three busses, three PLCs**
- **two sensors to two Genius inputs, two busses, two PLCs**



- **one sensor to one Genius input**

  Single blocks can be configured as non-voted GMR blocks, allowing them to take advantage of the GMR autotest feature. Both discrete and analog blocks can be used; however, analog blocks cannot be autotested.

Non-Voted I/O in the Input Subsystem

The input subsystem can also include three types of non-voted inputs:

- **Inputs from single-block (simplex) GMR input groups**

  Individual blocks can be included in the GMR configuration as “simplex groups”, and can utilize the GMR features such as autotesting. Inputs from simplex blocks are placed into the area of the Input Table used for GMR inputs.

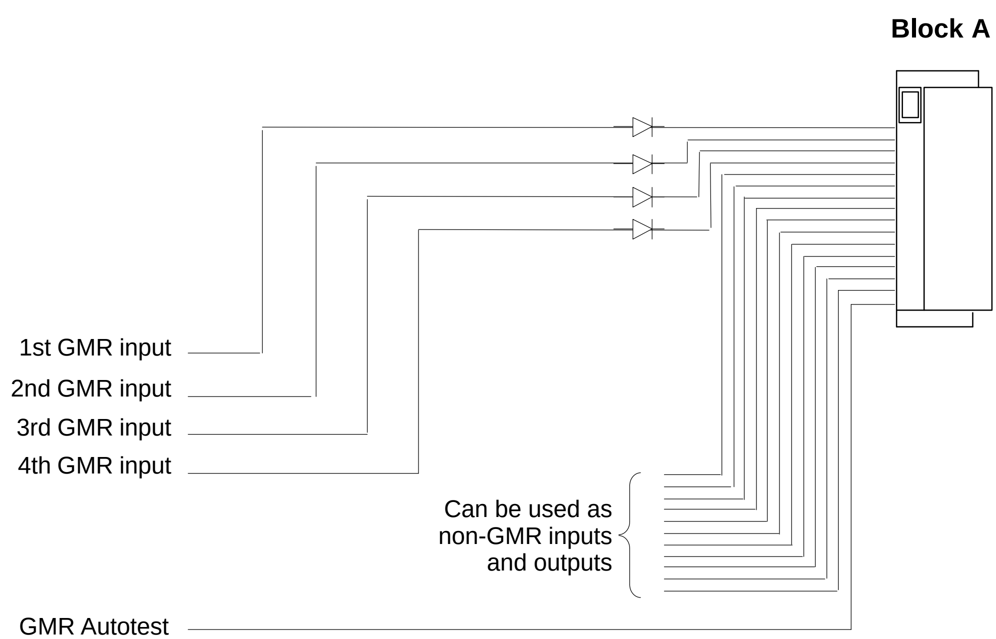
- **Inputs from non-GMR I/O blocks**

  “Non-voted” blocks are individual blocks that are present on a GMR bus and are included in the GMR configuration. However, their inputs are not voted on by the PLC(s), and are located in a different area of the Input Table.

- **Non-voted points on individual blocks in a multiple-block GMR input group**

  Non-voted I/O points may be placed within a voted input group, to take advantage of unused circuits. These extra circuits can be used as either inputs or outputs. If the group utilizes GMR autotesting of inputs, circuit 16 on each block, which is required for autotest, cannot be used for non-GMRI/O.

  Example: a discrete input group consisting of three 16-circuit blocks has only four voted inputs. That leaves circuits 5 through 15 on each block for use as non-GMR inputs or outputs. Circuit 16 is used for the autotest feature.



Blocks B and C are the same

Individual input points used in this way can be autotested if autotesting is set up as part of their GMR configuration.

Discrete Inputs

Types of Blocks in the Input Subsystem

The following discrete block versions can be configured for GMR version 2.06 operation and used as GMR input blocks:

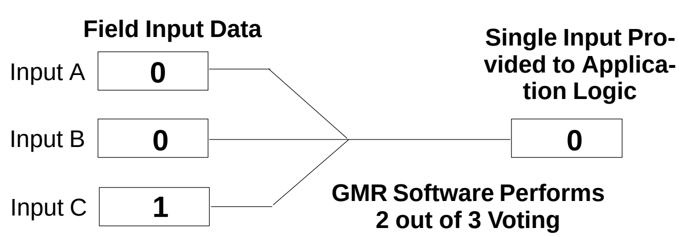
24 / 48VDC 16-Circuit Source block:	IC660BBD020M or later
24 / 48VDC 16-Circuit Sink block:	IC660BBD021M or later
12 / 24VDC 32-Circuit Source block:	IC660BBD024N or later
5 / 12 / 24VDC32-Circuit Sink block:	IC660BBD025N or later

All types of Genius blocks can be used as *non-GMR* blocks in a GMR system.

Note that the GMR Input Autotest feature requires point 16, so if the system uses Input Autotest, point 16 is not available as an I / O point for the application (leaving either 15 or 31 points available on the blocks listed above).

Discrete Input Processing

Discrete input processing is handled in each PLC, by the GMR system software. The manner in which inputs are handled depends upon whether a block is included in the GMR configuration, and if it is, upon whether it is part of a 3-block, 2-block, or 1-block group. Input processing by the PLC is explained in detail in the PLC chapter. In general, 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.



Discrepancy Reporting for GMR Inputs

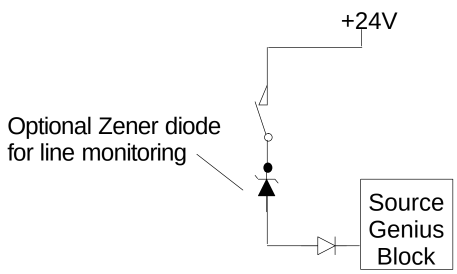
For GMR inputs, if there is a discrepancy between the original input data for an input and the voted input state, the GMR software automatically places a message in the I / O Fault Table, where it is available to the Logicmaster 90 software and the application program logic. This is also described in 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.

Input Autotest for GMR Inputs

During GMR configuration, input autotesting can be individually turned on or off for each input in an input group. The GMR software will automatically test the selected inputs for the ability to reach the alarm state. The ability to diagnose short circuits on inputs depends on whether the circuit is set up as a bistate or tristate input, and on whether the block itself is configured for GMR mode (using the Hand-held Monitor).

- Autotesting checks the ability of the input electronics to recognize both the On and the Off state. During each Input Autotest, some inputs are forced to the Off state by de-energizing the power feed output, and some are forced to the On state via the Genius block electronics. See page 5-6 for more detailed information.
- Input autotesting also detects circuit-to-circuit shorts.
- Note: blocking diodes are required to use the Input Autotest feature. These diodes are in addition to a Zener diode that may be added for line monitoring.



See page 5-6 for more detailed information about input autotesting. Also see pages 8-3 through 8-9 for Autotest wiring information.

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 inserted at the field device to provide an input threshold range for three states. The table on the next page 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 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).

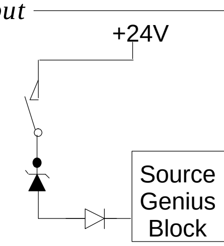
Line Monitoring for Discrete Inputs

Normally-closed inputs on GMR-configured blocks can be monitored for short circuit faults. Normally-open inputs on blocks which are not configured in GMR mode can be monitored for open circuit faults.

Normally-closed 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.

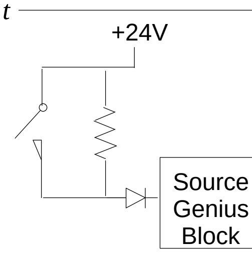
Typical Normally-closed Input



Normally-open Inputs

For applications such as Fire and Gas Detection, normally-open 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.

Typical Normally-open Input



When a block is configured (with a Hand-held Monitor) as a GMR block, its input thresholds change to those listed below.

		Input Voltage	InputStatus	InputState
Source Blocks	**tristate inputs**	<30% V_{dc}	off	0
		>50% V_{dc} < V_{dc}–7V	on	1
		< V_{dc}–4V	short circuit fault	1
	bi-state inputs	<30 V_{dc}	off	0
		>50% V_{dc}	on	1
Sink Blocks	**tristate inputs**	<4V	short circuit fault	1
		>7V <50% V_{dc}	on	1
		>70% V_{dc}	off	0
	bi-state inputs	<50% V_{dc}	on	1
		>70% V_{dc}	off	0

Input Filter Time

For any circuit configured as a tristate input, the Input Filter Time configured *for the block (using a Hand-held Monitor)* must be at least 30mS.

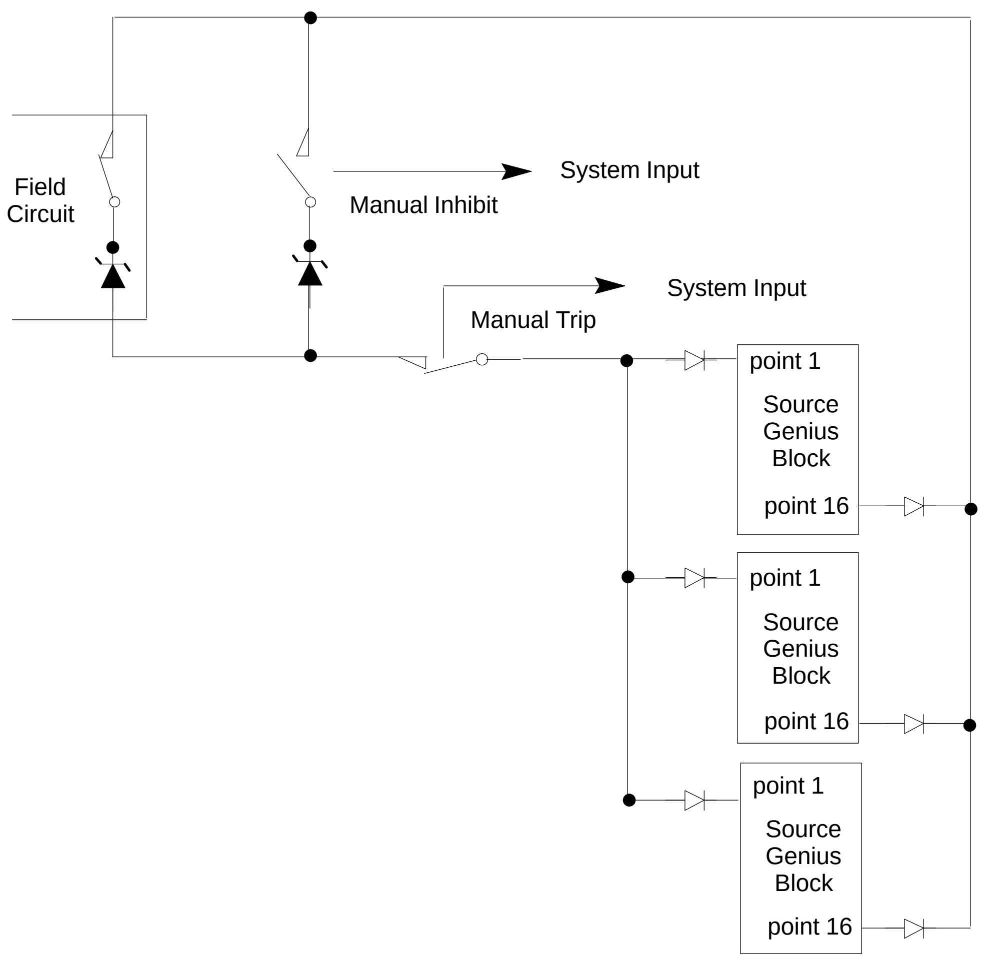
Manual Input Controls

Safety systems often use controls for manual trip and manual inhibit. The GMR autotest and fault processing operations are unaffected by such controls.

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

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

Hardware control 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.



Analog Inputs

Like discrete blocks, analog blocks can be used in the input subsystem as members of GMR input groups of 1 to 3 blocks, or as non-voted blocks. Also like discrete blocks, individual circuits of analog blocks in multiple-block GMR input groups can be used as non-voted analog inputs.

Analog blocks in GMR input groups are *not* autotested by the GMR software.

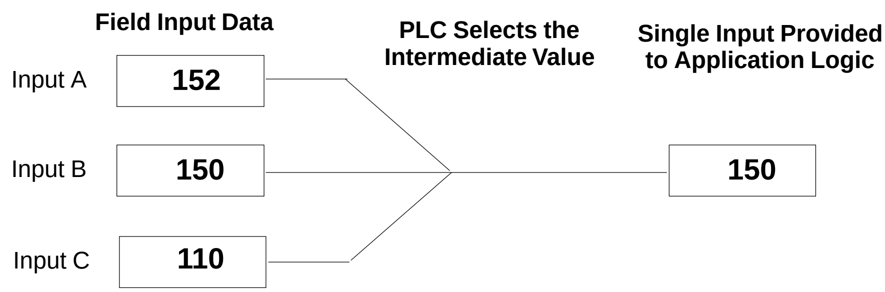
All of the available types of analog blocks can be used, including the Thermocouple and RTD blocks. See the *Genius I/O Discrete and Analog Blocks User's Manual* for information about the various analog Genius blocks.

The application program can reference all analog inputs directly, whether they are located in the non-voted analog inputs area or not.

Voted Analog Inputs

For voted analog inputs, analog blocks must be set up as 2-block or 3-block input groups. The input values are in engineering units.

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 application program can also access the original input values.



For example, in the illustration 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.

Number of Input Sensors per Voted Channel

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.

Current-loop (4-20mA) devices must be converted to voltage when a single sensor is used.

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.

Non-Voted Analog Inputs in GMR Input Groups

If a system includes analog inputs that do not require redundancy, they are usually located on individual analog blocks. However, they can also be located on channels of blocks in a GMR analog input group that do not require redundancy. For example, a group of three 6-channel analog input blocks might use only four voted inputs on each block. That would leave inputs 5 and 6 available for connection to other sensors not requiring voting.

Non-GMR Analog Blocks

Individual analog blocks can be used as input blocks or combination input / output blocks. All of the operating features of these blocks are available.

Individual non-voted analog blocks can be included in the GMR configuration.

Chapter 3 Output Subsystem

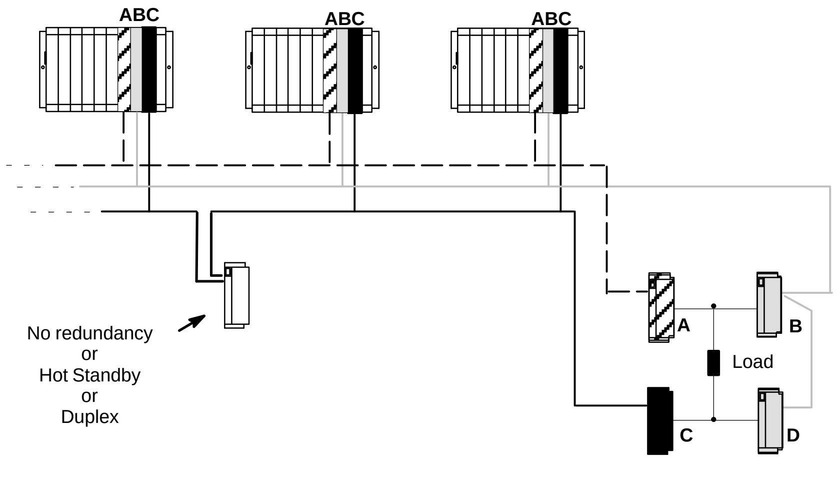
This chapter describes GMR output subsystem.

Overview

The output subsystem is the part of a GMR system that provides output data. It may consist of:

- GMR Output groups of 4 discrete blocks
- Individual non-GMR discrete and analog blocks

The following illustration represents basic elements of an output subsystem.



In a 4-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 the three separate processors. Three Genius busses are used.

Individual Genius blocks can also be connected to the system. These blocks may be configured for either hot standby or duplex CPU redundancy if desired.

Types of Blocks in the Output Subsystem

The following discrete block versions can be configured for GMR operation. They will perform output voting and autotesting when used in GMR mode:

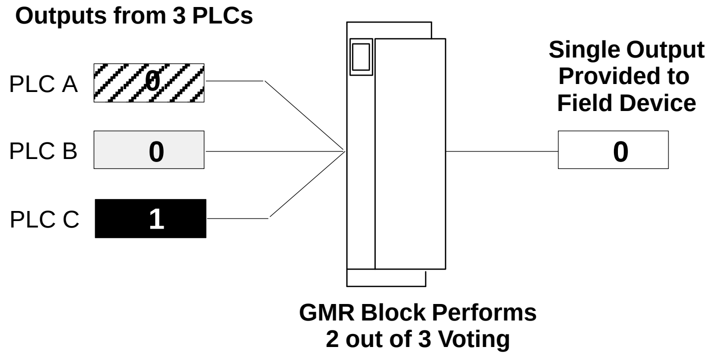
24 / 48 VDC 16-Circuit Source block:	IC660BBD020M
24 / 48 VDC 16-Circuit Sink block:	IC660BBD021M
12 / 24 VDC 32-Circuit Source block.	IC660BBD024N
5 / 12 / 24VDC32-Circuit Sink block:	IC660BBD025N

GMR Output Handling

Unlike GMR input voting, which is done by the GMR software in the PLCs, output voting is performed *at the output block groups*. To perform output voting, the blocks must be one of the listed types, and they must be configured (with a Hand-held Monitor) to be in GMR mode.

Output Voting

A GMR output block group compares 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 bus 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 configured as the next item. When the PLC shuts down and a block group is no longer receiving output data, outputs will go to their default state or last state, as configured at each block group.

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

The voted state of the output is available to the GMR system for monitoring purposes to determine output discrepancies. However, the voted output state is not available to the application program.

Duplex Default for Outputs

As mentioned, 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 group, 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 when only two PLCs are providing outputs. This is explained on the next page.

The following three tables compare voting results for a block group receiving outputs from all three PLCs with results when one of the three PLCs is offline.

Results of Block Group Voting with Three PLCs Online

For comparison, this 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, and 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	0		1	0
0	1		1	1
0	1		1	1
1	0		1	1
1	0		1	1
1	1		1	1
1	1		1	1

Results of Block Group Voting with Two PLCs Online, and 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	0		0	0
0	1		0	0
0	1		0	0
1	0		0	0
1	0		0	0
1	1		0	1
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
0			x	0
0			x	0
0			x	0
1			x	1
1			x	1
1			x	1
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 page 7-17.

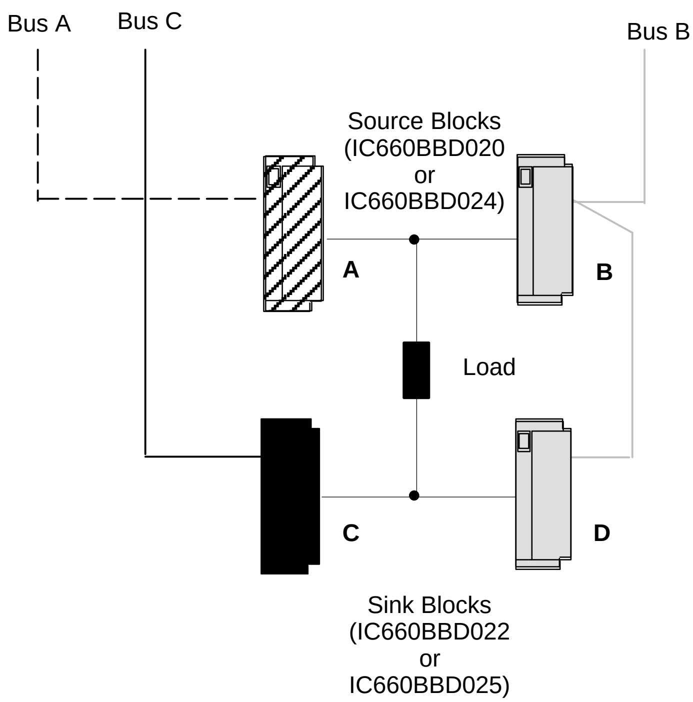
Output Fault Reporting

On detection of any block or circuit fault, a directed fault message is transferred to the three PLCs on an event-driven basis.

The PLC currently operating as the Autotest Master also monitors output blocks for discrepancies between the output values commanded by the PLCs. If a PLC is offline, its data is not considered “discrepant”. But if a PLC is online and its data is discrepant, the GMR software logs a fault into the I/O Fault Table of the PLC that detects the discrepancy which is copied to the other PLCs. The appropriate fault references are also set in each PLC.

4-Block Output Groups

All four blocks in a group must be either 16-circuit or 32-circuit blocks. In a 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.



There are three busses. One source block and one sink block are connected to either bus A or bus B (see blocks B and D on bus B in the illustration above). The other two blocks are connected to the remaining two busses (A and C above).

The illustration shows just one load for a group of four blocks. However, up to 16 loads could be controlled by the same group of four blocks (using 16-circuit blocks).

When the blocks are configured, each is assigned the same output reference addresses using Logicmaster 90. Then, 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 on page 8-12 (for 16-point blocks) and page 8-17 (for 32-point blocks) to verify that it can be autotested and / or used in a 4-block output group.

Output Load Sharing

In a 4-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 a GMR output group are configured for No Load fault reporting, the minimum connected load that can be used is 100mA. If blocks in a 4-block output group are configured for No Load reporting, a system output No Load fault will only be reported if both of the source blocks or both of the sink blocks report No Load faults.

Operation of a 4-Block Output Group

Each GMR output state is sent to four blocks set up in an H-pattern as shown on the opposite page. This type of grouping creates a fault-tolerant system where any single point of failure does not cause the system to lose control of a critical load. This is achieved by:

- output voting (which is explained on page 3-3), and
- the electrical characteristics of sink and source blocks, and
- redundant busses.

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. Doubling the number of blocks to four and putting them in an H pattern means that if any single point of failure occurs, the system can still control the load.

The following chart shows how the GMR system uses the 4-block H-pattern output group to maintain control of critical loads following certain types of failures. All operating blocks receive the same I/O data, because within a fault-tolerant 4-block H-pattern 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 B 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

Bus Redundancy in a 4-Block Output Group

If one of the three busses in an output group is damaged or cut, there is still I/O data 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 the following 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.

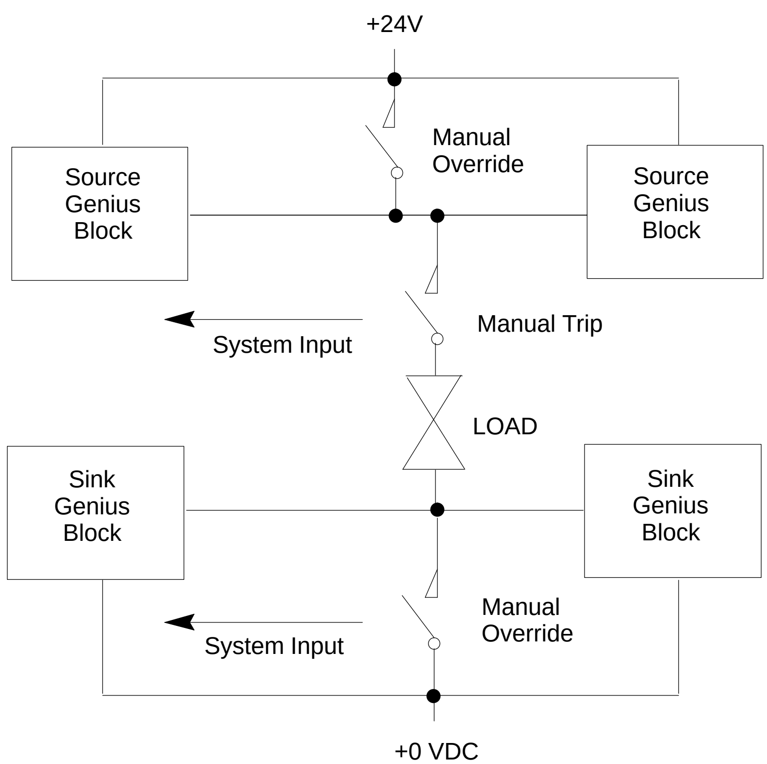
Manual Output Controls and Diagnostics

Safety systems are often provided with controls for manual trip and manual override.

- A manual trip causes the output to assume the alarm condition. For example, a normally-energized output would be de-energized.
- A manual override causes the output to remain in the normal condition. For example, a normally-energized output is held energized.

These manual controls can be implemented either in hardware, as represented below, or in software. If the software method is used, GMR autotest and fault processing operations are unaffected.

Hardware control usually consists of switch contacts applied to the output circuit, as shown below (for a normally-energized output).



In this circuit, operation of either the trip or override switch can cause no-load faults, state faults, and autotest faults to be generated. In the GMR system, fault reporting can be modified to suppress no-load faults and state faults by wiring additional inputs that reflect the states of the manual override and manual trip input switch to the GMR system. The GMR system then takes these into account before reporting faults. Use of manual controls does not affect fault reporting for Short Circuit, Overtemperature, Overload, or Discrepancy faults. (see chapter 5, "Monitoring Manual Output Controls").

Redundancy Modes for Output Blocks

There are three separate configuration processes for a GMR system:

- GMR configuration, which supplies parameters used by the GMR system software.
- PLC configuration, which is performed as usual for a Series 90-70 PLC system using the Logicmaster 90 software.
- Genius block configuration, which sets up the operating characteristics of the blocks themselves.

It is during Genius block configuration that the redundancy mode of blocks is selected. This is particularly relevant to the operation of output blocks. The four possible choices for redundancy mode are:

A. GMR

B. Hot Standby PLC Redundancy

C. Duplex PLC Redundancy

D. No PLC Redundancy

Blocks in an output group must be set up for GMR mode. This changes the operating characteristics of the block as described.

Individual output blocks (or combination I/O blocks) can be set to any of the latter three modes (above). Block operation in these modes is described in the *Genius I/O System User's Manual* and in the *Genius Discrete and Analog Blocks User's Manual.*

If an individual block is configured for Hot Standby redundancy mode, it can be included in the GMR configuration as a Non-voted Discrete Group.

Blocks that are set up for Duplex PLC redundancy or no redundancy are not autotested. They operate in the same manner as Duplex blocks in a non-GMR system.

GMR Mode

Configuring a block for GMR mode changes its operating characteristics as described below.

- GMR mode supports non-redundant outputs with or without pulse test, and redundant outputs with or without output autotest.
- 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 No-load faults being falsely reported during switching transitions.
- Operation of Block OK LED is modified. For the 16-circuit DC block, the Unit OK LED does *not* indicate No-load faults when the block is in GMR mode. This is necessary, since blocks may share output loads.
- Modified fault reporting. In GMR mode, blocks automatically report faults to bus controllers at serial bus addresses 29, 30, and 31.

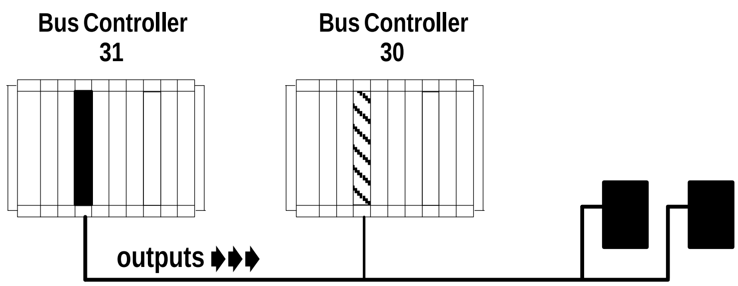
Hot Standby Mode

Individual blocks can be included in the output subsystem as GMR blocks, Hot Standby blocks, or non-GMR blocks. There are significant differences in block operation between these three operating modes.

Operation of GMR output blocks and non-GMR blocks is explained elsewhere in this chapter. Hot Standby mode is a type of Genius redundancy that can be used with or without GMR.

Basic Hot Standby Mode Operation

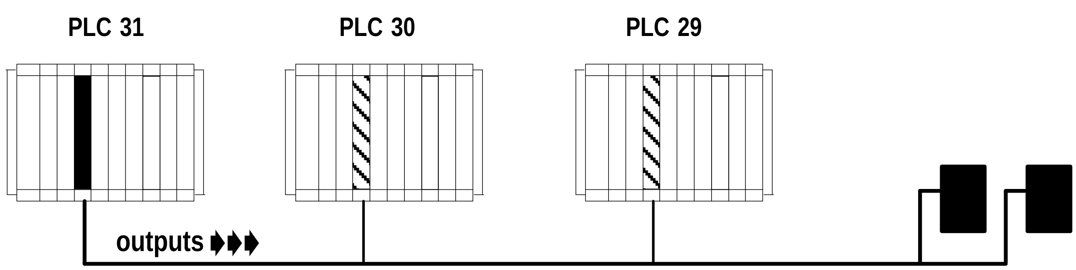
In basic Hot Standby mode (without GMR), blocks receive outputs from two PLCs, but they are normally controlled directly by the PLC at serial bus address 31. If no output data is available from bus address 31 for a period of three bus scans, the outputs are immediately controlled by the PLC at bus address 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.



Selection of Hot Standby mode is made during block configuration.

Hot Standby Mode in a GMR System

If a block is set up for Hot Standby mode in the GMR configuration, its Hot Standby operation is automatically expanded to include three PLCs: 31, 30, and 29.



The manner of operation is the same. 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 on–line, it always has control of the outputs.

As mentioned, this assignment of an additional Hot Standby PLC happens automatically for a Hot Standby block that is included in the GMR configuration.

Chapter 4

PLC Subsystem

This chapter describes operation of the PLC subsystem in a GMR system.

- System Startup
- CPU Sweep in a GMR System
- PLC Operation
- Input Processing
  - Discrepancies
  - Discrete Inputs
  - Analog Inputs
- Output Processing
  - Discrete Outputs
- I/O Shutdown
- Communications Between PLCs
  - Global Data Redundancy
  - Entering, Clearing, or Setting Global Data

System Startup

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

1. Each PLC disables its 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 a PLC, all bus controllers that have been 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 differing serial bus addresses, or with addresses outside the range 29–31, it logs an “Invalid Bus Address” fault into its PLC Fault Table and stops the PLC.
3. Each PLC checks the online status of the other PLCs. “Online” means the other PLC is running its application program, and its outputs are enabled.
4. Each PLC compares its initial program checksum with those of the other PLCs. If they do not match, the PLC may (as configured) either stop or keep running. The next table compares the effects of checksum mismatches with the PLC configured to allow or reject online program changes:
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 a synchronizing PLC detects that an online PLC has gone offline during synchronization, it attempts to restart data synchronization with the other PLC. If the other PLC is not online, the synchronizing PLC will flag that synchronization 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. (PLC B or PLC C) initializes data values. This is described in more detail on page 4-4.
8. The Inhibit bit is released, allowing the PLCs to start executing the application program.
9. When the Continue control flag is set by the user’s application program, the PLC begins sending outputs computed by 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 covered on more detail on page 7-17.

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

Online Changes

The GMR configuration can be set up to either permit or reject online program changes. These changes result in checksum mismatches. Such mismatches are handled as described below by the PLCs in the system.

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 change to the GMR Configuration information takes effect only when the PLC is transitioned 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 will resume.

Data Initialization

During startup, a PLC either sets a flag to notify the application program to initialize %R and %M memory, or synchronizes the data with corresponding data in the other PLC(s). The %M data is typically latch logic states, while the %R data is typically timer / counter data. The beginning addresses and lengths of both areas are set up during configuration.

- If both the other PLCs are offline (application programs not running and not sending output data), the initializing PLC sets a (cold start) flag to the application program, which can initialize the selected memory areas (%R and %M) as appropriate.
- If either or both of the other PLCs is already online (running the application program and transmitting output data), the initializing PLC synchronizes the %M and %R data with that of the other PLC(s).

1. The initializing PLC first reads %R then %M data from the online PLC with the higher bus controller serial bus address (31 takes precedence over 30, 30 over 29). Data is read in ascending order.

   The 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 %R area (because it is read last).

2. After reading all of the selected %R and %M data from the first online PLC, the initializing PLC then reads %M data from the other online PLC. It places this data into a configurable area of %R memory.

3. After reading the %M data from both online PLCs, the initializing PLC compares the data. If the data does not match, it tries again. After a total of three retries, if the data still does not match, the 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
%M12234	System fault at startup

   The action taken is determined by the GMR configuration (see page 6-22).

4. 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.

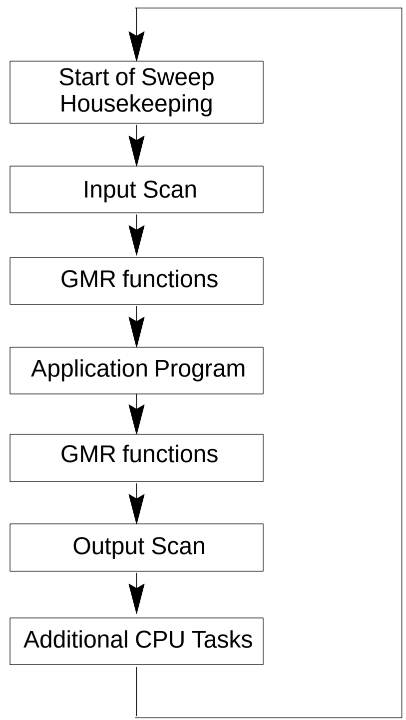
5. If the initializing PLC is unable to successfully read all the data from the other PLC(s), it sets a flag “Synchronization hardware failure” for the application program. The entire synchronization sequence then begins again, excluding the Genius bus with which communications failed.

During GMR configuration, the PLC can be configured to either stop or continue in the event of synchronization failure.

After successful synchronization, the PLC clears a flag “Inhibit User Application”. This must be used in the application program to prevent execution of the program until it has been cleared.

CPU Sweep in a GMR System

The special functions required for Genius Modular Redundancy include autotest, input voting, and alarming. These GMR functions are provided by a set of Program Blocks that are placed into the Program Folder using the LM90 librarian feature. After this is done, the GMR logic is executed automatically by the CPU as shown below.



PLC Operation

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

The GMR software performs any input voting required for both discrete and analog inputs and provides voted input data to the PLC. It notes any data discrepancies and provides fault bits and fault messages that can be accessed by application program.

As always, the application program determines the required state of the outputs as a function of the inputs received. The application program sets a single output bit for each device to be controlled. The appropriate number of redundant Genius blocks are configured to identical output references.

The CPUs monitor the voted output state computed by each Genius output block group and provide diagnostic information on the detection of 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

The GMR system software runs on Series 90-70 CPU788 or CPU789 PLCs. It produces a "base" CPU sweep time that becomes a part of the overall sweep time of the CPU with a ladder logic application program in it. This base sweep time should be taken into consideration during the 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 788 and 789 CPUs are shown below. In this example, there are six Bus Controllers in each PLC,

	with table sizes of Voted %I = 64 Voted %AI = 64 Logical %Q = 64	**with table sizes of** Voted %I = 256 Voted %AI = 256 Logical %Q = 256
Base Sweeptime=	79 Milliseconds	Base Sweeptime = 88 Milliseconds

The base sweep time for your system could be less or more depending on the table sizes you configure. Also, base sweep time varies by $ 10mS during single sweeps when the GMR system software performs diagnostics on the CPU subsystem and I/O subsystems.

Sweep Time Contribution of Genius I/O and GBCs

The contribution of Genius I/O and Genius Bus Controllers to the sweep time of the PLC CPU 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 sweep time impact; and a transfer time (per word) sweep time impact for all I/O data.

The potential Bus Controller sweep time impact on the CPU has three parts:

1. Time to open the system communications window, added only once when the first intelligent option module (such as a Bus Controller) is placed in the system.
2. Time needed 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 technique should <u>NOT</u> be used in a GMR system.

Input Processing

During the Input Scan portion of the CPU sweep, the PLC receives inputs from the discrete and analog input blocks. It stores the input data in different areas of memory as described below.

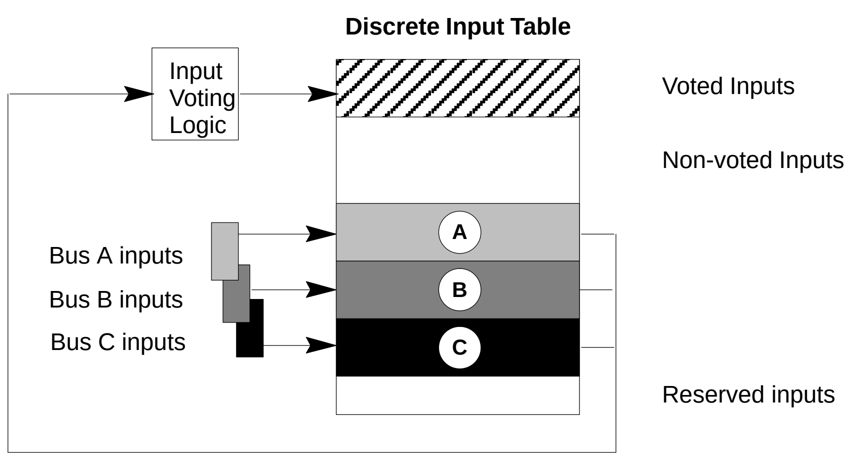
After the Input Scan, the GMR logic performs voting on the inputs configured for GMR redundancy, and places the results into the discrete and analog input tables where they are available to the application program.

Discrepancies

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. Also, fault bits that report the discrepancy fault for each voted input are available to the application program, so it can take appropriate action if a discrepancy fault occurs. Discrepancy faults are latched. Discrepancy reporting is discussed in the chapter on Diagnostics.

Discrete Inputs

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 labelled 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.



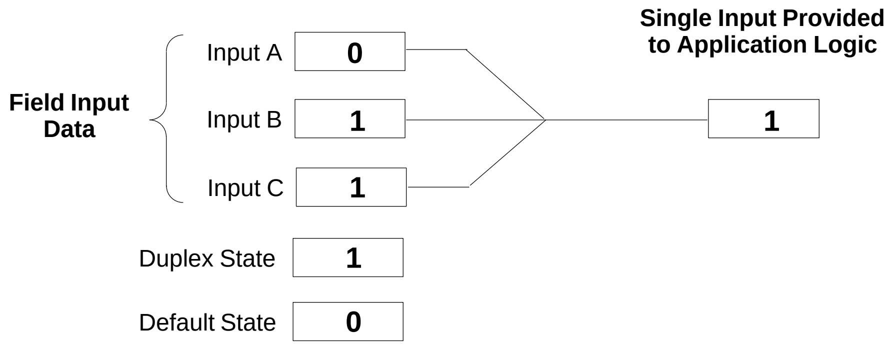
The GMR software creates and maintains the separate areas of the discrete Input Table. In addition to the four areas used for the inputs received from Genius blocks, there are two additional areas. The first, at the beginning of the Input Table, is for voted inputs. The other, at the end of the table,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

The chapter on Programming explains in detail how the Discrete Input table memory is allocated.

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.

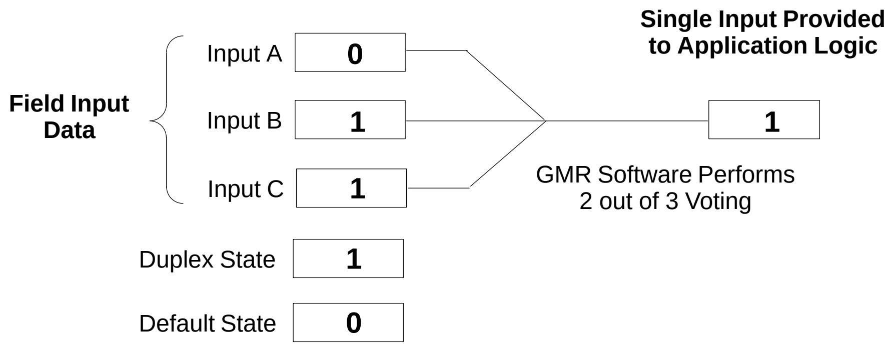
Duplex State The Duplex State is a "tiebreaker" value used when there are two field inputs operating. Its operation is described on page 4-10.

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 Duplex or Triplex group configured for 3–2–1–0 Voting Adaptation.
- Either of the two inputs to a Duplex group configured for 3–2–0 Voting Adaptation.
- Either of the two remaining inputs to a Triplex group configured for 3–2–0 Voting Adaptation.

Voting with Three Discrete Inputs

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

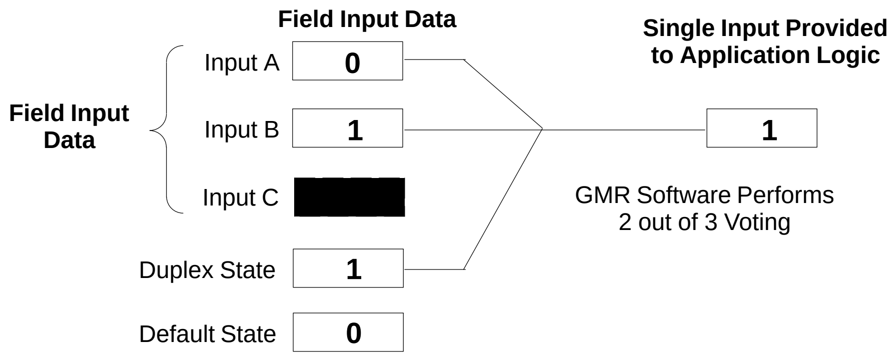


The Duplex State and Default State are not used when three field inputs are available.

Voting with Two Discrete Inputs

Two inputs may be present in either a Duplex input group, or in a Triplex input group where one of the three inputs has failed.

For its 2 out of 3 voting, the GMR software uses the group's configured Duplex State 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.

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

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

Voting for One Discrete Input

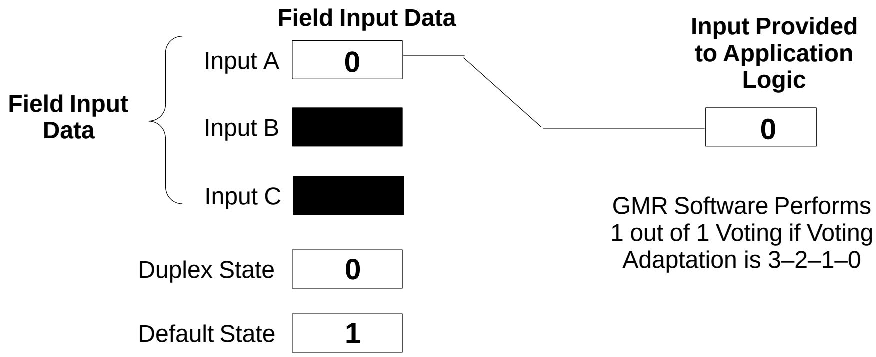
One input may be present in a non-voted input group, in a Simplex input group, in a Duplex input group where one input has failed, or in a Triplex input group where two inputs have failed.

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

In a voted input group, if only one input is available the result of the voting depends on the Voting Adaptation mode that has been configured for the input group.

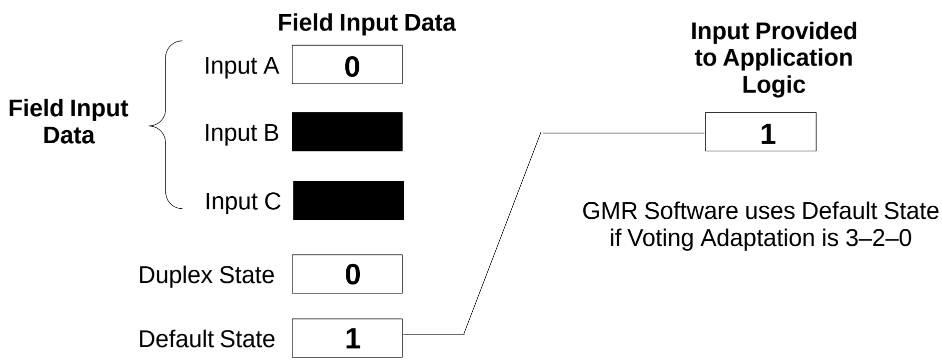
Discrete Input Voting with One Input Present and Voting Adaptation Set to 3–2–1–0

For a Simplex Input group (one input) the voted input is the same as the actual input. This is also true if there is just one actual input present on a Duplex or Triplex group configured for 3–2–1–0 Voting Adaptation.



Discrete Input Voting with One Input Present and Voting Adaptation Set to 3–2–0

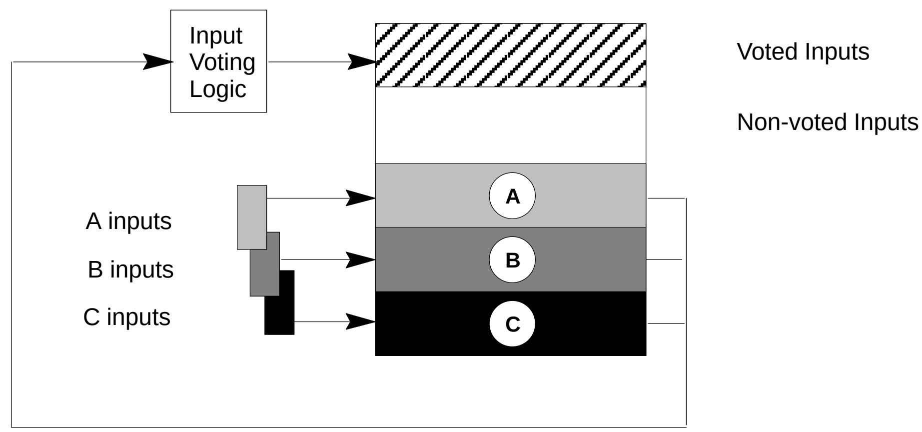
Configuring a Duplex or Triplex input group for 3–2–0 Voting Adaptation prevents the data from just one input being used as the only input data for that group. If a Duplex or Triplex group configured for 3–2–0 Voting Adaptation has just one input present, the configured input Default State is used instead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



Analog Inputs

The method of analog input processing is similar to the method used for discrete inputs. 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 labelled 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.

Analog Input Table



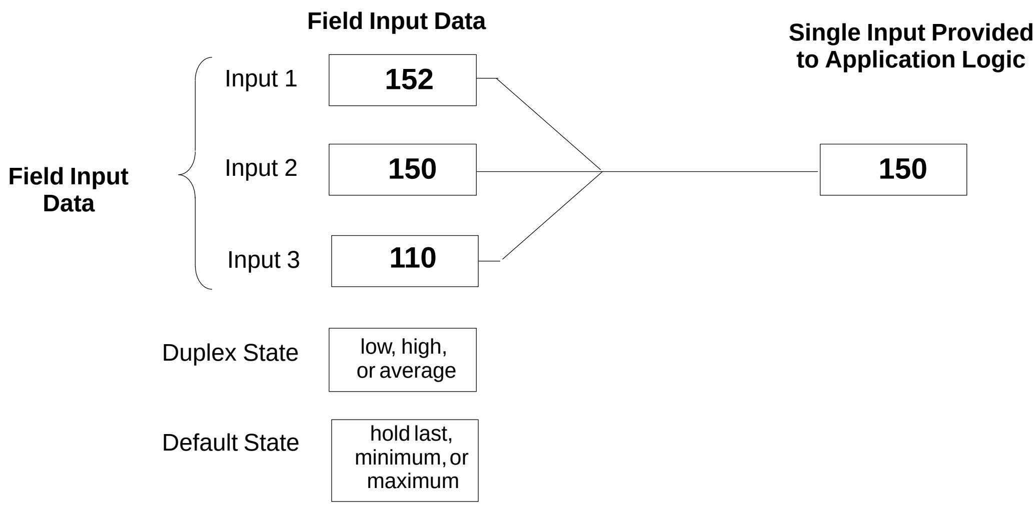
The GMR software creates and maintains the separate areas of the analog Input Table. In addition to the four areas used for the inputs received from Genius blocks, there is an additional area at the beginning of the analog Input Table for voted inputs.

The chapter on Programming explains in detail how Analog Input table memory is allocated.

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 a "tiebreaker" value that 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.

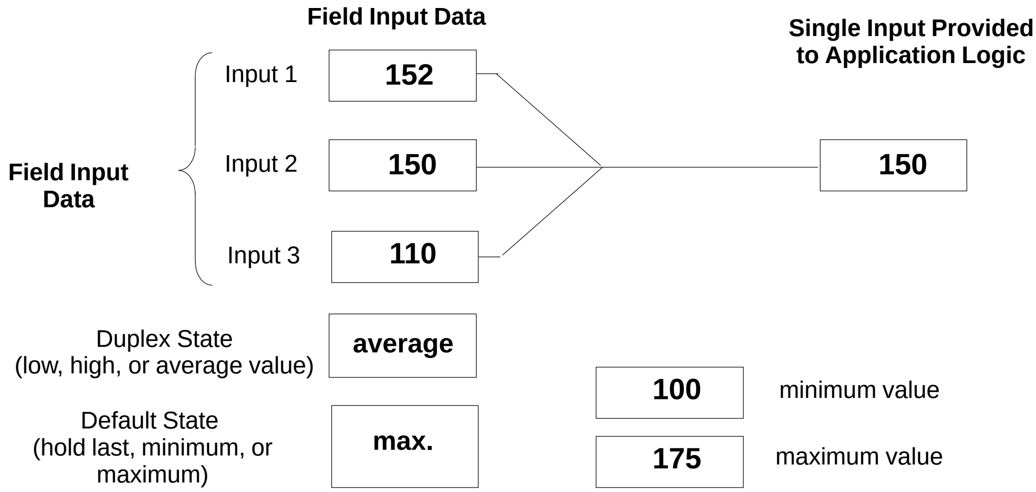
Default State The Default State is the value that will be provided directly to the PLC instead of a voted input value if the following inputs fail:

- The single input in a Simplex group.
- The remaining input in a Duplex or Triplex group configured for 3–2–1–0 Voting Adaptation.
- Either of the two inputs to a Duplex group configured for 3–2–0 Voting Adaptation.
- Either of the two remaining inputs to a Triplex 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 Three Analog Inputs

For a triplex 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.



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

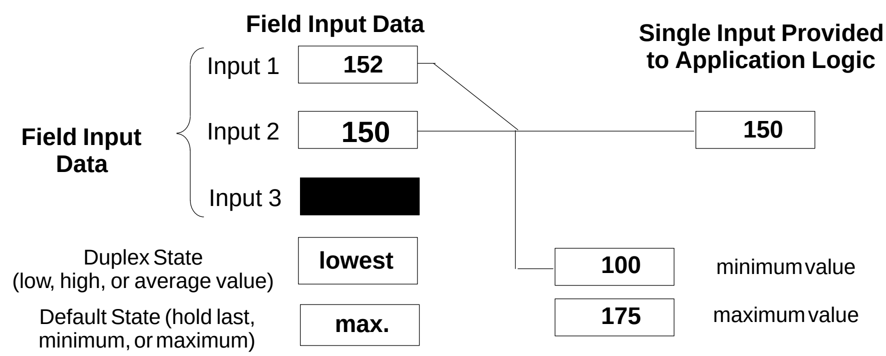
In the illustration above, inputs A, B, and C might represent the first input channel on each block in a three-block group. The PLC would place the selected input value into the first voted input word for that group.

Voting for Two Analog Inputs

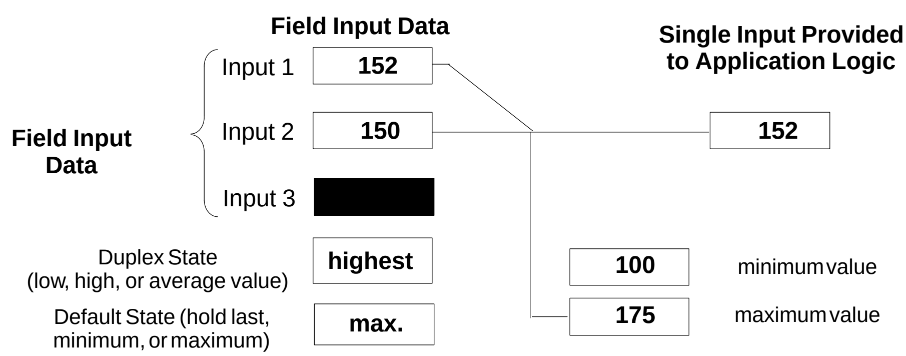
Two inputs may be present in either a Duplex input group, or in a Triplex input group where one of the three inputs has failed.

Three vote options in duplex mode are determined by the duplex state: highest, lowest, or average.

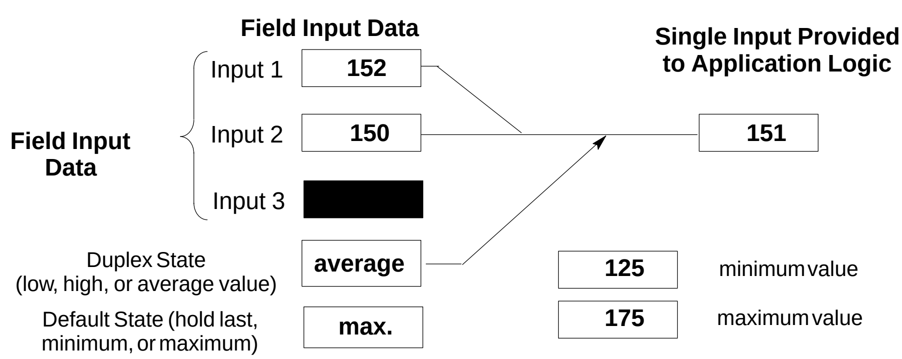
- If lowest has been configured, the GMR software selects the intermediate value with the unused (third) channel being assigned its minimum configured value.



- If highest has been configured, the GMR software selects the intermediate value, with the unused (third) channel being assigned its maximum configured value.



- If average has been configured, the GMR software averages the two remaining input values and supplies the result to the PLC Input Table.



Voting for One Analog Input

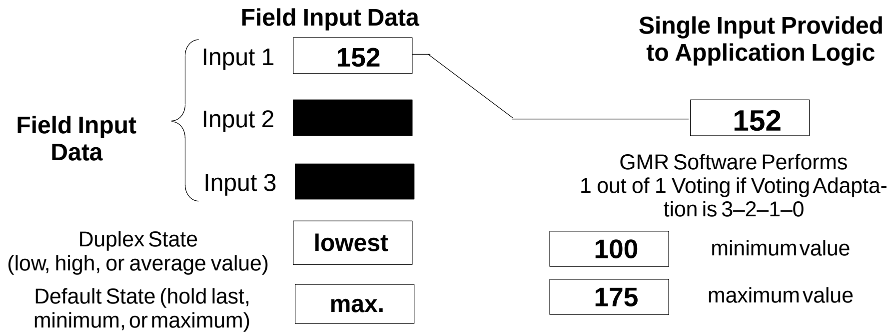
One input may be present in a non-voted input group, in a Simplex input group, in a Duplex input group where one input has failed, or in a Triplex input group where two inputs have failed.

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

In a voted input group, if only one input is available the result of the voting depends on the Voting Adaptation mode that has been configured for the input group.

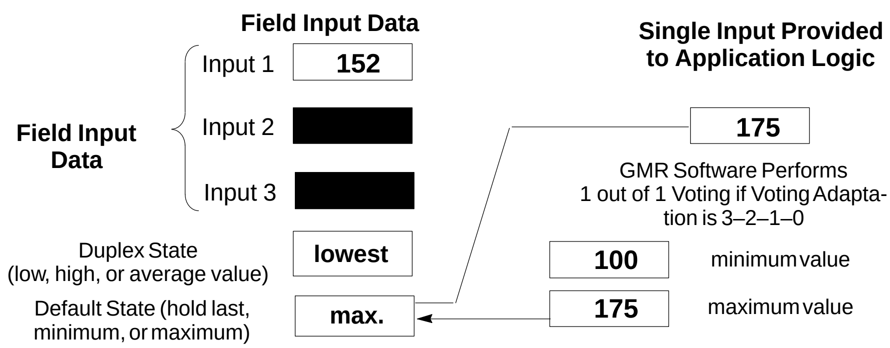
Discrete Input Voting with One Input Present and Voting Adaptation Set to 3–2–1–0

For a Simplex Input group (one input) the voted input is the same as the actual input. This is also true if there is just one actual input present on a Duplex or Triplex group configured for 3–2–1–0 Voting Adaptation.



Discrete Input Voting with One Input Present and Voting Adaptation Set to 3–2–0

Configuring a Duplex or Triplex input group for 3–2–0 Voting Adaptation prevents the data from just one input being used as the only input data for that group. If a Duplex or Triplex 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.



Output Processing

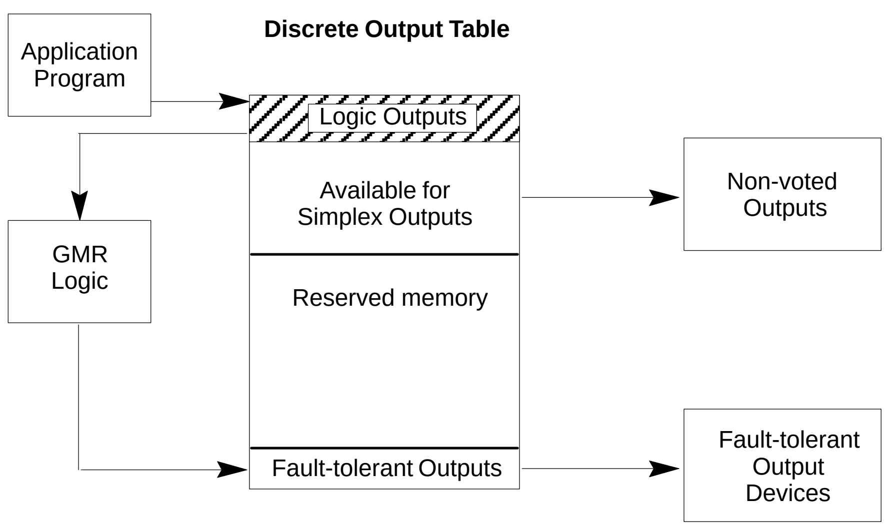
For outputs, the PLC does not perform “redundancy” voting. Instead, voting is done by the specified types of discrete output block groups. Analog blocks do not provide redundancy voting or autotest features. Both discrete and analog Genius blocks can be used in the output subsystem as non-GMR blocks,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

Discrete Outputs

As it does for inputs, the GMR software uses separate areas of the Output Table for non-voted outputs, fault-tolerant outputs and copies of the fault-tolerant 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 labelled “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 Fault-tolerant 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 fault-tolerant outputs to the Genius blocks.



I/O Shutdown

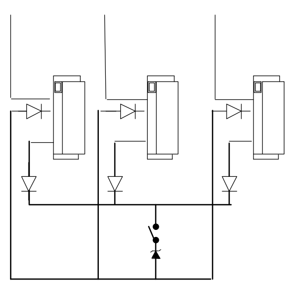
When the GMR system diagnoses a discrete I/O fault, it logs the appropriate faults in its fault tables and set the appropriate fault contacts. For certain types of discrete I/O faults, the system optionally allows a predefined amount of time for the problem that caused the fault to be repaired. If the problem is not rectified within this period of time, an I/O Shutdown of the I/O corresponding to the affected block(s) occurs. **I/O shut down can be completely disabled and prevented by turning on the Cancel I/O Shutdown control bit (%M12265).**

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

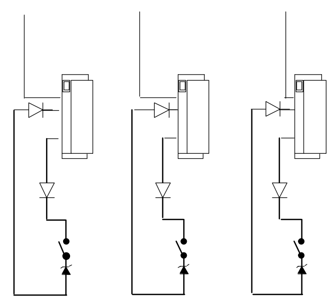
Synchronous or Asynchronous Input Autotest and I/O Shutdown

In the GMR configuration discrete input groups can be configured for either Synchronous or Asynchronous input autotesting.

If redundant discrete input devices are used, which allows the individual blocks in a group to stay isolated from each other (I.E. the power feed outputs (point 16) of each block ARE NOT wired together), asynchronous input autotesting can be selected. Asynchronous input autotesting can also be selected if non-redundant simplex discrete input devices are used with isolation between blocks. Using this option allows the input autotest to continue executing on other blocks in a group which are not affected by the fault. Because input autotesting continues in this case, an I/O shutdown is not necessary and WILL NOT occur. (See Chapter 8 – installation information)



Blocks Wired Together



Blocks Not Wired Together

If non–redundant simplex discrete input devices are used without isolation between blocks (I.E. the power feed outputs (point 16) of each block ARE wired together), then synchronous input autotesting must be selected in the GMR configuration for the input group. (See Chapter 8 – installation information)

For this configuration there are two types of faults which may prevent the autotest from continuing to execute for that input block group and thus cause a I/O shut down for the inputs in the group:

1.) Loss of a block within the group. (I.E. any failure which causes the block to no longer communicate on the Genius Bus such as loss of power.)

2.) Autotest failure of the power feed output (point Q16) of any of the blocks in a group.

Output Faults that Cause I/O Shutdown

For discrete output groups there are also two types of faults which may prevent the output autotest from continuing to execute for that output group and thus cause an I/O shut down for the outputs in the group.

1.) Loss of a block within the group. (I.E. any failure which causes the block to no longer communicate on the Genius bus such as loss of power.)

2.) Output autotest failure detected of a type which could potentially prevent a normally energized output from being tripped off. An example is the short of a source block output to +24 Vdc.

Programming for I/O Shutdown

To be made aware of a pending I/O Shutdown, the program can monitor this GMR Status Bit:

%M12244 – (IO_SD) Any I/O Shutdown Timer Activated

To completely prevent an I/O Shutdown from occurring, the program can set this GMR Control Bit:

%M12265 – (SD_CAN) Cancel I/O Shutdown

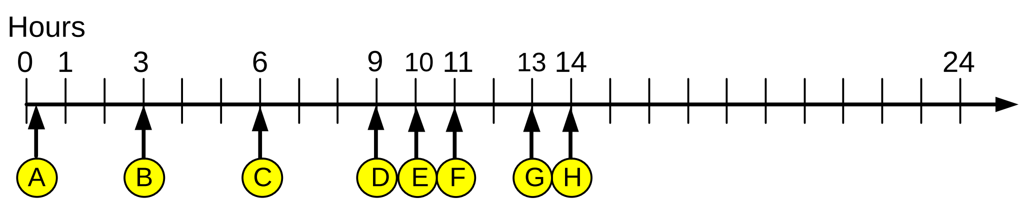
Interval Until Shutdown in Each PLC

The period of time before an I/O Shutdown occurs depends on the autotest interval which is set for the system. The initial autotest interval is set by the autotest interval value selected in the GMR configuration.

The configured autotest interval can be adjusted in each CPU through the application program by varying the value in the autotest interval register. The system allows for a total maximum time of 24 hours between a fault occurring and the resultant I/O shut down when the autotest interval is set to 8 hours.

Examples

The first example shows the I/O Shutdown sequence when the autotest interval is 3 hours.



A.) A fault occurs just after the autotest interval at PLCA begins.

B.) PLCA executes the autotest and detects the fault, then starts the 8 hour shutdown timer. The message “Shut down in 8 hours” is logged in the fault table. The “I/O Shut Down in Progress” status bit (%M12244) is set in each PLC. The autotest master function passes to PLCB.

C.) PLCB executes the autotest and detects the fault, then starts its 8 hour shutdown timer. The message “Shut down in 8 hours” is logged in the fault table. The autotest master function passes to PLCC.

D). PLCC executes the autotest and detects the fault, then starts its 8-hour shutdown timer. The message “Shut down in 8 hours” is logged in the fault table. The autotest master function passes to PLCA.

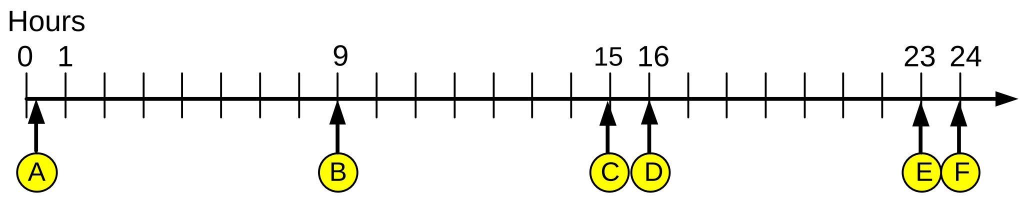
E.) The message “Shut down in 1 hour” is logged at PLCA.

F.) The shutdown timer expires in PLCA. The message “I/O Shut Down” is logged in fault table of PLCA. PLCA shuts down the I/O of the affected I/O group. Real I/O is not yet affected because of the 2 out of 3 voting mechanism, although output discrepancy errors may be generated.

G.) The message “Shut down in 1 hour” is logged at PLCB.

H.) The shutdown timer expires in PLCB. The message “I/O Shut Down” is logged in fault table of PLCB. PLCB shuts down the I/O of the affected I/O group. Real I/O **IS NOW** affected because of the 2 out of 3 voting mechanism.

This example shows the I/O Shutdown sequence when the autotest interval is 8 hours.



A.) A fault occurs just after the autotest interval at PLCA begins.

B.) PLCA executes the autotest and detects the fault, then starts the 8 hour shutdown timer. The message “Shut down in 8 hours” is logged in the fault table. The “I/O Shut Down in Progress” status bit (%M12244) is set in each PLC. The autotest master function passes to PLCB.

C.) The message “Shut down in 1 hour” is logged at PLCA.

D.) The shutdown timer expires in PLCA. PLCA shuts down the I/O of the affected I/O group. The message “I/O Shut Down” is logged in fault table of PLCA. Real I/O is not yet affected because of the 2 out of 3 voting mechanism, although output discrepancy errors may be generated. PLCB executes the autotest and detects the fault, then starts its 8 hour shutdown timer. The message “Shut down in 8 hours” is logged in the fault table. The autotest master function passes to PLCC.

E.) The message “Shut down in 1 hour” is logged at PLCB.

F.) The shut down timer expires in PLCB. “I/O Shut Down” message is logged in fault table of PLCB. PLCB shuts down the I/O of the affected I/O group. Real I/O **IS NOW** affected because of the 2 out of 3 voting mechanism.

I/O Shut Down Prevention

If an I/O fault causes an I/O shutdown to initiate, there is up to 16 hours of time to repair the fault and put the block(s) back into operation before the shutdown occurs. When the next autotest occurs on the PLC(s) that started its shutdown timer, that PLC automatically cancels its I/O shutdown (If the autotest is executed without faults on the affected block(s) before the actual shut down occurs). This autotest can be one that occurs automatically as specified by the configured autotest interval, or one that is initiated manually via the GMR control bit Autotest Manual Initiate (%M12260 – ATMANIN). To clear any standing faults at the block(s) and in the I/O fault table of the PLCs, an I/O fault reset should be executed by turning on GMR Control bit %M12258 (IORES). Also note that at any time the Cancel I/O Shutdown (%M12265 – SD_CAN) bit can be used to prevent the shutdown from occurring.

I/O Shut Down Recovery

If an I/O shutdown is allowed to complete, the affected I/O is set to its safe state. Recovery from an I/O shutdown is accomplished with the following steps:

1) Repair the fault that caused the I/O shutdown to initiate. This may require simply replacing a blown fuse which had supplied power to a block, or replacing a damaged or failed block or repairing field wiring.

2) Initiate an I/O autotest in each of the three PLCs so that the PLC(s) can determine that the block(s) is repaired and again functioning properly. The autotest has to be executed at the PLCs which had actually started and expired their shutdown timers. The autotests can be those that occur automatically as specified by the configured autotest interval, or initiated manually via the GMR control bit Autotest Manual Initiate (%M12260 – ATMANIN).

3) In the case of a block being powered off or replaced, a shut down of outputs the output block(s) may require a force logon to get them to accept output data from the CPUs. This can be done by using the GMR control bit %M12263 (FORCLOG).

4) To clear any standing faults at the block(s) and in the I/O fault table of the PLCs, an I/O Fault Reset should be executed by turning on GMR Control bit %M12258 (IORES).

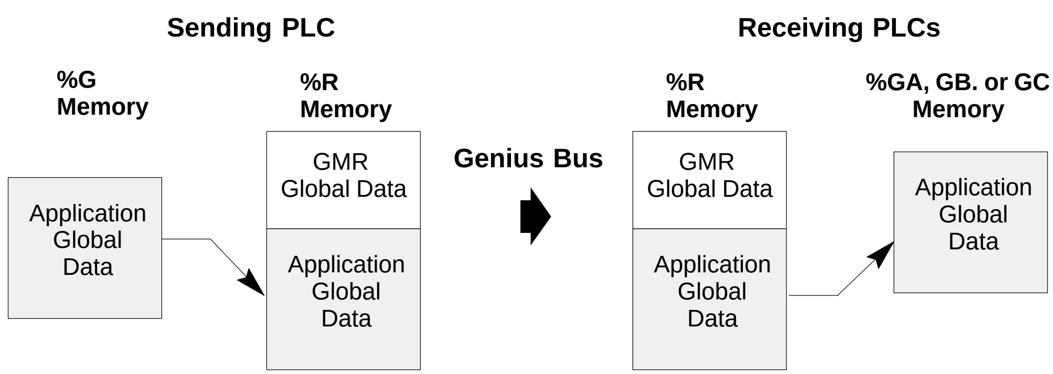
Communications Between PLCs

Data is transferred between the PLCs in the system using Genius global data. Two busses are used to transfer duplicate data. While the system is operating, they transfer global data automatically. This global data includes two types of information:

- Application program global data from %G memory. The GMR software automatically copies this data into %R memory before sending it.
- Additional %R data used by the GMR software.

Each scan of the Genius bus, a PLC takes the application program global data it has copied into %R memory, plus its own additional %R data, and broadcasts it on the bus.

During the same Genius bus scan, when the other PLCs have their turn on the bus, they send global data in the same way. When a PLC receives Global Data, it copies that portion of the data that is intended for application program use into %GA, %GB, or %GC memory (see the Programming chapter for details). The following diagram summarizes the transfer of GMR global data.



Global Data Redundancy

During normal GMR operation, each PLC receives two sets of global data from each of the other PLCs (one set over each of the two busses mentioned above). The system defaults to use the data from the first bus (bus a) unless that bus has failed, in which case the data from the second bus (bus b) will be used). 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. See the chapter on Diagnostics for more information.

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 the chapter on Programming.

Entering, Clearing, or Setting Global Data

The application program can read or transmit Global Data as required. Refer to the Programming chapter for details.

In addition, the application program can use the PLC OK flag to clear or preset the data as required. This is also described in the Programming chapter.

Chapter 5 Diagnostics

This chapter describes:

- Diagnostics in a GMR System
- GMR Autotesting
- GMR Discrepancy Reporting
- Input Line Fault Detection in a GMR Application
- The PLC and I/O Fault Tables in a GMR System
- Monitoring Manual Output Controls
- Fault and Alarm Contacts

Programming for Diagnostics

The Programming chapter of this book explains some programming considerations for a GMR application. It includes information about:

- Programming for Fault and Alarm contacts
- I/OPoint Faults
- Monitoring the System Status references
- Monitoring system forces and overrides
- Monitoring the I/O and PLC Fault Tables

Diagnostics in a GMR System

In a GMR system, extensive diagnostic capabilities are provided by standard Genius I/O diagnostics and by the special autotesting and discrepancy reporting features of the GMR software. Standard Genius diagnostics, which are covered in other books, are not described in detail here.

Each PLC provides a full range of fault table and program access to fault information.

Input Diagnostics

- ***Genius Diagnostics:***
  - ***Line fault***. a feature of the 16-circuit DC blocks. To report line faults, an input must be configured for tristate operation and installed as explained on page 5-14.

    For blocks in GMR mode, a line fault represents a short circuit fault on the field wiring.

    For blocks in any other mode, a line fault represents an open circuit fault in the field wiring.
- ***Autotest Diagnostics.*** for discrete inputs configured for autotesting., autotesting determines whether inputs can attain their opposite state (alarm state) and checks for channel to channel shorts.
- ***Discrepancy Reporting***: between the raw input data from each bus and the corresponding voted inputs.

Output Diagnostics

- ***Genius Diagnostics:***
  - ***No-load fault***: 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 100mA (not 50mA, as it would be for a block not used in a GMR group). For an individual block:

    If outputs are On with no output load, no-load fault reports may be generated at any time except during a Pulse Test.

    If outputs are Off with no output load, no-load fault reports are generated during a Pulse Test.
  - ***Short circuit fault***.
  - ***Overtemperature fault***.
  - ***Overload fault***
  - ***Failed switch***:. Occurs if the actual output state differs from the commanded state.
- ***Autotest Diagnostics***. for discrete outputs configured for autotesting. Autotesting determines whether outputs can attain the opposite of their normal state.
- ***Output Discrepancy Reporting:*** Blocks configured for GMR mode operation report to each PLC the discrepancy status for the data from each PLC, together with each PLC's online/offline status.

Setting Up Blocks to Report Genius Faults

By default, most Genius blocks, including the types of blocks normally used in GMR systems, send only one copy of a Fault Report. For a GMR system, blocks can be set up to send additional Fault Reports. The setup needed for a block depends on two things: what type of block it is, and how many PLCs should receive its Fault Reports..

Setting Up 16- and 32-Circuit DC Blocks to Send Multiple Fault Reports

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 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 on "Non-Voted I/O" screen of the GMR configuration software.

Setting Up Other Blocks to Send Multiple Fault Reports

Other blocks may also send "extra" copies of Fault Reports.

- Inputs-only blocks 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 block is configured in the GMR configuration, the GMR software issues an "Assign Monitor" datagram to cause a block to send the third fault report.

Summary Table

The following table summarizes how many Fault Report messages are sent by blocks configured for different types of CPU Redundancy, with or without the Assign Monitor datagram. X means the feature is not configurable for that block. (Page 6-50 describes configuring Genius blocks for Fault Reporting)

Block 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	X	1	2	2	3

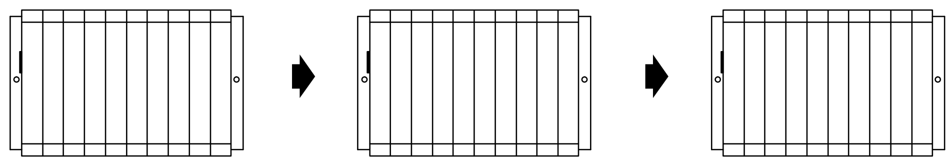
GMR Autotesting

The GMR software automatically performs autotesting on discrete inputs and outputs that have been configured to be autotested. Analog inputs and outputs are not autotested by the GMR software. GMR autotesting can be used in a system with one, two, or three PLCs.

Autotest Sequence

GMR autotesting goes on at the configured interval (0 to 65535 minutes) during system operation. Each PLC in turn controls the sequence.

PLC A | **PLC B** | **PLC C**



PLC A:
1. Autotest GMR inputs
2. Complete GMR output autotest
3. Pass autotest control to next PLC (here, B).

PLC B:
1. Autotest GMR inputs
2. Complete GMR output autotest
3. Pass autotest control to next PLC (here, C).

PLC C:
1. Autotest GMR inputs
2. Complete GMR output autotest
3. Pass autotest control to next PLC (here, A).

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. These may include the following types of groups:

Input groups: non-voted (1 block)
simplex (1 block)
duplex (2 blocks)
triplex (3 blocks)
Output group: 4-block redundant

Discrete Input Autotest

Discrete Input Autotest exercises the system inputs to assure their ability to detect and respond to actual inputs. It can be used on both 16-point and 32-point blocks.

Input autotest will:

- accommodate normally-closed and normally-open devices with the device in either state.
- detect any input failure associated with an input that would result in a failure to respond.
- not cause spurious outputs.

Input autotest is internal to each Genius block. With the exception of an initiation command, it requires no interaction with the PLCs during the autotest sequence.

Configuration Required for Discrete Input Autotest

Blocks that will be autotested must be *configured* as "combination" (input and output) blocks. However, the blocks must be *used* as all-input blocks with point 16 *only* on each block set up as an output. Point 16 must be configured to be "Default On".

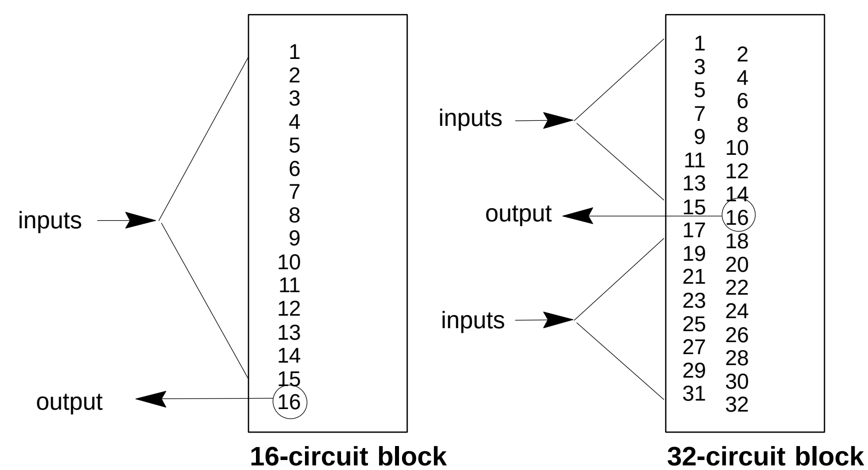
Whether or not inputs on an input block group will be autotested is configurable on a circuit-by-circuit basis.

Setup for Input Autotest

Inputs to 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 32 input devices.

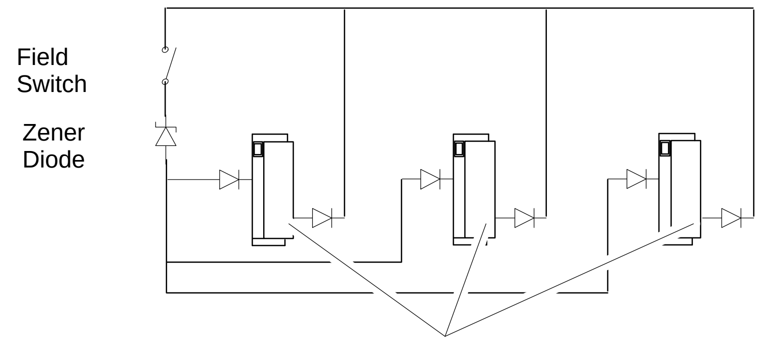
Block Setup for Input Autotest



Installing isolation diodes permits the Input Autotest to also detect circuit-to-circuit shorts. When a single input sensor is wired to more than one input block, isolation diodes are also required on the power feed outputs.

The following illustration shows connections from a single input sensor to a group of three blocks. The Zener diode shown at the field switch is for line monitoring, as explained on page 5-14.

Single Input Sensor to Triplex Block Group



Operation of the Input Autotest

The following actions are performed during the Input Autotest:

- the power feed outputs * are pulsed Off. Selected input channels are pulsed On.
- all associated inputs are checked for their ability to detect the On or Off state, as appropriate, and a fault is reported if the correct state is not detected..

While it is being tested, a block continues to supply its last valid set of inputs instead of the physical inputs to the PLCs.

Test Verification

By allowing some inputs to be turned On, the Input Autotest 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 B Block C	Block C Block A Block B	Block B Block C Block A	Block A Block B Block C	1,3,5,7,10,12,14 2,4,6,8 9,11,13,15	2A55 00AA 5500
32 Circuit DC	Block A Block B Block C 	 Block A Block B Block C	Block C Block A Block B	Block B Block C Block A	1,5,9,13,17,21,25,29 2,6,10,14,18,22,26,30 3,7,11,15,19,23,27,31 4,8,12,20,24,28,32	11111111 22222222 44444444 88880888

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

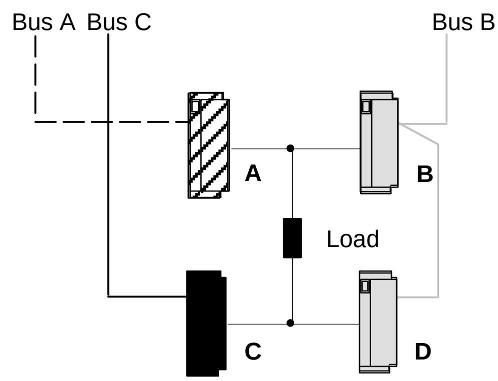
For 16-Circuit blocks, each circuit is turned On each cycle when looked at across all 3 blocks, but the same circuit is never turned On at more than one block at a time.

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.

* also see chapter 8 for installation and wiring information.

Discrete Output Autotest

Discrete output autotest checks the ability of outputs to respond to the commanded output state.



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

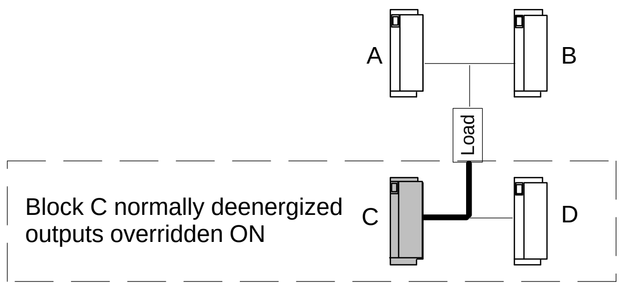
The PLC that is presently the autotest master informs the other PLCs (if any) which autotest group it is about to test.

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.

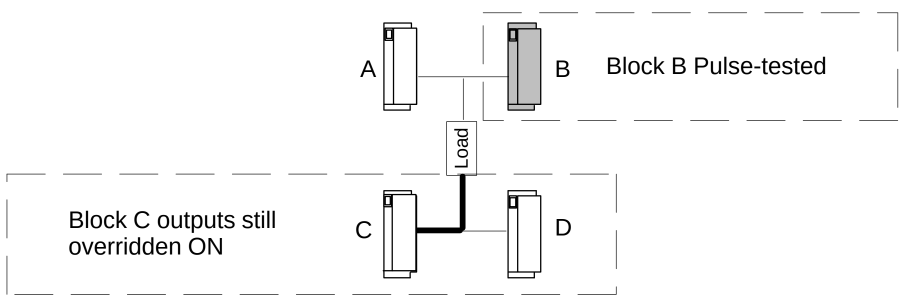
The autotest master PLC reads the current output state and force state for each circuit in the output group.

Then, the autotest master pulse-tests the blocks in the output group (details of pulse test operation are explained on page 5-10). The test sequence is described below.

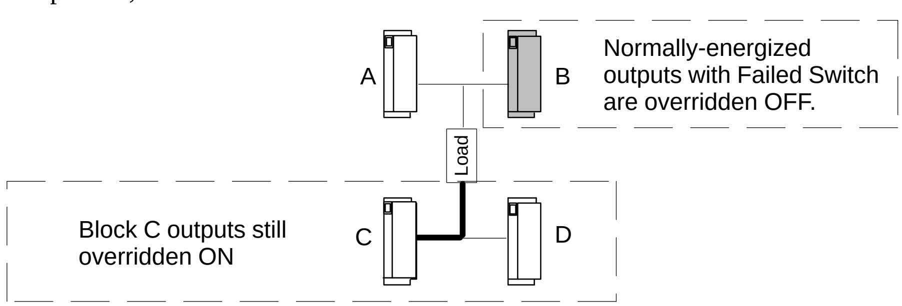
1. For the 4-block output group, the autotest master overrides the normally deenergized outputs on block C to ON.



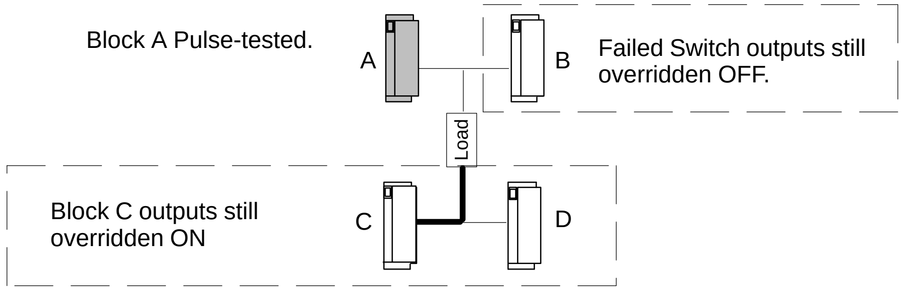
2. The autotest master pulse-tests block B. Any faults on block B are noted.



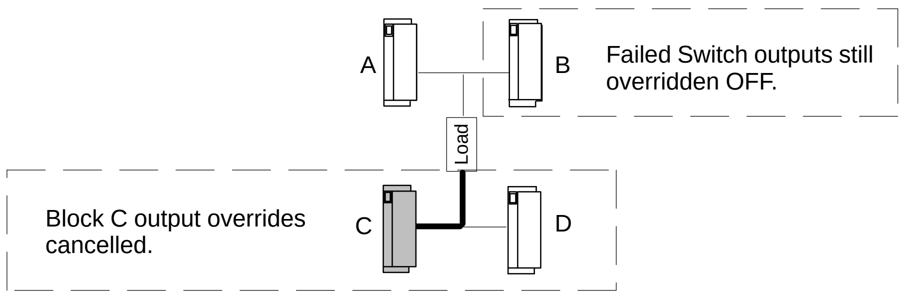
3. If any outputs on block B configured as normally-energized logged a Failed Switch when pulsed, the master overrides them to OFF.



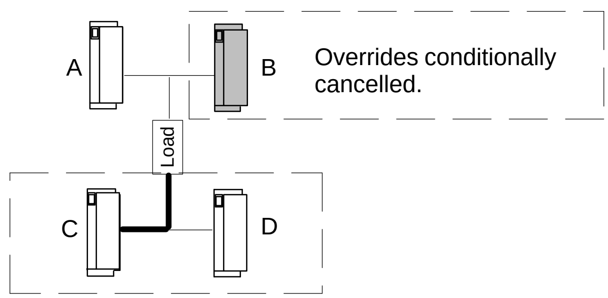
4. The autotest master pulse tests Block A. Any faults on block A are noted.



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.

Pulse Test Operation

The Output Autotest uses the standard Genius block Pulse Test feature. During this test, the system is on-line and available.

For the test to be performed:

- All blocks in the group must be on-line.
- There may be no I/O override applied to any block in the group.
- In addition, for each block output that is associated with a given system output within the group:
  - there may be no I/O force applied.
  - there may be no hardware fault (such as a failed switch).
  - all block outputs associated with the system output must presently be in the same logical state. (Monitoring of system status references to detect forces and overrides is discussed later in this chapter).

Outputs that are OFF are pulsed OFF-ON-OFF and checked for correct voltage, for the presence of diagnostic data, and for correct current (if the No Load diagnostic is enabled). If a point reports correct voltage and/or current data, the point passes and is not re-pulsed. However, if a point does not report correct voltage and/or current data, it is retested up to a maximum of seven times, in successively longer pulses. The ON pulse times begin at approximately 1.7mS, and can increase up to approximately 20mS. There is a delay of approximately 5mS to 15mS between successive pulses of the same point.

Outputs that are ON are pulsed ON-OFF-ON. This checks whether a point's feedback voltage matches its commanded state. Points are pulsed OFF for approximately 5ms. If the voltage matches, a point passes. If not, the point is pulsed OFF again, for approximately 7.5mS.

Note that the times given here are typical for 16-circuit blocks (pulse times and quantities are different for 32-circuit blocks). Actual times in any application depend on the presence of other scheduled tasks and the configuration of the points.

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 Discrepancy Reporting

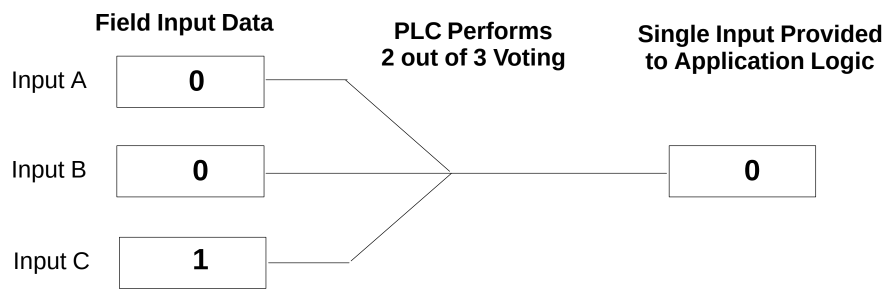
The GMR software performs discrepancy reporting for:

- Voted discrete inputs
- Discrete outputs
- Analog inputs

There is no discrepancy reporting for analog outputs.

Discrete Input Discrepancy Reporting

As explained in the chapter on PLC operation, the PLC compares corresponding inputs from bus A, bus B, and bus C, and performs voting:



If there is a discrepancy between any original input data value for an input and its voted input state, the PLC automatically places a message in the I/O Fault Table, where it is available to the Logicmaster 90 software and the application program logic. Discrepancy faults are latched.

When a discrepancy occurs, the PLC sets the fault contact for that voted input. See page 5-25 for information about these fault contacts.

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

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

Input Data			Voted Inputs	Discrepancy		
A	B	C		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

Discrete Output Discrepancy Reporting

Output discrepancy monitoring is the process of monitoring the block output voting function to detect both processor discrepancies and lost communication between the block and the other processors. All PLCs periodically monitor all blocks' discrepancy status. On interrogation by any PLC, the block responds with a discrepancy message indicating the discrepant output and disagreeing PLC.

The system uses output discrepancy checking to determine if the output data sent from each of the PLCs agrees with the voted output state. If a discrepancy check reveals that a PLC is sending incorrect 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 (i.e. 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.

How Output Discrepancy Checking is Performed

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

Discrete Output Discrepancy Reporting with Dynamic Outputs

Output Discrepancy Checking gives valid results as long an output changes 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 may be ignored. Nuisance discrepancy faults (caused by transitioning outputs) should NOT ever be logged. However, a message is logged in the PLC fault table. The message indicates that output discrepancy processing could not be completed for a device at rack X, slot Y, SBA x due to transitioning outputs.

In an ESD 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.

Analog Input Discrepancy Reporting

If there is a discrepancy in the data from a set of inputs, so that a channel deviates by more than a configurable percentage from the voted value, the PLC automatically places a message in the I/O Fault Table where it is available to the Logicmaster 90 software and the application program logic.

Discrepancy is calculated for engineering units values inputs. Two distinct discrepancy bands are provided: threshold and limit.

- The threshold discrepancy occurs where an A, B, or C engineering units input value exceeds a specified percentage of the voted value. For example, if channels A, B, and C report 91, 100, and 111, respectively, the GMR software selects 100 as the intermediate value. If the threshold discrepancy for the input is set to 10%, this yields 90 and 110 as the upper and lower threshold discrepancy values. In this example, channel A is within the threshold band, but channel C is outside, and is discrepant.
- The limit discrepancy occurs where an engineering units input exceeds a given percentage of the full-scale deflection of the input. For example, if channels A, B, and C report 9, 10, and 15, respectively, then the GMR software selects 10 as the intermediate value. If the limit discrepancy is set to 10% of a 200 full-scale deflection (20 in this case) then no limit discrepancy is reported.

An analog discrepancy is reported where the limit discrepancy and the threshold are both exceeded. Up to two of the three analog inputs may be discrepant at any given time.

Discrepancy faults are latched, but can be cleared by performing an I/O Fault Reset (see chapter 7, Programming).

When a discrepancy occurs, the PLC sets the fault contact for that voted input and adapts according to its configuration. See page 5-25 for information about these fault contacts.

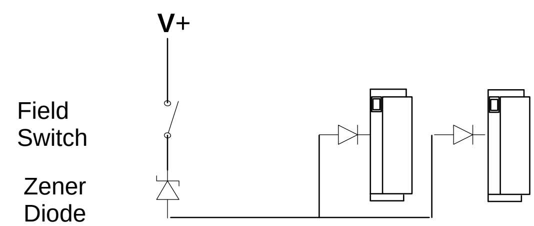
Discrepancy signals are filtered for the configured input discepancy filter time to eliminate transient discrepancies caused by timing differences.

Input Line Fault Detection in a GMR Application

The 16-circuit Genius blocks are capable of continually monitoring field circuits for input short circuit or open circuit faults. The blocks detect On, Off, Short Circuit, or Open Wire conditions on circuits set up as tristate inputs.

If a block is in a “non-GMR” mode, a resistor must be installed in the circuit to provide Open Wire fault detection. However, if the block is in GMR mode, a zener diode is used instead to detect short circuits. The diode is installed in series between the field switch and the tristate input blocks, but physically at the field switch device. The Zener diode rating is 6.2V.

Block Setup for Tristate Inputs



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.

DC Source Block Tristate Input Thresholds

Range	Non-GMR		GMR	
	Status	Input	Status	Input
<30% VDC	open circuit fault	0	off	0
>50%, < VDC+ –7V	Off	0	On	1
>VDC+ –4V	On	1	short circuit fault	1

DC Sink Block Tristate Input Thresholds

Range	Non-GMR		GMR	
	Status	Input	Status	Input
<4V	On	1	short circuit fault	1
>7V, <50% VDC+	Off	0	On	1
>70% VDC+	open circuit fault	0	Off	0

When used with a GMR block, a Genius Hand-held Monitor will correctly report a short circuit fault instead of Open Circuit.

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

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. Faults can be displayed with the programmer in either On–Line or Monitor mode.

```
|PROGRM |TABLES |STATUS |        |        |LIB    |SETUP  |FOLDER |UTILTY |PRINT
1plcrun 2passwd 3plcflt 4io flt 5 lcmem 6 lkmem   efsiz   veep     ear   z  om
02 481200 00301010200 0A02 01 01 02 9B030100000000000000000000000000000000000
>
                         I / O   F A U L T   T A B L E

 TOP FAULT DISPLAYED: 0007                    TABLE LAST CLEARED: 09-21 11:22:17
       TOTAL FAULTS: 0007                       ENTRIES OVERFLOWED: 00000
  FAULT DESCRIPTION: SHORT IN USER WIRING           PLC DATE/TIME: 10-14 10:05:13

   FAULT      CIRC  REFERENCE       FAULT             FAULT       DATE    TIME
  LOCATION    NO.     ADDR.        CATEGORY           TYPE         M-D   H: M: S
___________ _____ _________ ________________ ________________ _____ ________
0.3.1.1         %QI 00017        FORCED CIRCUIT                  03-08 11:23:16
0.3.1.1         %QI 00017      UNFORCED CIRCUIT                  03-08 11:23:16
0.3.1.1         %QI 00017        FORCED CIRCUIT                  03-08 11:23:16
0.3.1.1      1  %Q  00019        CIRCUIT FAULT   DISCRETE FAULT  03-08 11:23:16
0.3.1.1         %QI 00017        FORCED CIRCUIT                  03-08 11:23:16
0.3.1.1      3  %Q  00017        CIRCUIT FAULT   DISCRETE FAULT  03-08 11:23:16
0.3.1.1      2  %Q  00018        CIRCUIT FAULT   DISCRETE FAULT  03-08 11:23:16

ID:        RUN/OUT EN         ms SCAN    ONLINE   ACC: WRITE LOGIC    LOGIC EQUAL
D:\P060\GMRSYS                          PRG:SYS3
REPLACE
```

The same fault table features are available in a GMR system, with the following additional types of messages:

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

More fault information can be displayed by pressing CTRL/F, as described on the next page.

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

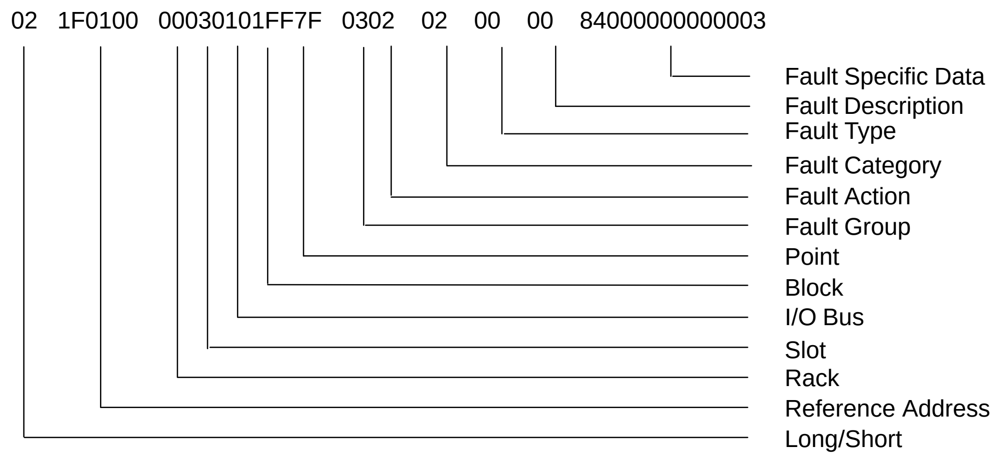
Caution

Use these %M references to clear the PLC Fault Tables. *Do not use the Logicmaster F9 key to clear the 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.

I/O Fault Table Messages for GMR

I/OFault Table format is detailed in the *Series 90-70 PLC Reference Manual (*GFK-0265).



In the I/O Fault Table, the following additional types of messages are available for GMR:

- 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.

Reporting of No-Load Faults on 4-Block Output Groups

The pairs of source and sink blocks in a four-block output group share loads. If outputs are off, a No-load will be 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 the pair, it 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 in the group 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 second 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.

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

11	Block A & B short circuit to 0V
12	Block C & D short circuit to +24V
13	Block A cannot turn on
14	Block B cannot turn on
15	Block C cannot turn on
16	Block D cannot turn on
17	Load disconnection
18	No Load connection on Block A
19	No Load connection on Block B
1A	No Load connection on Block C
1B	No Load connection on Block D
1C	Inconsistent No Load reporting
21	Block A switch failed off
22	Block B switch failed off
23	Block C switch failed off
24	Block D switch failed off
25	Block A not connected to Block B
26	Block C not connected to Block D
27	Block A cannot turn off
28	Block B cannot turn off
29	Block A & B cannot turn off
2A	Block C cannot turn off
2B	Block D cannot turn off
2C	Block C & D cannot turn off
30	Force override (spurious trip)

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	Meaning
100	No CPU Clock	There is no PLC clock present
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
100+ GBC ID	CFPT, 0 attempts wwww	Number of attempts exhausted while trying to send a COMREQ
10009	GMRx ornge GBC g req	Out of range Bus Controller (g) was requested by GMRx module
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
1	Unauthorized GMR Access	Initialization module was invoked with incorrect password
10102	Incorrect GMR Version	Initialization module was called with incorrect version number
10103	GMR Software Exception	An invalid call number was detected
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
10110	Invalid Bus Address	Initialization detected bus addresses not equal to 29, 30, or 31
10111	Sync Not Possible	Synchronization cannot be performed
10112	Output discrepancy	Output discrepancy detected
10113	Miscomp, no more retries	Sync detected miscompare
10114	GMR Coldstart	GMR is performing coldstart
10115	GMR Warmstart	GMR is performing a warmstart
10116	Cannot get all GBCs	Cannot acquire all GBCs during initialization
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
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
10129	Num dequeues = n	N dequeue entries were dequeued at startup
10130	Programmismatch A / B	PLCs A and B program mismatch, C is not online
10131	Programmismatch B / C	PLCs B and C program mismatch, A is not online
10132	Programmismatch A / C	PLCs A and C program mismatch, B is not online
10133	Programmismatch A / B&C	PLC A program mismatch with B and C
10134	Programmismatch B / A&C	PLC B program mismatch with A and C
10135	Programmismatch C / A&B	PLC C program mismatch with A and B
10136	Programmismatch A / B / C	All three PLCs mismatch
10137	Program changed A	PLC A program changed
10138	Program changed B	PLC B program changed
10139	Program changed C	PLC C program changed
10140	Configmismatch A / B	PLCs A&B config mismatch, C not online
10141	Configmismatch B / C	PLCs B and C config mismatch, A is not online
10142	Configmismatch A / C	PLCs A and C config mismatch, B is not online
10143	Configmismatch A / B&C	PLC A config mismatch with B and C
10144	Configmismatch B / A&C	PLC B config mismatch with A and C
10145	Configmismatch C / A&B	PLC C config mismatch with A and B

Code	Message	Meaning
10146	Config mismatch A / B / C	All three PLCs mismatch
10147	Config changed A	PLC A config changed
10148	Config changed B	PLC B config changed
2	Config changed C	PLC C config changed
10201	Unauthorized GMR Access	Inter-PLC Comms module was invoked with incorrect password
10202	Incorrect GMR Version	Inter-PLC Comms module has incorrect GMR version number
10203	GMR Software Exception	Inter-PLC Comms module was called with invalid call number
10204	Invalid GMR Pointer	Inter-PLC Comms module was called with invalid data pointer
10211	Comms Fail PLC A bus a	Communications with PLC A has failed on bus a
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
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
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
10301	Unauthorized GMR access	Fault Processor Module was invoked with incorrect password
10302	Incorrect version number	Fault Processor Module was invoked with incorrect version number
10303	Invalid call number	Call number was invalid
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
10310	Invalid block type	Block type currently unsupported
10311	GMR3 Rr Ss comreq Fail	A COMREQ sent by GMR to a bus controller in rack r slot s has failed
10312	GMRS / WExcept. %L	%L range error
10313	Value out of range	Calculated value is out of range
10322	IO Reset Seq Timeout	I / O reset timed out in step 2
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
10602	Invalid GMR Version	I / O Module S / W version does not match expected version
10603	GMRS / WExcept. Call	I / O Module was invoked with incorrect call number
10604	GMRS / WExcept, %L	I / O Module was invoked with out of range input parameters
10607	Invalid Switch Case	No cases satisfied by switch condition
10801	Unauthorized GMR Access	GMR Configuration Module was invoked with incorrect password
10802	GMRS / WExcept Null FH	GMR Configuration Module failed to load fault handler
10802	GMRS / WExcept I / O FH	GMR Configuration Module encountered an error loading the fault handler
10803	GMRS / WExcept 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	GMRS / WExcept %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
10811	GMR cfg err GBCxx	GMR Configuration Module detected invalid GBC record xx in the config data
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

Code	Message	Meaning
10814	GMR cfg err no of PLCs	GMR Configuration Module detected more than 3 PLCs in the config data
10815	GMR cfg errW / dogtimer	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
10819	GMR cfg err comreq %R	GMR Configuration Module detected invalid positioning of the comreq status %R area
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 exceed-ed
10823	GMR cfg err voted DIN	GMR Configuration Module detected that the maximum number of voted digital inputs has been exceeded
10824	GMR cfg err voted AIN	GMR Configuration Module detected that the maximum number of voted analog inputs is exceeded
10825	GMR cfg errredund O / P	GMR Configuration Module detected that the maximum number of redundant out-puts is exceeded
10826	GMR cfg err alpha rack	GMR Configuration Module detected that alpha inter-PLC GBC is in an invalid rack
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
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 / Tint	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
10837	GMR cfg err no of GBCs	GMR Configuration Module detected invalid number of GBCs
10840	GMR version MM.mmE	GMR software version number
10841	Cfg util ver MM.mmE	GMR config utility version number
10842	GMR config crc 0xXXXX	Config utility 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
10851	Invalid NV Dig I / P data	Invalid data detected in nonvoted digital input record
10852	Invalid Ana I / P data	Invalid data detected in voted analog input record
10853	Invalid NV Ana I / P data	Invalid data detected in nonvoted analog input record
10860	GMR cfg err %R Write	%R register external device write access range is invalid
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
10871	Shutdown Cancelled	System simplex shutdown cancelled
10872	System Shutdown	System has shut down
10894	Config changed r.s.b.d.	The block-level configuration was changed by the specified device.
10898	GMR Fault Handler Error	Fault handler received a fault for an invalid discrete block
10899	GMR Fault Handler Error	Fault handler received a fault for an invalid analod block
10902	User_IF–GMR version	Module version number does not match the GMR system version number

Code	Message	Meaning
10903	User_IF–Invalid Table	Module was called with extended mode table number when the module was in normal mode
10903	Bad Table c (h)	Module was called with an invalid table number (c=requested table in decimal, h=requested table in hexadecimal)
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.
11001	Null GMR Configuration	Configuration Module has detected a Null GMR configuration
11101	Unauthorized GMR Access	GMR Configuration Module was invoked with incorrect password
11102	GMRS/WExcept. %L	%L parameter out of range
11201	Unauthorized GMR Access	GMR Configuration Module was invoked with the incorrect password
11202	GMRS/WExcept %L	%L parameter out of range
11401	Unauthorized GMR Access	GMR14 was invoked with the incorrect password
11402	Incorrect GMR Version	GMR14 version does not match the GMR system version number
11403	GMR Software Exception	Invalid call number was detected
11404	Invalid GMR Pointer	The error code pointer was out of bounds
11410	GMR1–IS x at y	GMR1 state machine went to step x (illegal). Step no. at offset y in GMR1 diagnostics
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
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

Code	Message	Meaning
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
11456	GMR15–ST x at y	GMR15 state mach. exceeded allowed time in step x. Step no. at offset y in GMR15 diagnostics
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
11502	Incorrect GMR Version	GMR15 version number does not match the GMR system version number
11503	GMR Software Exception	An invalid call number was detected
11504	Invalid GMR Pointer	The error code pointer was out of bounds
11505	More than 1 Master	GMR15 detected that more than 1 PLC was operating as master
11506	Invalid Switch Case	GMR detected an illegal internal condition
11507	Discrep NAK PLC A	PLC A failed to acknowledge discrepancy results
11508	Discrep NAK PLC B	PLC B failed to acknowledge discrepancy results
11509	Discrep NAK PLC C	PLC C failed to acknowledge discrepancy results
11510	Disc results read fault	The PLC was unable to read output discrepancy results data from the master PLC
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
11521	CR fail x.y.l.zf / s	COMREQ with function code f and subfunction code s failed when sent to the device at rack x, slot y, SBA z
11522	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
11523	Null timeout from PLC A	Timeout occurred while waiting for PLC A to transmit a null test number
11524	Null timeout from PLC B	Timeout occurred while waiting for PLC B to transmit a null test number
11525	Null timeout from PLC C	Timeout occurred while waiting for PLC C to transmit a null test number
11530	I / OS / Dr.s.b.d	I / O Shutdown on the specified block
11530	I / OS / Dcancelr.s.b.d	I / O Shutdown cancelled on the specified block
11530	I / OS / D8hrsr.s.b.d	I / O Shutdown in 8 hours on the specified block
11530	I / OS / D1hrr.s.b.d	I / O Shutdown in 1 hour on the specified block
1rsdd	I / PA / Trestimeout	A / T results for SBA dd on GBC at rack r slot s

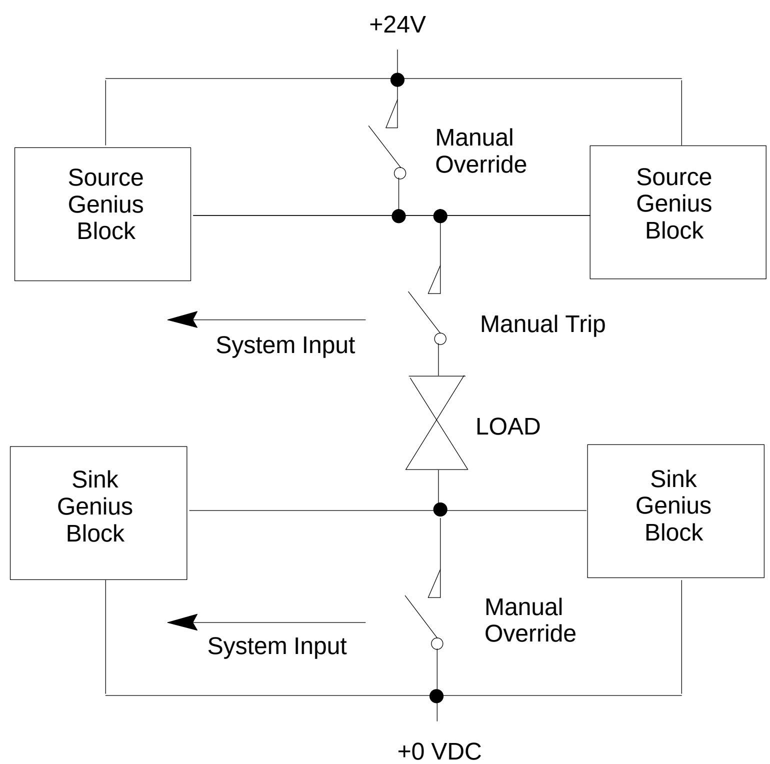
Manual Output Controls and Diagnostics

Safety systems are often provided with controls for manual trip and manual override.

- A manual trip causes the output to assume the alarm condition. For example, a normally-energized output would be de-energized.
- A manual override causes the output to remain in the normal condition. For example, a normally-energized output is held energized.

These manual controls can be implemented either in hardware, as represented below, or in software. If the software method is used, the GMR autotest and fault processing operations are unaffected.

Hardware control usually consists of switch contacts applied to the output circuit, as shown below for a normally-energized output.

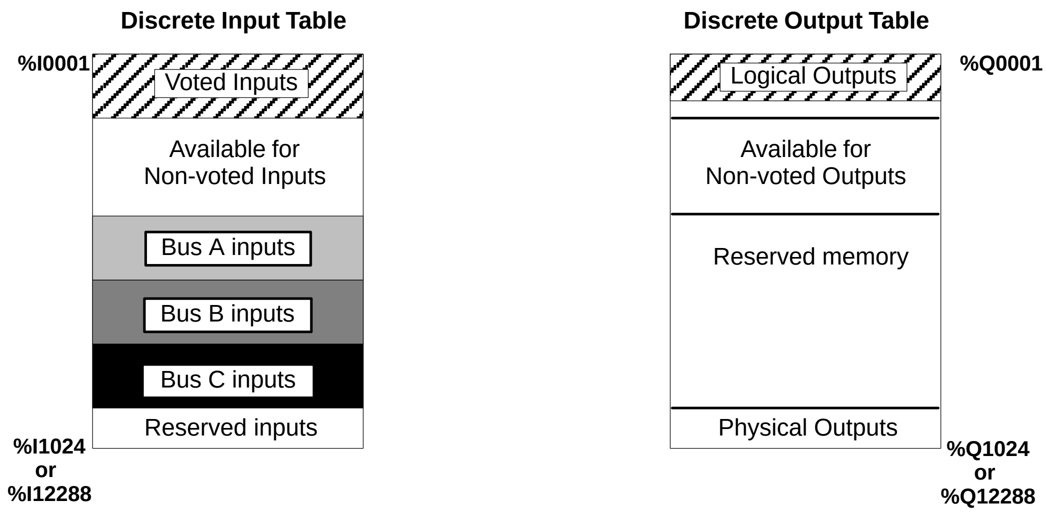


In this circuit, operation of either the trip or override switch can cause no-load faults, state faults, and autotest faults to be generated. If these manual inputs are wired in the GMR system, fault reporting is modified to suppress no-load faults and Failed Switch faults. Use of manual controls does not affect fault reporting for Short Circuit, Overtemperature, Overload, or Discrepancy faults.

Monitoring Manual Output Controls

The operation of manual trip and output override devices can be monitored and reported by connecting them as inputs to Genius blocks.

These inputs should be configured to use references at the end of the Discrete Input Table shown as "reserved inputs" below.



There is a one-to-one correspondence between Reserved Inputs and physical outputs.

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).

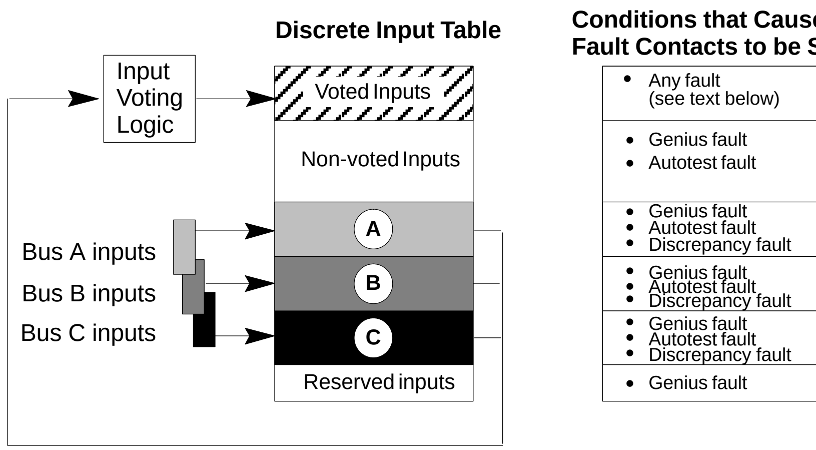
The application program must not command pulse testing on GMR outputs.

Fault, No Fault, and Alarm Contacts

Fault and No Fault contacts can optionally be used to detect fault or lack of fault conditions on a discrete (%I or %Q) or analog (%AI or %AQ) reference. They can also be programmed with the Series 90-70's built-in fault-locating references. In a GMR system, there are fault contacts associated with voted inputs, with the original block inputs, and with logical outputs. Alarm contacts can also be used to detect high or low alarm conditions on an analog (%AI or %AQ) reference. See the Programming chapter for information about using these contacts.

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 more information about fault contacts, see page 7-21.

- **For the voted input**, 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 digital 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.

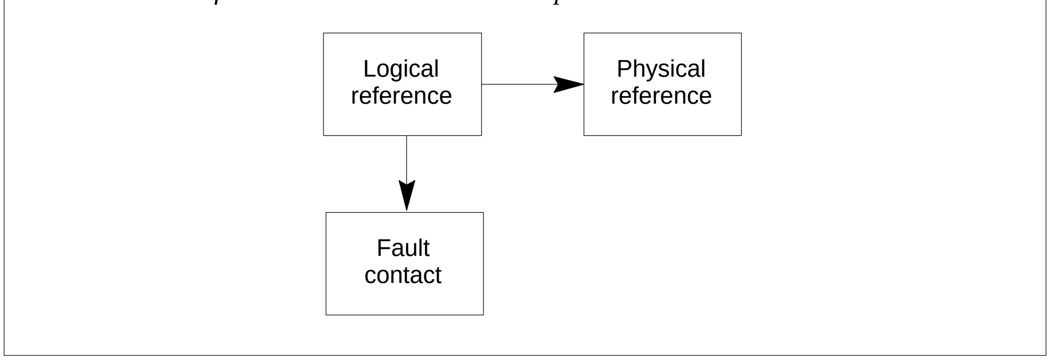
    For blocks in GMR mode, a line fault represents a short circuit fault on the field wiring.

    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 Output Fault Contacts for GMR

For discrete outputs, the fault contact is associated with the logical outputs (outputs from the application program).

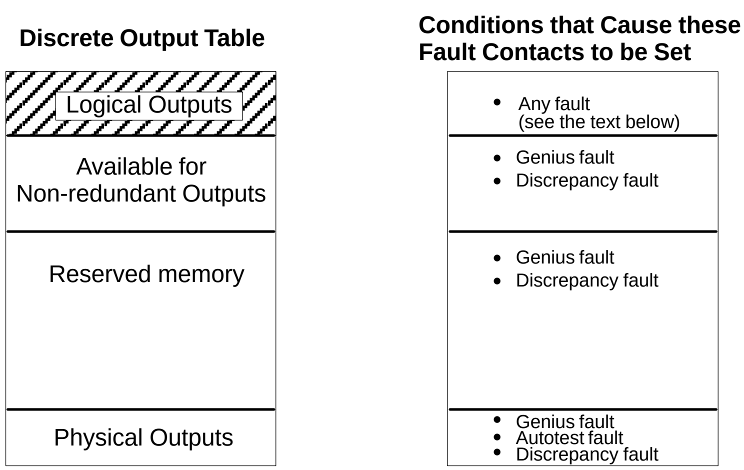
Contact References Associated with an Output



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.

Conditions that Cause Discrete Output Fault Contacts to be Set

The following illustration summarizes the 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 fault***
  - ***Genius faults*** including Loss of Block, and the following additional faults:

    Failed switch: Occurs if the actual output state differs from the commanded state.

    No-load fault: 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 100mA (not 50mA, as it would be for a block not used 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.

Short circuit fault

Overtemperature fault

Overload fault

- ***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.

- **For non-redundant outputs**, the single fault contact is associated with the physical output. The fault contact is set under the following conditions:

  - ***Discrepancy fault***
  - ***Genius faults*** including Loss of Block, and the following additional faults:

    Failed switch: Occurs if the actual output state differs from the commanded state.

    No Load fault: 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.

    Short Circuit fault.

    Overtemperature fault

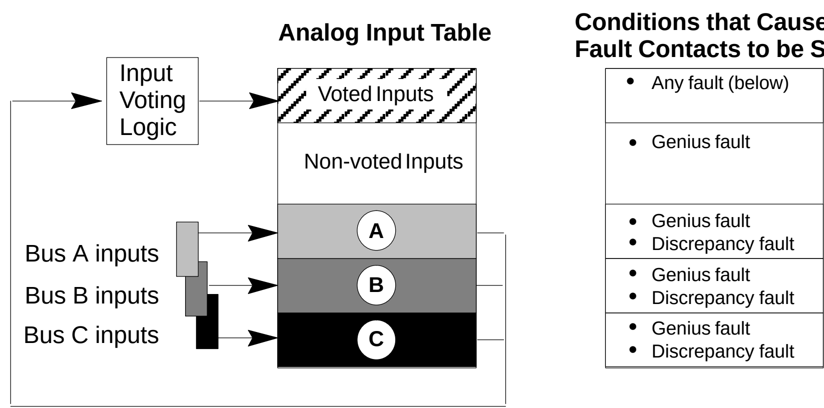
    Overload fault

Analog Fault and Alarm Contacts for GMR

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. (For more information about fault contacts, see page 7-21.)



- ***Genius faults*** include Loss of Block, 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.
- ***Discrepancy fault***: the A, B, or C input is subject to voting and is outside the discrepancy range.

Fault Contacts for Analog Outputs

For analog outputs, a fault contact is set for any Genius fault, including Loss of Block.

Alarm Contacts

For analog data, there are two additional types of diagnostic contacts that can be used in the application program, the High Alarm and Low Alarm contacts. These contacts indicate when an analog reference has reached one of its alarm limits. Alarm contacts are not considered to be fault contacts.

Alarm contacts can be used on a separate bus in a GMR system, but they can not be used on any parts of the system that are included in the GMR configuration.

Chapter 6 Configuration

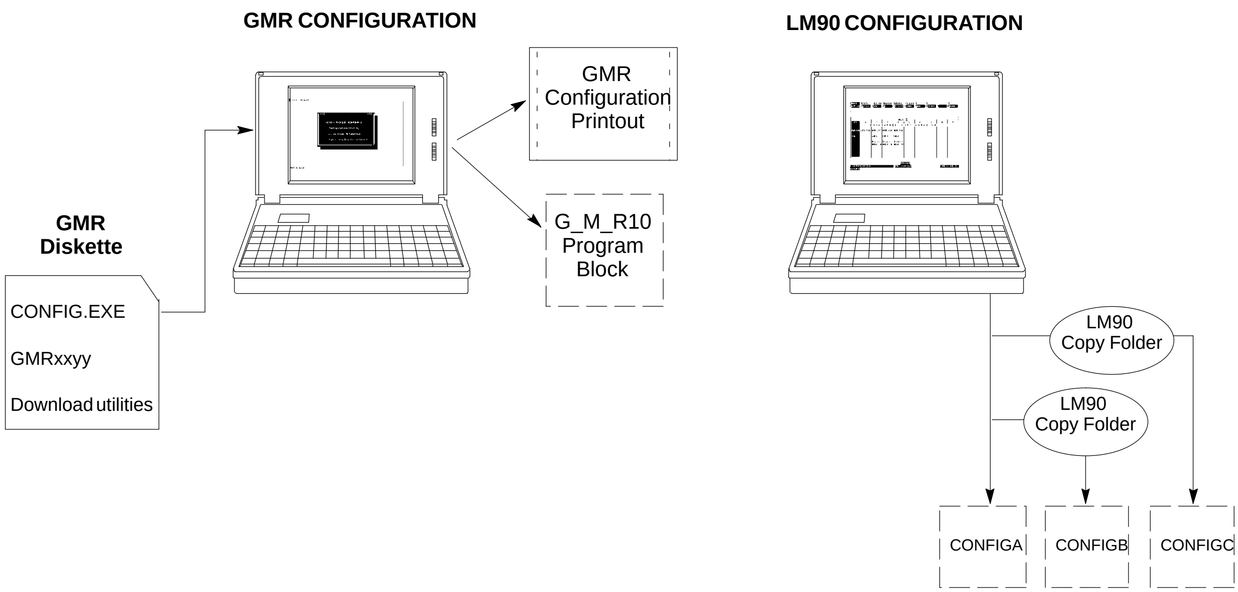
This chapter describes configuration for a GMR system:

- Configuration Overview
  - The Basic Steps of Configuration
- Using the GMR Configuration Software
  - Getting Started
  - Creating / Selecting a File
  - System Configuration Screen
  - Autotest Interval
  - CPU Configuration
  - I / O Limits
  - Initialization Data
  - Fault Actions
  - Genius Bus Controller Group Configuration
  - Configuring the Input Subsystem for a Bus Controller Group
  - Configuring the Output Subsystem for a Bus Controller Group
- Completing the Logicmaster 90 Configuration
  - Configuring Bus Controllers
  - Creating and Copying the PLC Configuration
  - Logicmaster Configuration Summary
- Configuring Genius I / O Blocks
  - Editing the Reference Addresses
  - Copying Configurations

Configuration Overview

In a GMR system, there are three basic configuration steps:

- Completing the GMR configuration using the GMR configuration software.
- Configuring the Series 90-70 PLCs.
- Configuring the Genius blocks in the system (not shown below).



The basic configuration steps are described below.

The Basic Steps of Configuration

1. **Complete the GMR configuration. This information is the same for the redundant PLCs – there is only one GMR configuration needed for the system.**

   GMR configuration sets up the parameters that will be used by the system, *including reference addresses.* The GMR configuration produces:

   - A printout of the GMR Configuration. Use it as a reference during subsequent programming and configuration.
   - A program block named G_M_R10. This is later added to (imported into) the application program.

2. **Create a Logicmaster configuration for each PLC. The easiest way to do that is to:**

   A. Create a Folder for PLC A, PLC B, and PLC C.

   B. Select to the folder for PLC A. With the GMR configuration printout as a reference, complete its Logicmaster configuration.

   C. 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. To do this:

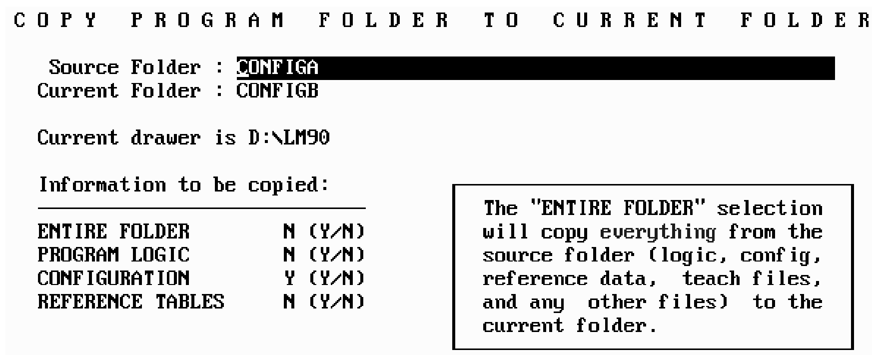
   (1) From the Logicmaster configuration software, return to the Logicmaster programming software. Select the Program Folder functions.

(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 then edit the configurations for PLC B and PLC C as necessary. For example, change the bus controller serial bus addresses and Global Data send and receive addresses.

3. Also, complete the Genius block configuration. Genius block configuration sets up the operating characteristics of each block in the GMR system.

Basic configuration steps for Genius blocks are the same as for a non–redundant system. Instructions for completing configuration are detailed in the *Genius I/O Blocks User's Manual*. This chapter gives additional details needed to configure blocks for use in a GMR system.

Using the GMR Configuration Software

The GMR Configuration Software is used to enter data needed by the GMR program software.

- Autotest interval
- CPU type for the system
- I/O limits for the system
- initialization data for the system
- fault actions for the system
- all GBC (bus controller) groups, with all Genius I/O blocks that will use GMR features

The GMR Configuration Software is not part of the Logicmaster 90 software package. It is a separate utility that operates on an IBM PC or compatible computer. It runs under DOS. Either a keyboard or mouse can be used for making entries.

After all the necessary configuration entries have been made, the data is added to the GMR system software. The GMR system software is provided as a Logicmaster 90 Program Folder, to which the application program is then added.

To assure matching the entries made with the GMR Configuration Software to corresponding entries made during Logicmaster 90 configuration and Genius block configuration, the GMR configuration data should be printed out and used as a reference.

The GMR software requires that:

- all PLCs have the same number of bus controllers in the same positions (not including "non-GMR" bus controllers).
- all PLCs are connected to the same "GMR" Genius busses.

Genius busses used for either I/O or communications that are not common to all PLCs in the system, or that do not use bus addresses as described above must *not* be included in the GMR configuration.

GMR Configuration Software Revision and Checksum

The system monitors the checksums of both the configuration data and the application program, including the GMR software modules. As part of the GMR configuration, you can select whether to permit online changes. If online changes are permitted, a configuration mismatch will not stop the PLC. If online changes are not permitted, a configuration mismatch will stop the PLC. The table on page 4-3 shows in detail what happens if a configuration mismatch is detected.

Getting Started

To complete the configuration, you will need to provide the following information:

- the CPU type (788 or 789)
- the register memory table size.
- the Analog Input table size.
- the CPU Watchdog timer value.
- I/O block serial bus addresses.
- I/O block "logical" (%Q) and "voted" (%I and %AI) addresses to be used in the application program.
- Bus controller rack and slot locations.

The GMR Configuration Software will supply default values for these selections. However, the defaults may not be appropriate for your application. Before beginning, decide on entries for the items listed above. During configuration, change any defaults that are not suitable.

Installing the Configuration Software

The GMR Configuration Software can be run directly from diskette, or copied to a hard drive. Operation from a hard drive is more efficient.

To copy the GMR Configuration Software to a backup disk or to the hard drive of a personal computer on which it will be run, copy all of the files listed below from the CONFIG subdirectory of your Master GMR software disk.

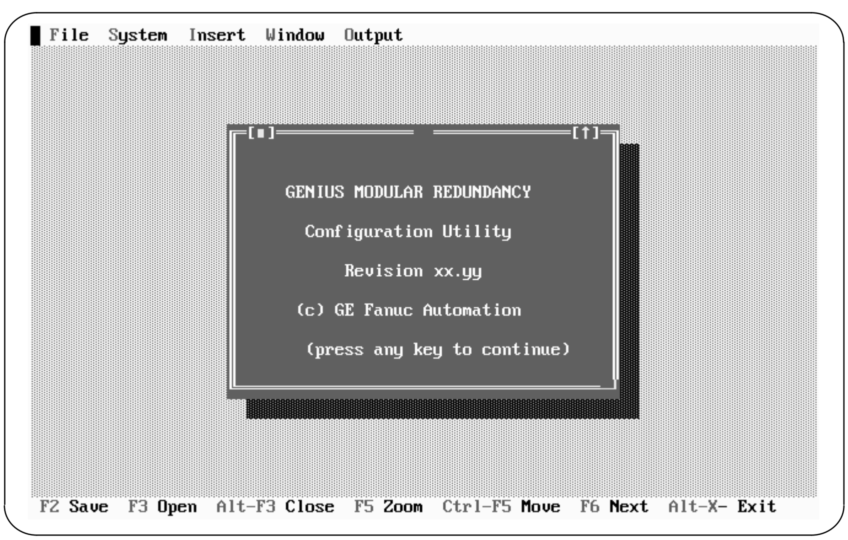
CONFIG.EXE
G_M_R10.16K
G_M_R10.32K
G_M_R10.48K
G_M_R10.64K

If you are using a mouse with the configuration utility, you also need to install any necessary mouse driver on your computer.

When you are ready to begin using the software, at the DOS prompt type:

config <return>.

The following screen appears:



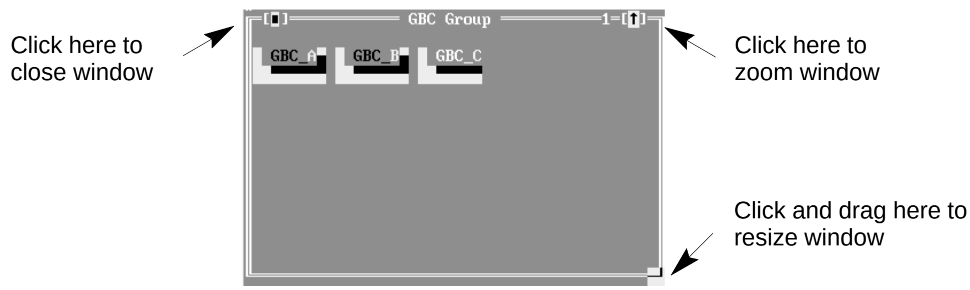
Mouse and Keyboard Guide for the Configuration Software

Either a mouse or keyboard can be used with the GMR Configuration Software. It is easiest to use a mouse.

Using a Mouse

When using a mouse, simply move to the item you want to select, and click on it.

Some windows can be closed, zoomed, or resized using a mouse. Look for the symbols illustrated below:



Using a Keyboard

When making selections and entries from a keyboard, refer to the special key assignments shown at the bottom of the configuration screen:

```
F2 Save  F3 Open  Alt-F3 Close  F5 Zoom  Ctrl-F5 Move  F6 Next  Alt-X- Exit
```

Additional keyboard functions are described below.

Alt–(letter) Press the Alt key then the highlighted letter key to select one of the functions displayed at the top of the configuration screen:

```
File  System  Insert  Window  Output
```

Save (F2) Use the F2 key to save a configuration.

Open (F3) Use the F3 key to open a previously-saved configuration.

Close (Alt/F3) Use the Alt / F3 pair only if you want to close an open configuration ***without saving it. (NOTE: No prompt will appear)***

Zoom (F5) Use the F5 key to enlarge a configuration window, or to return a window to its original size.

Move (Ctl/F5) Use the Ctl / F5 pair to move a configuration window on the screen. The window color changes to show that is in a movable state. Use the cursor, Home, End, PgUp or PgDn keys to move the window. When it is positioned where you want it, press the Return (enter) key.

Next (F6) Use the F6 key to move from one window to the next.

Exit (Alt/X) Use the Alt / X pair to exit the GMR Configuration Software. ***NOTE: if the configuration is not saved, it will be lost.***

There are two basic ways to select a menu item from the keyboard:

A. pressing the letter key that corresponds to the highlighted letter on the display (for example, the letter “c” in CPU, below.

B. moving the cursor to that item (using the cursor keys) and pressing Return (enter).

GMR Configuration Summary

GMR configuration is described in detail on the following pages. The basic steps are:

1. **Select File to create a New System configuration**
2. **In the System menu, create the CPU configuration**
   - CPU Type (788 / 789)
   - Number of CPUs (1 – 3)
   - Watchdog timer (must match PLC configuration)
   - Enable or disable online programming.
   - Simplex shutdown (enable / disable)
   - Timeout (0 – 65535 seconds)

   Select [O]K or [C]ancel to quit the CPU Configuration window
3. **In the System menu, select Autotest Interval and Register**
4. **In the System menu, select Input Discrepancy Filter Time**
5. **In the System menu, specify the I/O Configuration Limits**
   - Number of Voted Discrete Input Groups for that GBC group
   - Number of Voted Discrete Output Groups for that GBC group
   - Number of Analog Input Groups for that GBC group
   - Number of words of %AI memory (must match PLC configuration)
   - Number of registers of %R memory (must match PLC configuration)

   Select [O]K or [C]ancel to quit the I/O Config window
6. **In the System menu, specify the Initialization Data**
   - Rack and slot locations of the two bus controllers that will be exchanging global data
   - %R and %M references and lengths for startup initialization data

   Select [O]K or [C]ancel to quit the Initialize Data window
7. **In the System menu, specify the initialization Fault Actions**
   - Data fault (diagnostic or fatal)
   - System fault (diagnostic or fatal)

   Select [O]K or [C]ancel to quit the Fault Actions window.
8. **In the System menu, specify Write Access.**

9. **[Insert] the first GBC (bus controller) group**

   A. Select each bus controller in the group (GBC_A, GBC_B, GBC_C).

      (1) Specify a rack and slot location

      (2) Select [OK] or [C]ancel to quit the Rack / Slot window

   B. Configure all the input and output block groups <u>for the GBC group</u>.

      (1) [Insert] each Input block group. For each Input block group:

         (a) Select the group type (triplex, duplex, simplex, discrete, analog)

         (b) Configure the Input block group:

            - Enter an ID, starting reference address, serial bus address
            - Select Autotest and specify each input to be autotested and Test Type for the block group (Sync or Async)

              Select [O]K or [C]ancel to quit the Autotest window
            - Select VoteAdapt and specify each input for vote adaptation

              Select the Duplex state (0 or 1), Default state (0 / 1 / hold last), and Hot Standby mode for any outputs on the block group

              Select [O]K or [C]ancel to quit the VoteAdapt window

      (2) [Insert] each Output block group. For each Output block group:

         (a) Select the group type (16 point or 32 point)

         (b) Configure the Output block group:

            - Enter an ID, starting reference address, serial bus address
            - Select Autotest and specify each output to be autotested and its normal state.

              Select [O]K or [C]ancel to quit the Autotest window.
            - Select Options and specify the bus and bus address for the 4th block

              Select [O]K or [C]ancel to quit the Options window.

10. **[Insert] any additional GMR bus controller groups in the same PLC(s).** Configure each additional bus controller group as described in step 6.

11. **Save the configuration.** This creates a file with the filename extension .SAV in the selected directory (by default this is the same directory where the GMR CONFIG.EXE software is located).

12. **With the configuration file still present in the computer's RAM memory, create the GMR configuration output file.** Select **Output**, then select **Write Configuration** from the Output menu. This creates an output file with the filename G_M_R10.EXE. This file is stored in the currently-selected directory.

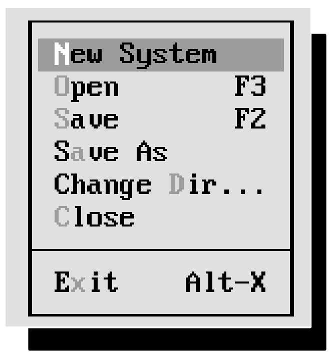
13. **Print out the configuration.** Select **Output**, then select **Print Out** from the Output menu.

14. **Import the configuration** into your application folder as described on page 6-46.

Creating/Selecting a File

To create a new configuration, or begin editing an existing file, select File. (If you are using a mouse, click on "File" in the upper left corner of the screen. If you are making keyboard entries, type Alt / F.)

You can now start a new configuration or open an existing configuration. From the same screen, you can also save a file with the same name or with a new name, close a file, or exit the GMR Configuration Software:

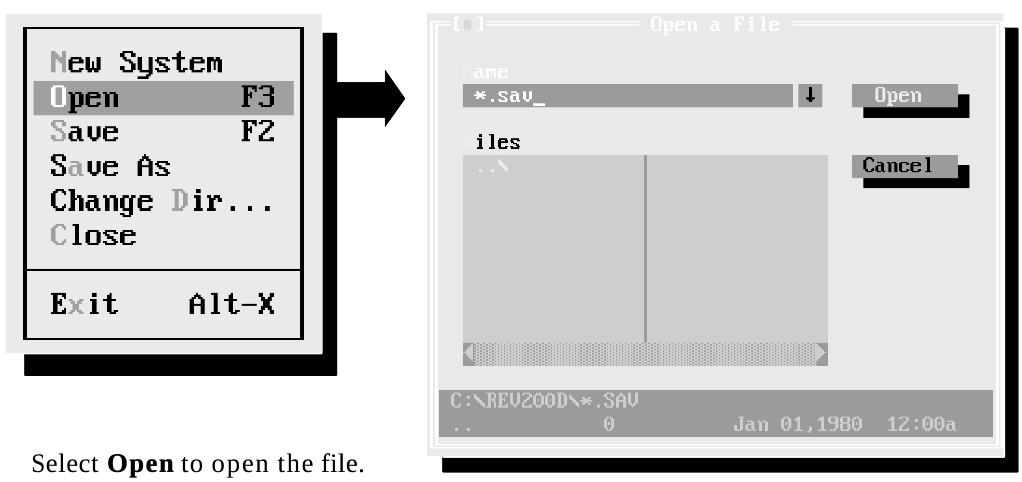


Start new configuration	New System (N or Enter)
Open previously-saved configuration	Open (O or F3)
Save a configuration	Save (S or F2)
Save and Rename	Save As (A)
Change directory	Change Dir (D)
Close without saving	Close (C)
Exit	Quit configuration (X)

In a menu, to select an item with a mouse, move the cursor to it and click. To select a menu item from the keyboard, use the cursor keys to move the cursor, and press Enter (Return) or press the highlighted letter key (without the ALT key).

Opening a Previously-Saved Configuration File

The GMR configuration software stores files with the filename you choose, and the extension .SAV. For example, CONFIG1.SAV. If you want to view, edit, write, or print a previously-saved configuration file, select **Open** (F3) from the File menu.



Select **Open** to open the file.

This loads the selected file into the computer's RAM memory.

Saving a Configuration File

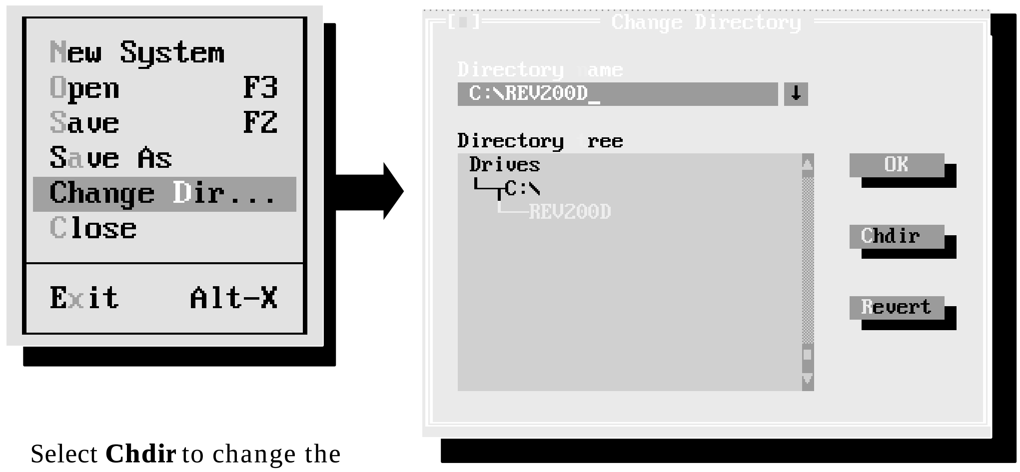
Select **Save** (F2) to save the configuration file presently in RAM memory (the one displayed on your computer screen). This function saves the file with the selected name, overwriting the previous version. If you want to specify another filename (for example, to create a new version of a configuration file *without* writing over the old one, select **Save As** instead. The software gives each saved file the filename extension .SAV.

During a file editing session, the first time you select **Save**, the software automatically displays the **Save As** screen so you can select a name for the file.

GMR configuration files are stored in the currently-selected directory. By default, this is the directory in which the GMR configuration utility software was installed, but you can change it before saving the file, as explained on the next page.

Changing to Another Directory

Use the Change Directory function if you want to access another directory. (Additional directories must be created in DOS.)



Select **Chdir** to change the directory.

Select **Revert** to return to the previous directory.

If you are using a mouse, you can click on the "elevator" bar at the right of the Directory Tree to scroll through the directory structure.

By default, the GMR configuration software uses the directory in which the GMR configuration utility was installed to save your configuration file(s). However, can use other directories if you prefer.

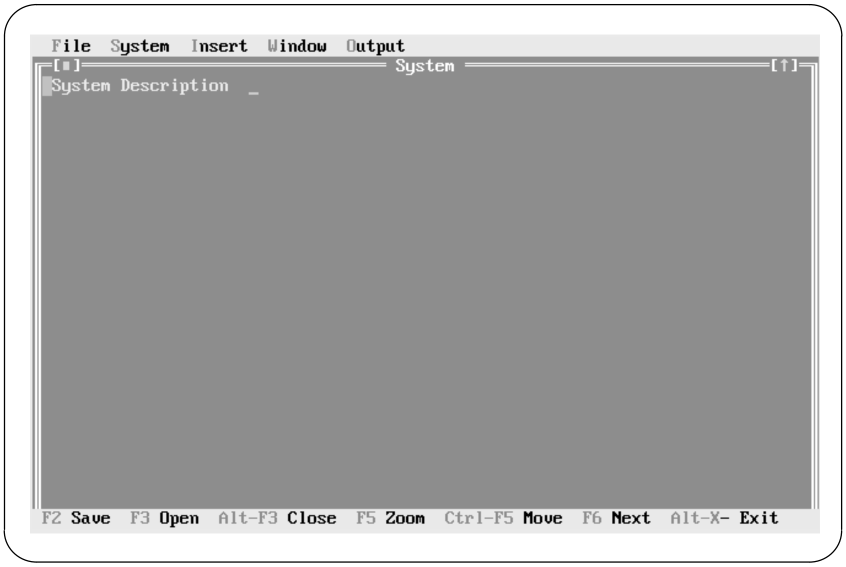
If you have made changes in this window but want to exit without saving your changes, you can click on the "close" button in the upper left corner of the window.

Closing a Configuration File without Saving It

If you want to exit a configuration without saving it, select **Close** from the File menu.

Starting a New Configuration

When you select New System from the File menu using the mouse, or using the Enter (Return) key, the System screen appears:



From this screen, you can:

- return to the file-handling functions (click on File or press ALT / F)
- change a system parameter (click on System or press ALT / S)
- add a configuration item to the current file (click on Insert or press ALT / I. When the Configuration menu appears, click on the item to insert, or press the highlighted letter key).
- print out a copy of the configuration (click on Output or press ALT / O When the Output menu appears, click on Print Out or press [P].).
- create the configuration output file (click on Output or press ALT / O When the Output menu appears, click on Write Config or press [W].)

Additional key functions are displayed on the bottom of the screen.

Entering a System Description

At the top of the screen, enter a description of up to 40 characters. This information will appear when you print out the configuration. It is also saved in the G_M_R10 file and can be used to determine what configuration is used in the system with the Report function (%M12262).

Closing and Deleting the System Configuration File

If you want to quit from this window without creating a file or saving any entries, you can click on the “close button” in the upper left corner of the screen.

GMR Configuration Selections

When you select System, the following menu appears

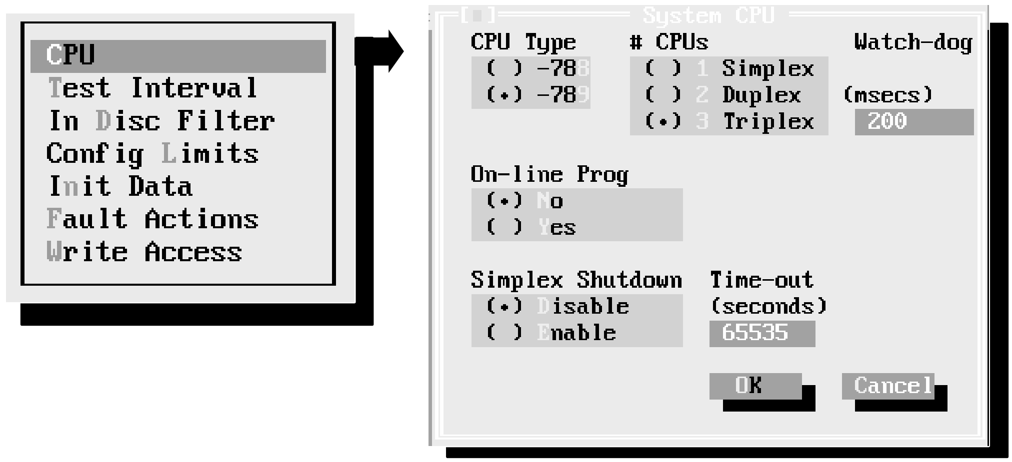
CPU configuration
Select autotesting interval
Input Discrepancy Filter
Set configuration limits
Select Initialize data areas
Select fault actions
Configure memory write access

Create the configuration by selecting items from the menu, then completing entries on the screens that appear. Instructions for completing these screens begin on the next page.

To display the configuration screen for the currently-highlighted menu selection, click on it with the mouse or press the Enter key.

CPU Configuration

Complete the entries on the CPU Configuration menu. The defaults are indicated with dots in the parentheses, as shown below. If a default selection is correct for your system, you don't need to edit that item.



CPU Type Specify whether the CPU is model IC697CPU788 or 798.

On Line Prog Specify whether Online programming will be permitted. If this item is set to Yes, online run mode stores, single word online changes, or block edits can be made without shutting down the PLCs. See page 7-37 for information about online changes.

Note: online changes are intended for system debug and commissioning only.

 # CPUs Specify 1, 2, or 3 CPUs in the GMR system.

Simplex Shutdown If Simplex Shutdown 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 configured as the next item. When the PLC shuts down the system, it sets its outputs to their default state or last state, as configured for each block.

Timeout If Simplex Shutdown is enabled, this selects the timeout period. The timeout period may be 0 to 65535 seconds (18.2 hours).

Watchdog This must be the same value as the watchdog timer in the Logicmaster 90-70 CPU Configuration. The default is 200mS.

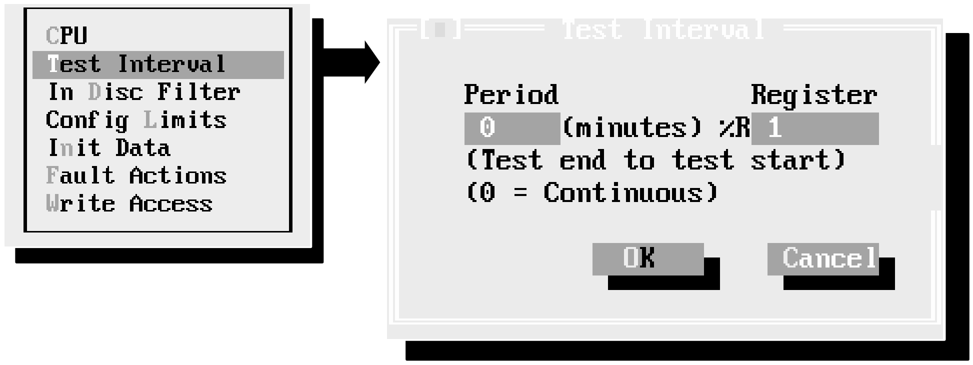
Exiting the Window

When you complete this screen, select OK to return to the System screen. When you select OK, your entries are saved in RAM and the window disappears.

If you want to exit the window *and reset all fields to their previous content,* select Close or Cancel instead.

Test Interval

First, configure the interval for autotesting, and a register where this interval should be stored.



On this screen, enter:

Period Specify an autotest interval of 1 to 65535 minutes. This becomes the time interval the system will wait between autotests of the I/O subsystem.

Register Specify a %R register. When the system is started and goes through initialization, this register is initialized to the period configured (above). The GMR system reads this register to determine the autotest interval. The contents of this register can be modified by the application program or changed using the Logicmaster programming software to alter the autotest interval (if desired) without reconfiguring the system.

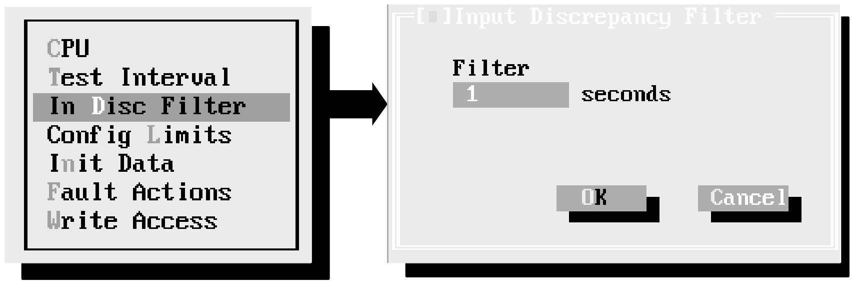
See the Programming chapter for information about %R memory usage in a GMR system.

When you have completed this screen, select OK to return to the System screen.

Exiting the Window

When you select OK, your entries are saved and the window disappears. If you want to exit the window *and reset all fields to their previous content*, select Close or Cancel instead.

Input Discrepancy Filter



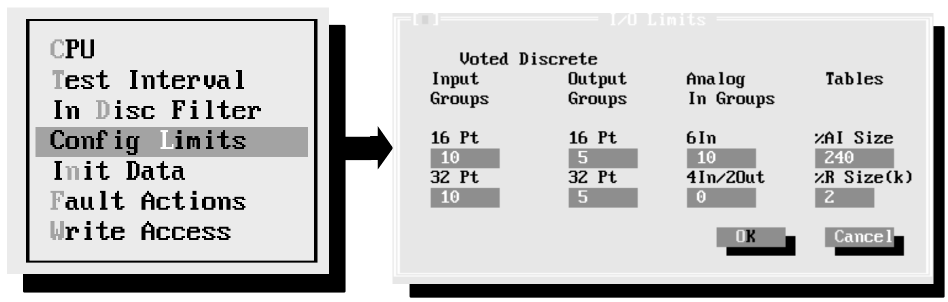
On this screen, enter the input discrepancy filter time in seconds. This is the amount of time, in seconds, that a particular input may be discrepant before the CPU places a message in the I/O Fault Table, and sets the appropriate fault contact for that voted input. This input discrepancy filter time applies to both discrete and analog inputs. This time defaults to one second. The range is 1 to 65535 seconds.

Exiting the Window

When you select OK, your entries are saved and the window disappears. If you want to exit the window *and reset all fields to their previous content*, select Close or Cancel instead.

I/O Limits

Select System again. From the configuration menu, select **Config Limits** (click the mouse on that line or cursor down and press Enter).



Entries made on this screen determine how the GMR software allocates memory. The maximum number of groups that can be configured is 128. Additional parameter limits for this screen are summarized below.

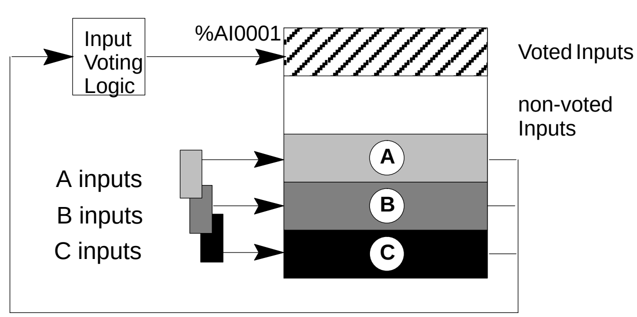
Item	Parameters	Comment
Total number of voted digital inputs and redundant outputs	1...112 (788 CPU) 1...2048 (789 CPU)	In increments of 16 or 32
Number of voted analog inputs	1...1024	In increments of 4 or 6
%AI Analog Input Table size	1...8192	
%R register table size	1 to 16	Specified in increments of 1K

Voted Discrete Enter the number of 16-circuit and 32-circuit discrete input and output groups in the system (plus any spare groups you may add in the future). Each input group may consist of 1, 2, or 3 blocks. The GMR software will assign these voted I/O addresses at the beginning of the I/O tables, and "raw" data addresses at the end of the I/O tables (similar to the illustration of analog inputs, below, and discussed in detail in chapter 7).

Analog In Groups Enter the number of groups made up of 6-input analog blocks and the number of groups made up of 4-input (2-output) blocks. Include any spare groups you may add in the future

Tables Enter the amounts of word memory to be allocated to analog input data (%AI) and register data (%R). These values must match the corresponding values configured using Logicmaster 90.

%AI Size: Allow enough %AI memory to accommodate all analog input data, as explained below. The maximum size is 8192 analog channels (words). %AI memory is divided into sections:



The voted analog references start 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 labelled A, B, and C in the preceding illustration. *Each* of these areas is equal in length to the number of voted inputs at the beginning of the table.

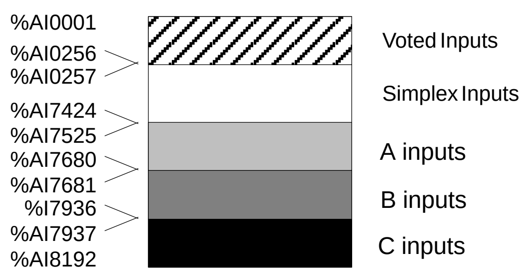
Unused portions of the Analog Input Table may be used for simplex inputs.

Example

The following illustration shows an example Analog Input memory configuration for a system with multiple GMR busses. There are a total of 30 input groups having 6 inputs each, and 19 input groups having 4 inputs each. So the total number of voted inputs is:

(6inputs X 30 groups) + (4 inputs X 19 groups)=256 voted inputs

The simplex inputs could then begin at %AI0257.



Data from an analog block occupies either 4 or 6 input words, depending upon the number of analog input channels on the block.

%R Size: In addition to any other specific %R memory required for the application program, there must be %R memory available to the GMR software for bus controller data and communications data.

To configure the correct amount of %R memory for the application, use this worksheet:

	________	**%R Initialization Data**
+	________	**%M Initialization Data** (number of 16-bit words)
+	________	**%R data needed for the application**
+	________	**%R spare**
+	320 words	**Global Data**
+	________	**(Number of GMR Bus Controllers in CPU x 66 registers)***
=	________	**Total Words of Register Data**

Configure the next higher 1K increment.

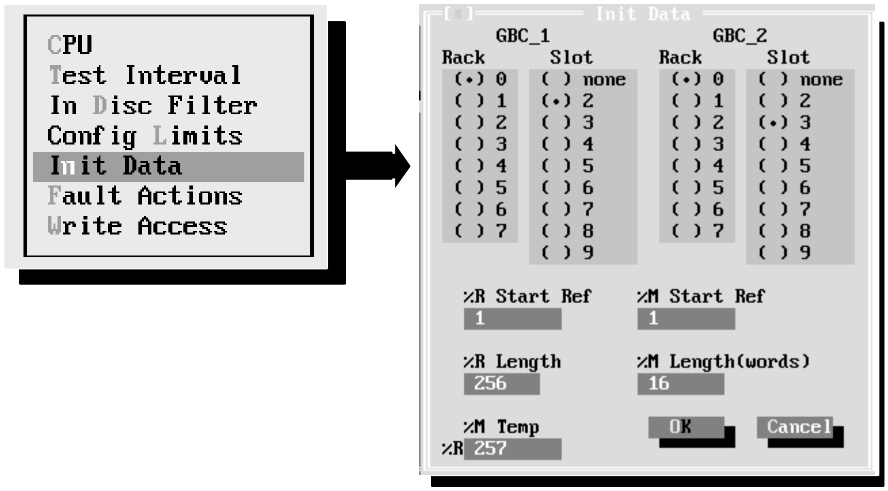
* For more information, please see chapter 7.

Exiting the Window

When you have completed this screen, select OK to return to the System screen. When you select OK, your entries are saved and the window disappears. If you want to exit the window *and reset all fields to their previous content*, select Close or Cancel instead.

Initialize Data

Next, select System to configure the Initialization Data.



Initialization data, as explained in the *PLC Subsystem* chapter of this book, is exchanged between PLCs during startup. It consists of data such as timers and counters and latched logic states.

It is important to be sure that the memory assignments you make here do not directly conflict with %R and %M memory used in the application program or required elsewhere by the GMR software. For more information about memory requirements for GMR, refer to the *Programming* chapter.

GBC_1
GBC_2

Enter the rack and slot location for the two bus controllers in the GMR group that will be exchanging global data. These can be any two bus controllers in the system, but they must be at the same rack and slot location in each PLC.

%M Start Ref

If the PLCs will exchange %M data during startup, enter a starting reference and length in words. (If the PLCs will not exchange %M data at startup, enter 0 in the %M length field).

If another PLC is already online during initialization, 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 data from the PLC with the highest serial bus address into this %M location.

This %M location can be the same as the %M memory used in the application program. It is a temporary storage area that is only used at startup, to store a copy of another PLC's %M data.

It must begin on a byte boundary (multiple of 8, +1). By default, this starting reference is %M0001. The default length (next field) is 16.

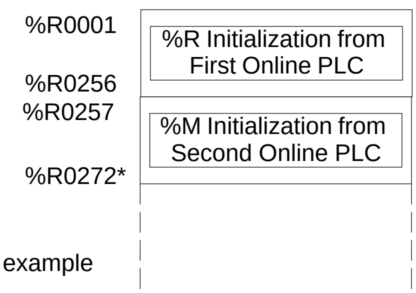
%M Length

Enter the length in words for the %M temporary storage area. It should equal the quantity (in words) of %M memory used in the application program.

%R Temp Ref 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.

In the **%R Temp Ref** field, enter a starting reference in %R memory to receive %M data from the second online PLC. (In this field, the %M refers to the type of data being received. In the two fields on the previous page, it refers both to the type of data being received and the memory location where it will be placed).

Notice that this field shows a 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

%R Start Ref If the PLCs will exchange %R data during startup, enter a starting reference and length in words. (If the PLCs will not exchange %R data at startup, enter 0 in the %R length field. Enter an starting reference for the %R data to be received from the other PLC(s) online during CPU initialization. By default, this starting reference is %R0001.

%R Length Enter a length in words for the %R data. The amount needed depends on %R memory usage in the application program. The default length is 256.

The table below lists *total* limits for these items.

Item	Parame-ters	Comment
Starting reference for %M init. data	1 to 12224	Must be on 8-bit boundaries.
Length of %M initialization data	0 to 764	Length in words. (start ref +16 X length)<=12288 0 if no %M init. data
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.
Starting reference for %R init. data	1 to 16384	
Length of %R initialization data	0 to 4096	0 if no %R init. data

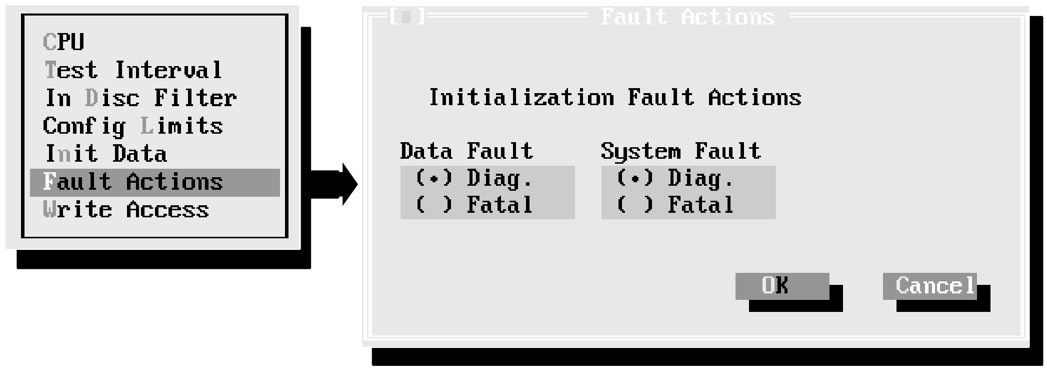
Exiting the Window

When you have completed this screen, select OK to return to the System screen. When you select OK, your entries are saved and the window disappears.

If you want to exit the window *and reset all fields to their previous content,* select Close or Cancel instead.

Fault Actions

Next, select System to configure Initialization Fault Actions:



These entries determine how the GMR software will respond to either of the following faults during CPU initialization:

- an initialization data error (**data fault**)
- a hardware fault (**system fault**)

For each type, select whether the GMR software will:

( ) Halt the PLC (fatal)

( ) Allow the PLC to continue operating (diagnostic) and set the appropriate %M status flag.

%M12232	Init Miscompare at startup
%M12234	System fault at startup

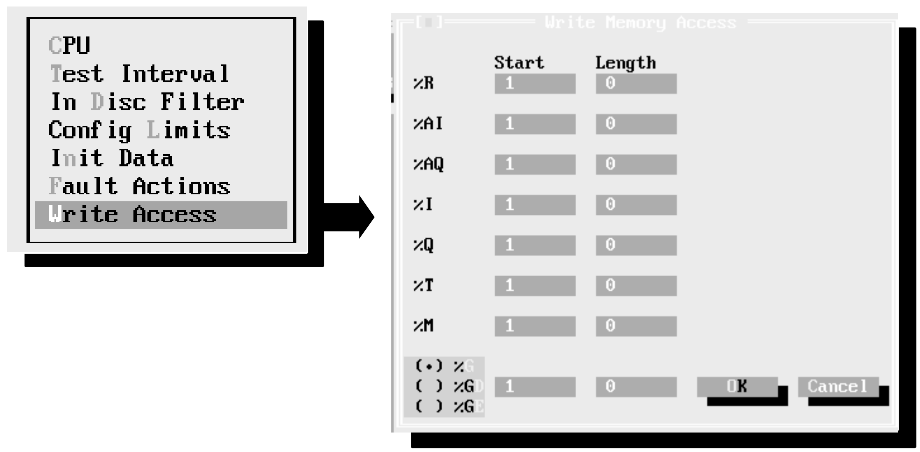
Exiting the Window

When you have completed this screen, select OK to return to the System screen. When you select OK, your entries are saved and the window disappears.

If you want to exit the window *and reset all fields to their previous content*, select Close or Cancel instead.

Write Access

Next, select System to configure Write Access:



On this screen, you can configure starting addresses and lengths for any memory areas to which data can be written to through a CMM, PCM, or Ethernet Communications Module. These configuration parameters do not prevent write access through Genius Bus Controllers, the CPU's built-in port or with serial or parallel Logicmaster 90-70.

The following memory areas can potentially be written to:

%R	Registers
%AI	Analog Input Table
%AQ	Analog Output Table
%I	Discrete Input Table
%Q	Discrete Output Table
%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

The Start parameter for each memory area is the start of the address range to which write access will be permitted. It may be from 1 to the maximum table size.

The Length parameter is the length of the address range to which write access will be permitted. A value of 0 (the default) 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...)

Global Data **%GA**, **%GB**, and **%GC** memories are not available. Those memory areas are used by the GMR system to exchange data (as explained on page 7-27), and cannot be accessed directly.

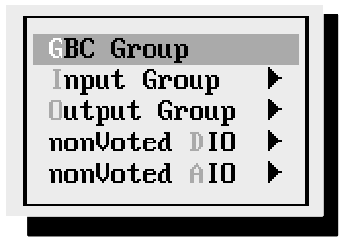
Exiting the Window

When you have completed this screen, select OK to return to the System screen.

When you select OK, your entries are saved and the window disappears. If you want to exit the window *and reset all fields to their previous content*, select Close or Cancel instead.

Adding Bus Controllers and I/O Modules

When you select Insert from the System screen, the following menu appears



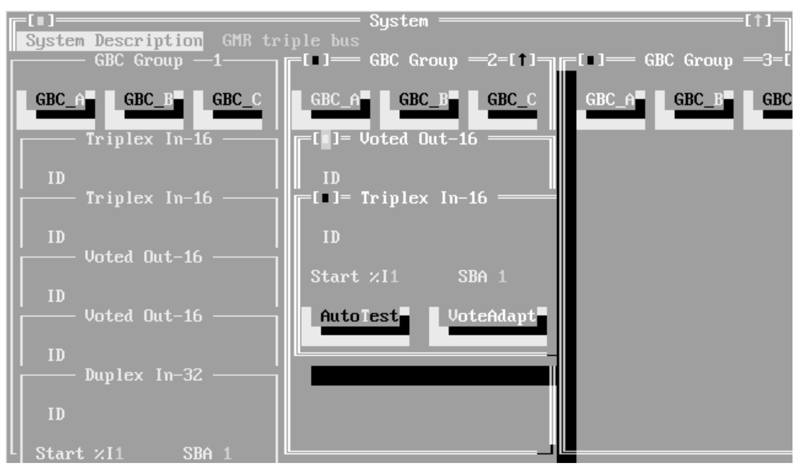
Configure Bus Controller groups
Configure Input Group
Configure Output Group
Configure non-voted discrete I/O
Configure non-voted analog I/O

Create the configuration by selecting items from the menu, then completing entries on the screens that appear. Instructions for completing these screens begin on the next page.

To display the configuration screen for the currently-highlighted menu selection, click on it with the mouse or press the Enter key.

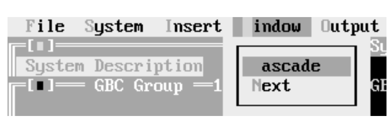
The Bus Controller and I/O group configuration windows have some additional mouse or keyboard features not used in other configuration windows.

On the example screen below, three Bus Controller groups have been configured. Group 1 has five input and output block groups. Group 2 has two I/O block groups. No I/O has yet been configured for Bus Controller Group 3.



On this screen, you can move between Bus Controller groups by clicking the mouse on the group you want or by pressing the Alt key then entering the number of the Bus Controller group.

If you want to display all of the I/O group windows as they are shown above, select Windows, then Cascade from the functions at the top of the screen.



Genius Bus Controller Group Configuration

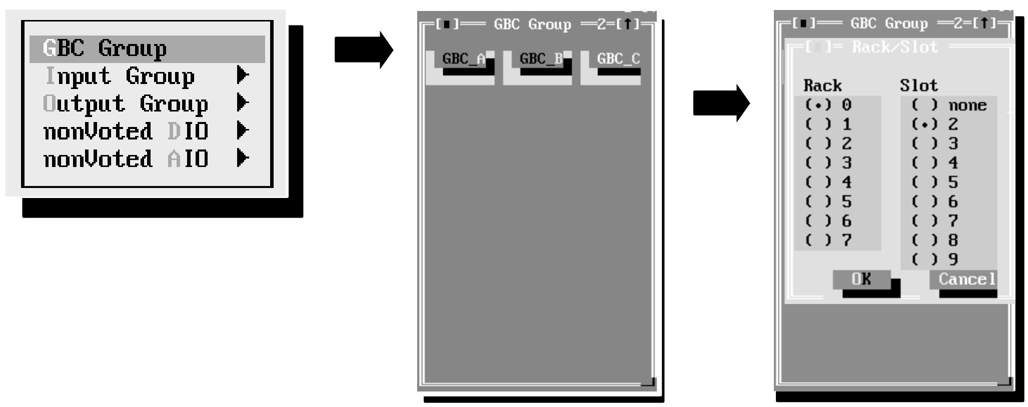
Note: It is possible that an application may include bus controllers in the PLC racks that are not part of the GMR system. *Do not include non-GMR bus controllers in the GMR configuration*. The only exception to this is a bus controller pair that is used for global data communications between PLCs. (Other, non-GMR bus controllers are included in the Logicmaster configuration *only*).

In each PLC, GMR Bus Controllers must be installed in the same rack and slot locations. The first default rack and slot locations are:

bus controller "A":	rack 0, slot 2
bus controller "B":	rack 0, slot 3
bus controller "C":	rack 0, slot 4

If those are the actual bus controller rack and slot locations that will be used for this GBC group, you can use the defaults and skip directly to the next step.

Click the mouse on the GBC Group button, or cursor to it and press the Return key.



This display represents the three bus controllers that would be present in the PLC system for a triple bus. They are shown as "GBC A, GBC B, and GBC C". If there are fewer bus controllers, they can be identified in any combination. For any bus controller not present, select "none" as the slot.

On the middle window shown above, you can use the Tab key to select bus controller A, B, or C. Use the space bar key to display the Rack / Slot configuration data for the selected bus controller.

To configure a bus controller rack / slot location, select **GBC_A**, **GBC_B**, or **GBC_C**, and press the space bar key. The rack / slot configuration window (shown on the right above) for that bus controller appears.

By default, bus controller A is specified in rack 0, slot 2, as shown. To edit rack / slot location choices, use the tab keys to move from field to field. Use the cursor keys to move within a field. When both the rack and slot locations are correct for the bus controller, select [O]K.

Complete the same steps for other bus controllers in the same group.

Exiting the Window

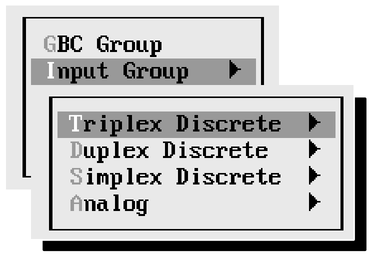
Normally, the GBC (Genius Bus Controller) group window remains on the screen, so you can insert the I/O groups for that bus controller group. (It must be the “active” window (identified by the double line border) to insert an I/O group into it).

However, if you want to exit the window, *and delete the window from your configuration*, click on the Close button in the upper left corner of the window. Be aware that in this window, and in the windows for I/O blocks and in the System screen window, clicking on the Close button deletes the window and its content. This is different from operation of the Close button in windows that are part of the standard GMR default configuration (for example, the CPU Configuration window), where default entries may be used.

Configuring the Input Subsystem for a Bus Controller Group

With the rack and slot locations for a bus controller group configured, the next step is to configure the input subsystem for that bus controller group.

Click on Insert or press ALT–I to display the Insert menu. Select Input Group from the menu by clicking on that item or by pressing [I]. Click on the type of group to insert, or press its highlighted letter key, or use the cursor keys to select an item then press the Return key to display a sub-menu of input block types:



From this menu, select and configure the types of input groups in the input subsystem.

Select:	To Configure:
triplex discrete	each group of three input blocks
duplex discrete	each group of two input blocks
simplex discrete	each “group” of one input block
analog	each group of analog blocks

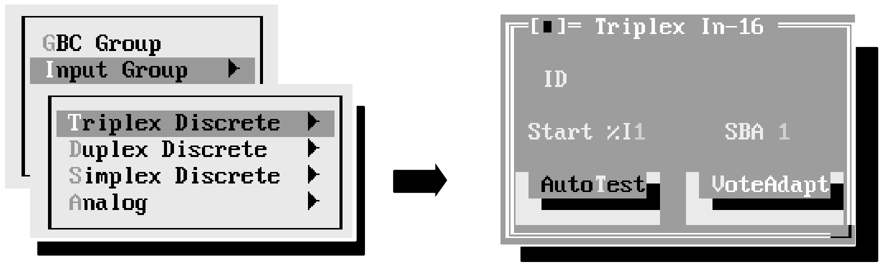
After you select the group type, additional configuration screens appear for configuring the GMR features for that group. See the instructions on the following pages.

Exiting a Block Group Window

When you have completed a block group screen, you can continue to configure another block group.

Configuring a Triplex, Duplex, or Simplex Discrete Input Group

To configure a discrete group, click on that line, or move the cursor there and press the Return key, or press the highlighted letter key. Then select whether the blocks in the group are 16-point or 32-point blocks. For example:



A configuration screen like the one shown above right appears. To item on this screen, use the Tab key or mouse.

ID Enter a name or a description of up to 12 characters, such as "in group 3". This entry is for your information only. It is not used by the GMR software.

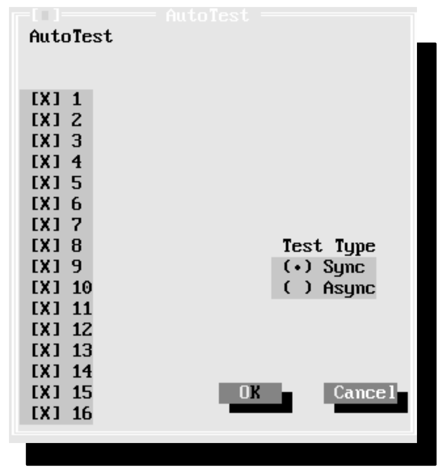
Start %I Enter the starting %I Input Table reference for the group. This is the %I address of the voted input data. The actual %I references used for the input data from each block are configured using the Logicmaster 90 software. This configuration utility will provide a printout of the addressing required for Logicmaster 90. The allowable reference ranges are:

0001 to 0112 (788 CPU)
0001 to 2048 (789 CPU)

Duplicate addresses are not allowed within a GBC group. You will not be permitted to continue until you have entered a unique address.

SBA Enter a serial bus address (also referred to as the "device number") from 0 to 28. Duplicate bus addresses are also not permitted within a GBC group. *However, each block in the group uses the same serial bus address on its respective bus.*

Auto Test Highlight this item then press the space bar key to display a screen for setting up Input Autotest and Test Type for individual circuits (screen for 16-circuit blocks shown here).



If input circuits on the blocks in the group should be autotested, circuit 16 (the powerfeed output) must have autotest enabled. If no circuits are to be autotested, circuit 16 can have autotest disabled, and input devices can be wired directly to the power source instead of being wired to circuit 16 (the powerfeed output).

By default, each circuit is set up for autotesting, as shown by the X next to the circuit number. To turn off autotesting, select that circuit (click on the circuit or select it using the cursor keys). Press the space bar to remove the X. **Note:** For all unused circuits on the blocks, autotest should be set to off. Also, it is possible for an input block to include I/O circuits that are not part of the GMR system, and which are not to be autotested. *Be sure to turn autotest off for non-GMR circuits.*

Test Type: Select whether the testing should be Synchronous (the default) or asynchronous.

Asynchronous Autotesting: allows the input autotest to continue executing on other blocks in a group which 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 blocks.

Synchronous Autotesting: synchronous input autotesting 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. See page 4-18 for more information.

1.) Loss of a block within the group. (I.E. any failure which causes the block to no longer communicate on the Genius Bus such as loss of power.)

2.) Autotest failure of the power feed output (point Q16) of any of the blocks in a group.

For discrete output groups there are also two types of faults which may prevent the output autotest from continuing to execute for that output group and thus cause an I/O shut down for the outputs in the group.

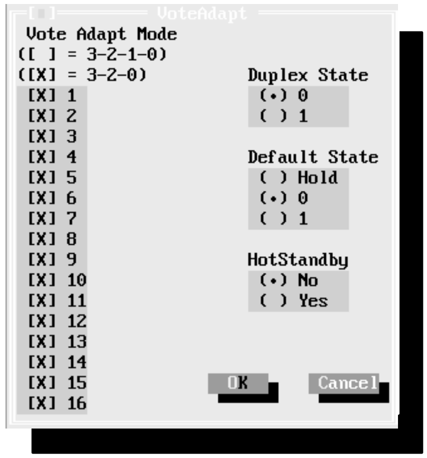
1.) Loss of a block within the group. (I.E. any failure which causes the block to no longer communicate on the Genius Bus such as loss of power.)

2.) Output autotest failure detected of a type which could potentially prevent a normally energized output from being tripped off. An example is the short of a source block output to +24 Vdc.

After completing the selections for Autotest, select OK.

Vote Adaptation

Similarly, select which Voting Adaptation method will be used for each circuit.



Vote Adapt Mode: Specify the manner in which the PLCs should perform voting adaptation. During operation, if a failure (discrepancy fault, Autotest fault, or Genius fault) occurs, the GMR software will reject the faulty data and perform voting adaptation as configured here.

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

For a simplex group, select 3–2–1–0.

Duplex State:

For a triplex group, the Duplex State determines the vote type when there are just two inputs present. Its operation is described on page 4-8.

- 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 duplex group, this state is used as the third input in the 2 out of 3 vote.

For a simplex group, this field does not apply.

Default State: Choose a default state: OFF (0), ON (1), or hold last state.

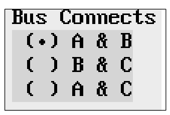
For a triplex group, this state will be provided to the application program if communications from all three blocks in the group are lost (if Voting Adaptation is 3–2–1–0). Alternatively, if Voting Adaptation is set to 3–2–0, this state is provided to the application program if communications from two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

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

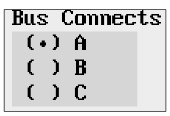
For a simplex group, this state will be provided to the application program if communications from the single block are lost.

Hot Standby: Select whether unused circuits to be used as outputs will operate in Hot Standby mode (see chapter 3 for a description of Hot Standby operation).

Bus Connects: a triplex group connects to all three busses, so no entry is needed for Bus Connects. For a duplex or simplex group, specify the bus connections as explained below.



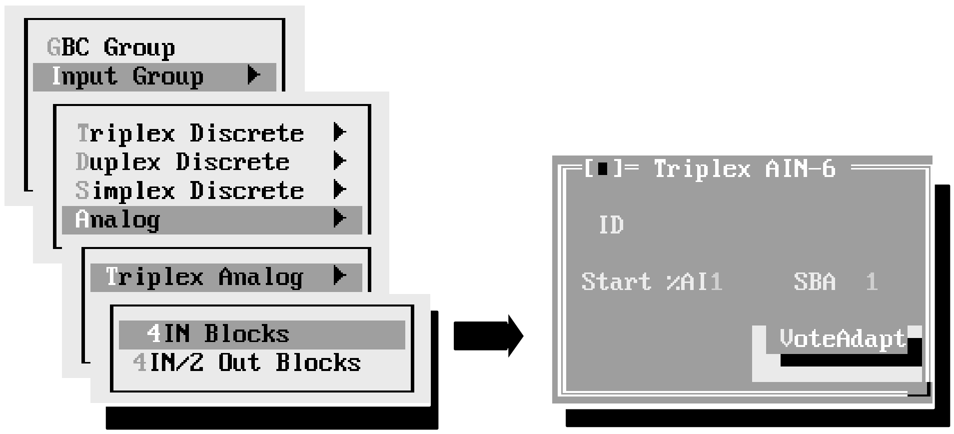
For a duplex group, configure the two busses the group is connected to: **A** (from the PLC using serial bus address 31) and **B** (from the PLC using serial bus address 30), or **B** and **C** (the PLC using serial bus address 29) or A and C.



*For a simplex group, c*onfigure the bus the group is connected to: **A** (from the PLC using serial bus address 31), **B** (from the PLC using serial bus address 30), or **C** (from the PLC using serial bus address 29).

Analog I/O Group Configuration

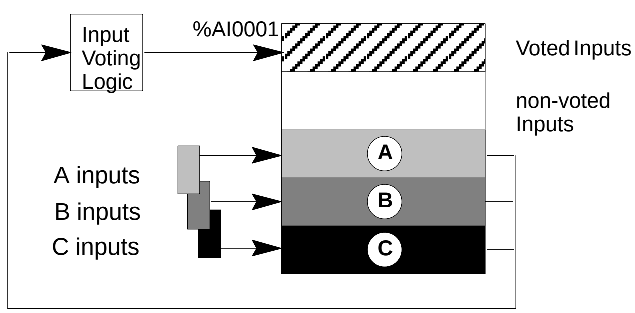
Select Analog to configure any analog group. Select a triplex, duplex, or simplex analog input group, then select the block type (6 inputs or 4 inputs/2 outputs). For example:



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 Analog from the menu of analog group types as described above.

ID — Enter a name or a description of up to 12 characters, such as "in group 6". This entry is for your information only. It is not used by the GMR software.

Start %AI — The voted analog references start at %AI0001. The size of the voted analog input area is determined by the number of voted analog inputs including spares. Within this area, enter the starting %AI Input Table reference for the block. This will be the %AI address of the voted input data. The actual %AI references used for the "raw" input data from the block (shown as A inputs, B inputs, C inputs in the diagram below) are configured using the Logicmaster 90 software. The GMR configuration software will provide a printout of the addressing required for Logicmaster 90. The allowable reference range is 1 to 1024.



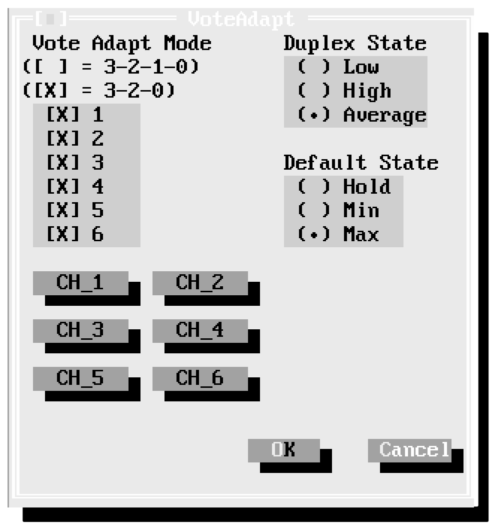
Duplicate addresses are not allowed within a GBC group. You will not be permitted to continue until you have entered a unique address.

SBA — Enter a serial bus address from 0 to 28. Duplicate bus addresses are also not permitted within a GBC group. *However, each block in the group uses the same serial bus address on its respective bus.*

Vote Adaptation

Specify how each circuit in a triplex or duplex group should utilize vote adaptation For a simplex group, this option does not apply.

If a failure (discrepancy fault, or Genius fault) occurs, the GMR software rejects the faulty data. Depending on the configuration entered here, 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.



For a 4 input/2 output block group, the window shows only four inputs.

Vote Adapt Mode:

For a Triplex 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 duplex 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.

Duplex State:

For a triplex group, the Duplex State determines the vote type when there are two analog inputs present. It may be configured as the higher actual input value, the lower value, or an average of the two. For more information, see page 4-13.

For a duplex group, the voted input data can be:

- an average of the two channels that are present.
- mid-value selection based upon the two input channels that are present, with the third (unused) channel assigned to its configured low value.
- mid-value selection based upon the two input channels that are present, with the third channel assigned to its configured high value.

For a simplex group, this information is not used.

Default State:

For a triplex 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, the GMR system software will use a selected minimum or maximum value (see below) in voting, or hold the last value updated.

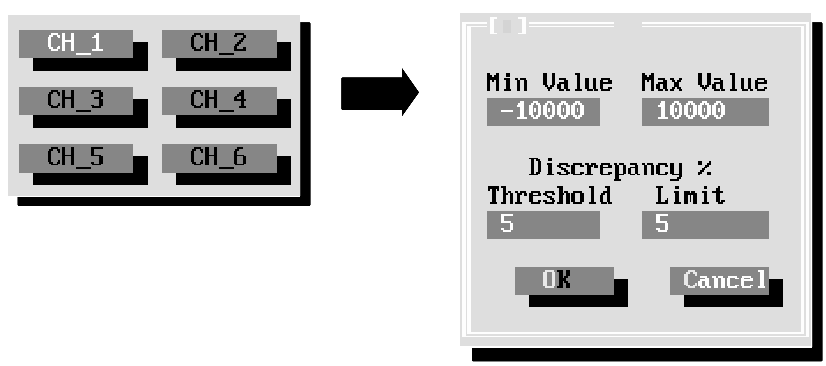
For a duplex group, select what should happen if both inputs for a channel are lost or if one block is lost and Voting Adaptation is selected as 3–2–0. The input can be:

- set to its configured maximum value.
- set to its configured minimum value.
- Hold its last value.

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

Maximum, Minimum: The maximum and minimum values (shown in the next illustration) entered for an input represent the block's configured engineering units. The maximum and minimum values are used in two ways. First, either the specified maximum or minimum value can be used as the Default State if actual input data for that channel is not available. Second, the maximum and minimum values entered here represent the full-scale deflection for the input. They are used by the software to monitor the point for limit discrepancy. This is explained in more detail on the next page.

Enter a maximum and minimum value for each GMR analog input channel by first selecting the channel (using the mouse or Tab and Return keys).



The range for either **maximum** or **minimum** is –32767 to +32767.

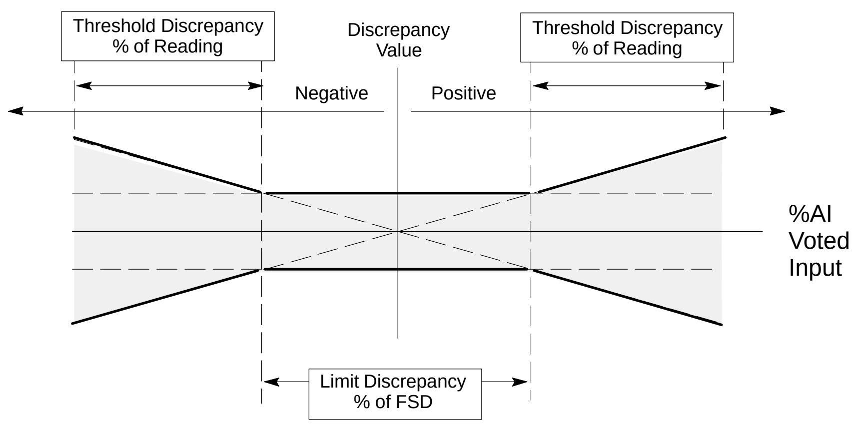
Threshold Discrepancy: Specify by what percent an individual input for the channel may deviate from the voted input value. During operation, if any of the corresponding physical inputs deviates from the voted input value by more than this amount (in either direction), it will generate a fault that must be cleared by the application program.

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.

Limit Discrepancy: 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). During operation, if any of the corresponding physical inputs deviates by more than this amount (in either direction) from the voted input value, it will generate a fault that must be cleared by the application program.

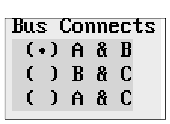
For example, if the physical inputs for a channel were 9, 10, and 15, and the full scale deflection were configured at 200, with a **limit discrepancy** of 10%, the voted input would be 10 and all three inputs would be within the discrepancy limit (of 20), and no fault would be reported.

Analog Discrepancy Thresholds and Limits

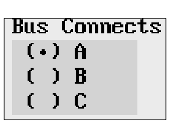


NOTE: Both a Threshold Discrepancy and a Limit Discrepancy must exist for a input channel before an Analog Input Discrepancy is logged in the fault table.

Bus Connects: a triplex group connects to all three busses, so no entry is needed for Bus Connects. For a duplex or simplex group, specify the bus connections as explained below.



For a duplex group, configure the two busses the group is connected to: **A** (from the PLC using serial bus address 31) and **B** (from the PLC using serial bus address 30), or **B** and **C** (the PLC using serial bus address 29) or A and C.

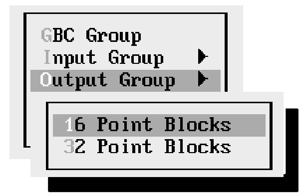


*For a simplex group, c*onfigure the bus the group is connected to: **A** (from the PLC using serial bus address 31), **B** (from the PLC using serial bus address 30), or **C** (from the PLC using serial bus address 29).

Configuring the Output Subsystem for a Bus Controller Group

Next, configure the output subsystem for that bus controller group.

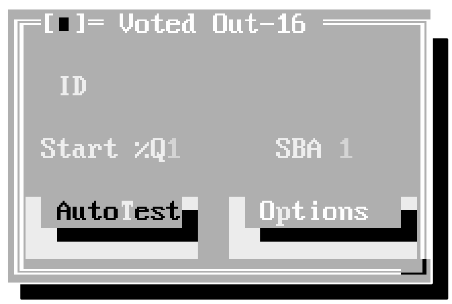
Select Output Group from the menu.



Repeat the following procedure for each group in the output subsystem:

Note: It is possible for a bus to include output blocks that are not part of the GMR system. *Do not include non–GMR blocks in the GMR configuration.* Non-GMR blocks are included in the Logicmaster configuration and in the Genius block configuration, however.

Select either 16-circuit Blocks or 32-Circuit Blocks from the menu. An additional configuration screen appears to configure the GMR features for that group.



On this screen, use the tab key to move from item to item.

ID Enter a name or a description of up to 12 characters, such as "out group 1".

Start %Q Enter the starting %Q Input Table reference for the group (all blocks in the group will have the *same* Output Table reference addresses). The allowable reference ranges are:

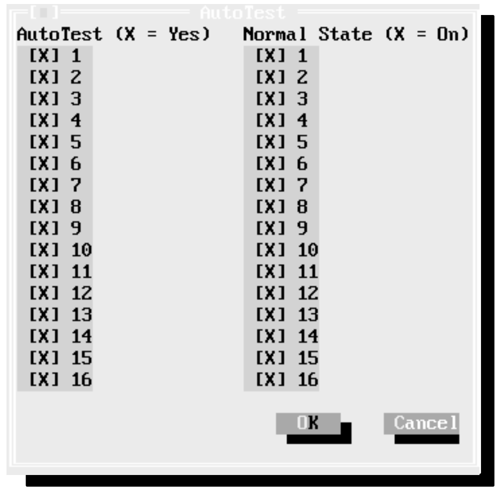
0001 to 0080 (788 CPU)
0001 to 2048 (789 CPU)

Duplicate addresses are not allowed within a GBC group. You will not be permitted to continue until you have entered a unique address.

SBA Enter a serial bus address (also referred to as the "device number") from 0 to 28. *Each block the group uses same serial bus address on its respective bus.* The exception to this is the 4th block ("block D") in the output group, which will have its SBA identified in the "Options" window.

Auto Test Highlight this item then press the space bar key to display a screen for setting up Output Autotest for the output circuits. Follow the instructions on the next page to complete the entries on that screen.

Autotest: By default, each circuit is set up for autotesting, as shown by the X next to the circuit number. To turn off autotesting for any circuit, select that circuit (click on the circuit or select it using the cursor keys). Press the space bar key to remove (or replace) the X.

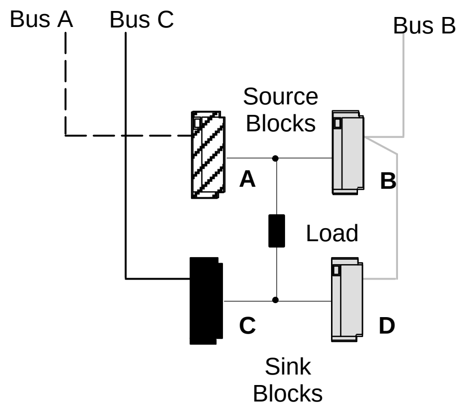


Note: It is possible for an output block to include circuits that are not part of the GMR system, and which are not to be autotested. *Be sure to turn autotest off for any unused and non-GMR circuits.*

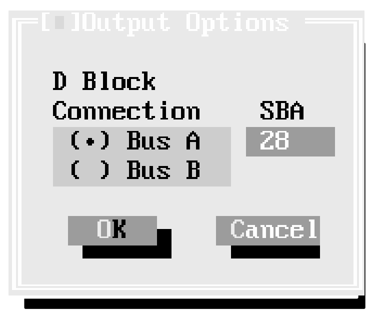
Normal State: By default, each circuit is set up to have On as its Normal (non-alarm) State for purposes of autotesting. The selection is shown by the X next to the circuit number. If the autotest alarm state of any circuit should be Off, select that circuit (click on the circuit or select it using the cursor keys). Press the space bar key to remove (or replace) the X.

Options

Finally, for each 4-block group, specify the bus and location (serial bus address) of the fourth block (the “D” block) in the group. While the A, B, and C blocks are installed on busses A, B, and C, respectively, the D block must be installed on either bus A or bus B (as in the illustration shown below).



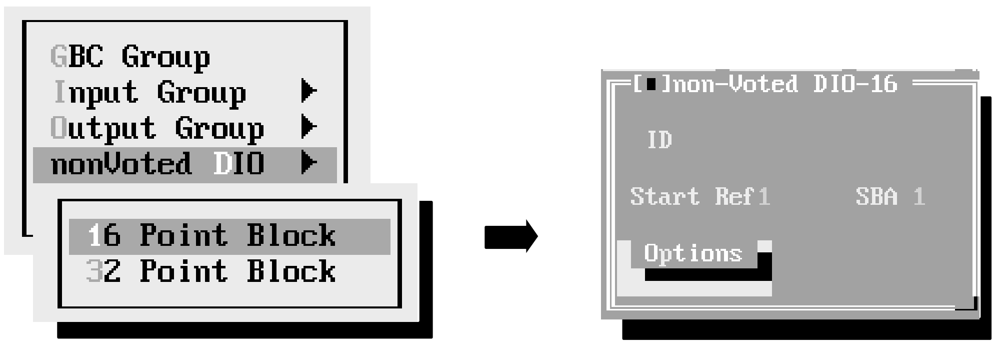
While busses A, B, and C can use the same serial bus address on their respective busses, block D, which is on the same bus as either block A or block B, must have a different serial bus (because each device on a Genius bus must have a *unique* serial bus address).



Configuring the Non-Voted Discrete I/O for a Bus Controller Group

If the bus controller group includes any non-voted discrete I/O, select nonVoted D I/O (Inputs and outputs may be mixed on a block.) Non-voted I/O are inputs and outputs on individual blocks (blocks that are not part of an input or output group) that are present on the GMR busses.

A sub-menu appears where you specify whether the blocks in that particular group are 16-point or 32-point blocks. For example:

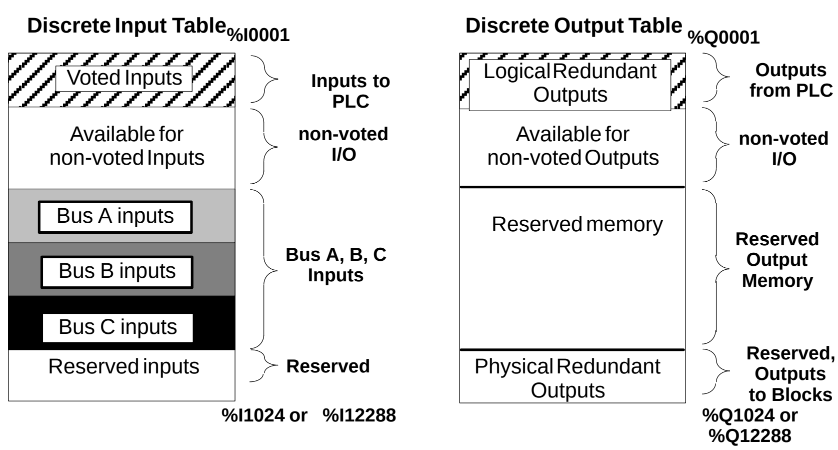


Press Return to configure the block. The configuration screen shown at the right appears.

ID Enter a name or a description of up to 12 characters, such as "nonvoted 1". This entry is for your information only. It is not used by the GMR software.

Start Ref Enter the starting I/O Table reference for the block. This is the %I and %Q addresses used for the block's I/O data.

Voted I/O data and non-voted I/O data use different areas of the I/O tables. This is shown below, and explained in more detail on page 7-5. (Discrete I/O tables are shown; the analog I/O tables are similar).

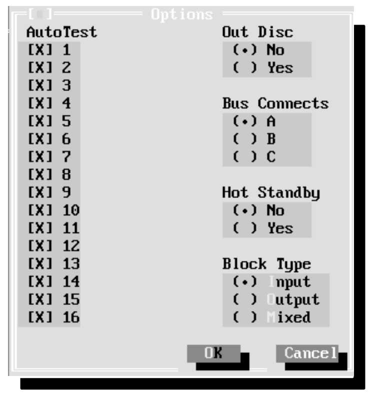


The starting address for non-voted data depends on the amount of redundant data, as explained in chapter 7.

Duplicate addresses are not allowed within a GBC group. You will not be permitted to continue until you have entered a unique address.

SBA Enter a serial bus address (also referred to as the "device number") from 0 to 28.

Options Select this item to display additional configuration choices.



Input Autotest: This feature applies to 16- and 32-circuit DC Sink / Source I / O Blocks IC660BBD020, 021, 024, and 025 only. The block can be either in GMR mode or not in GMR mode.

If any input circuits on the blocks in the group should be autotested, select them here. Circuit 16 must have autotest enabled. If no circuits are to be autotested, circuit 16 can have autotest disabled and input devices can be wired directly to the power source instead of being wired to circuit 16.

By default, each circuit is set up for autotesting, as shown by the X next to the circuit number. To turn off autotesting for any circuit, select that circuit (click on the circuit or select it using the cursor keys). Press the space bar key to remove the X. **Note:** For all unused circuits on the block, autotest should be set to off. Also, it is possible for an input block to include I / O circuits that are not part of the GMR system, and which are not to be autotested. *Be sure to turn autotest off for non-GMR circuits.*

Output Discrepancy: Specify whether the block should report output discrepancies. This applies to 16- and 32-circuit DC Sink/Source I/O Blocks IC660BBD020, 021, 024, and 025 only. The block ***must be*** in GMR mode.

Bus Connect: Select the bus to which the block is connected.

Hot Standby: Specify whether the block should use Hot Standby output redundancy. This feature applies to 16- and 32-circuit DC Sink / Source I / O Blocks IC660BBD020, 021, 024, and 025 only. Operation of Hot Standby mode is described in chapter 3. If the block is not in GMR mode, selecting Hot Standby here tells the system to configure the block to send fault reports to three PLCs.

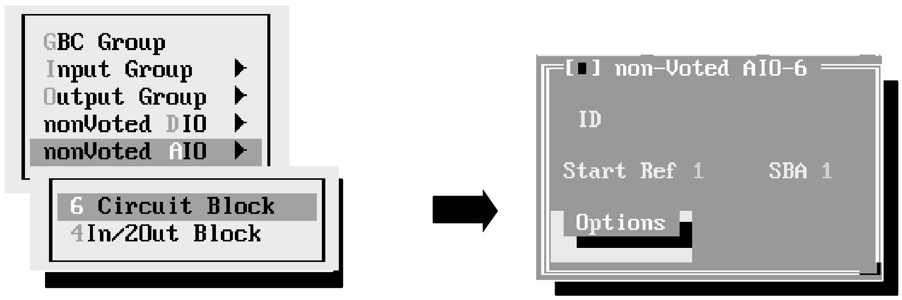
Block Type: Specify input, output, or mixed I / O. If the block will use the Input Autotest feature, it must be set up as a mixed I / O block.

Configuring the Non-Voted Analog I/O for a Bus Controller Group

If the bus controller group includes any non-voted analog I/O, select **nonVoted A I/O**.

Note: Non-voted analog I/O blocks that are configured here are considered part of the GMR system. It is possible for a bus to include I/O blocks that are not part of the GMR system. *Do not include non–GMR blocks in the GMR configuration.* Non-GMR blocks are included in the Logicmaster configuration and in the Genius block configuration, however.

A sub-menu appears where you specify whether the blocks in that particular group are 6-input or 4 input/2 output blocks. For example:



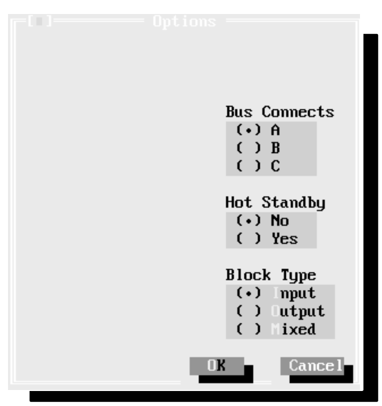
ID Enter a name or a description of up to 12 characters, such as "nonvoted 2". This entry is for your information only. It is not used by the GMR software.

Start Ref Enter the starting Analog I/O Table reference for the block. This is the %AI and/or%AQ addresses used for the block's I/O data. The allowable references are: 0001 to 8192

Duplicate addresses are not allowed within a GBC group. You will not be permitted to continue until you have entered a unique address.

SBA Enter a serial bus address from 0 to 28.

Options Select this item to display additional configuration choices.



Hot Standby: Hot standby mode is supported for analog blocks. This mode allows analog outputs to respond to CPU A or B. Selecting Hot Standby here tells the system to configure the block to send fault reports to three PLCs.

Bus Connect: Select the bus to which the block is connected.

Block Type: Specify input, output, or mixedI/O.

Creating the G_M_R10 Output File

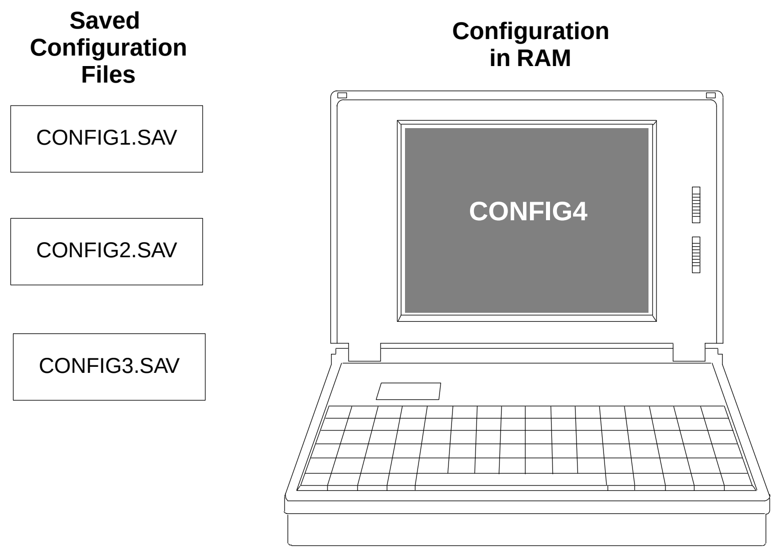
The output of the GMR configuration process is a program block named G_M_R10, which can be imported to the application program folder in Logicmaster 90.

The Write Output function of the GMR configuration software automatically creates a file named G_M_R10.EXE. This is the file required by Logicmaster 90.

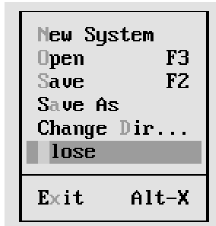
If the configuration you want to use is not the one currently displayed, first use the file utilities of the GMR configuration software to load it into RAM memory.

Example:

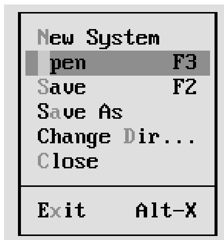
Previously, you created and saved three different configuration files, named CONFIG1, CONFIG2, and CONFIG3, as represented below. All three files are currently stored on your hard disk. A different configuration, CONFIG4, is currently in RAM memory.



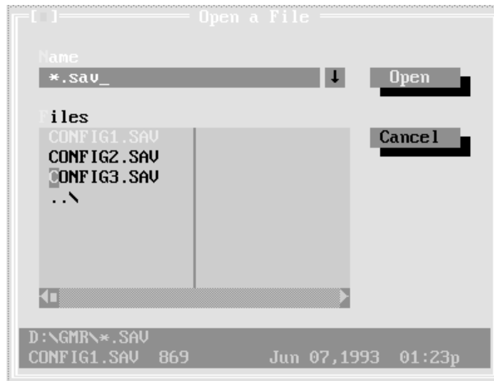
At this point, you decide you want to use CONFIG3 as the GMR configuration for the application. First, you need to load CONFIG3 into RAM memory. If you wanted to keep the file already in RAM memory, CONFIG4, you would need to use the file functions of the GMR software to save it.



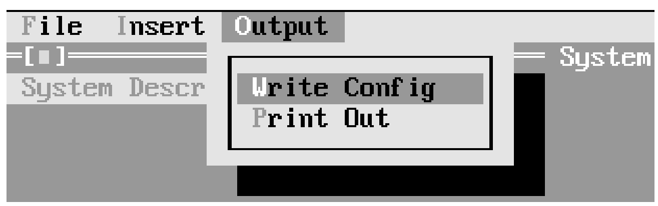
In this example, you decide that you don’t want to keep CONFIG4, so you go to the file functions and select **Close.** That ends the configuration session without creating a .SAV file.



Next, you select **Open a Configuration File**. A list of files appears:



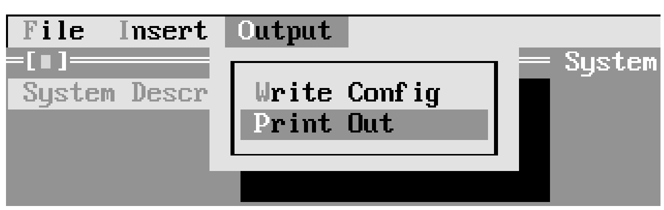
Click on the name of the .SAV file you want, or type in its filename. When the filename appears in the name box, click on **Open**. The configuration file is loaded into RAM. With the correct configuration file displayed, select **Output: Write Config** to create a G_M_R10 output file.



After creating the file, you can add it to the application program as instructed on page 7-29.

Printing the GMR Configuration

When the GMR configuration is finished, select **Output** to print it out. The GMR software establishes many parameters of the system configuration that you will need to be familiar with during Logicmaster configuration and Genius block configuration.



Printing defaults to the parallel port of the computer running the GMR Configuration Software. If you want to redirect printing to a serial port, exit to DOS and use the DOS “mode” command, as instructed in your DOS manual.

Completing the Logicmaster 90 Configuration

Logicmaster 90 configuration steps for a PLC In a GMR system are the same as for a non-GMR system. A typical configuration is summarized on the following pages. You should refer to the *Logicmaster 90 Software User's Manual* for detailed configuration instructions.

Since the configuration and program for the redundant PLCs in a GMR system are nearly identical, it is easiest to complete the configuration (and program) for one PLC, then copy and edit them for the other PLCs.

- One necessary change in the configuration is to edit the serial bus addresses (also referred to in other Genius documentation as "device numbers" of the Bus Controllers). See below.
- Genius I/O blocks use the same reference addresses in each of the redundant PLCs, so reference addresses are not changed from PLC to PLC.

It is very important to be sure that entries made during Logicmaster configuration match similar entries made during GMR configuration. Complete the GMR configuration first, print it out, and use the printout for reference during the Logicmaster configuration.

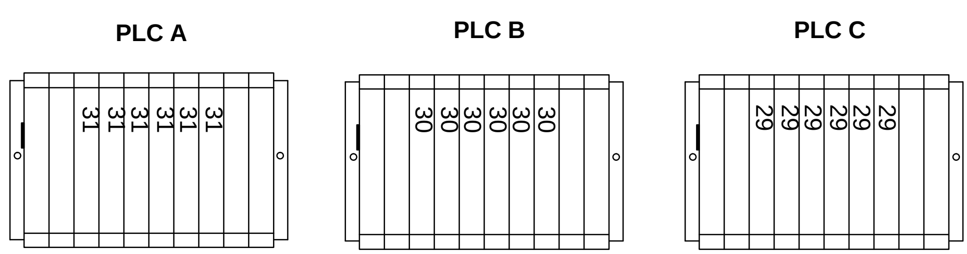
Configuring Bus Controllers

A Series 90-70 PLC can have up to 31 Genius bus controllers. In a GMR system, bus controllers 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.

All Genius bus controllers that are included in the GMR system must be assigned serial bus addresses (device numbers) as follows:

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.



Creating and Copying the PLC Configuration

The recommended method of completing the PLC configuration is described below.

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. 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.

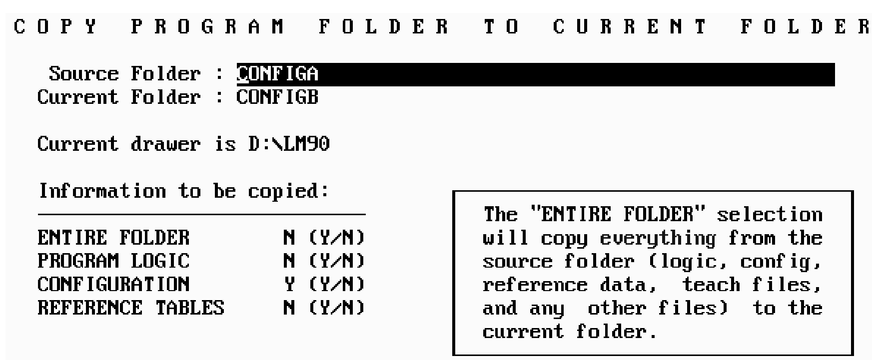
(1) From the Logicmaster configuration software, return to the Logicmaster programming software. Select the Program Folder functions.

(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 Prog ram 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.



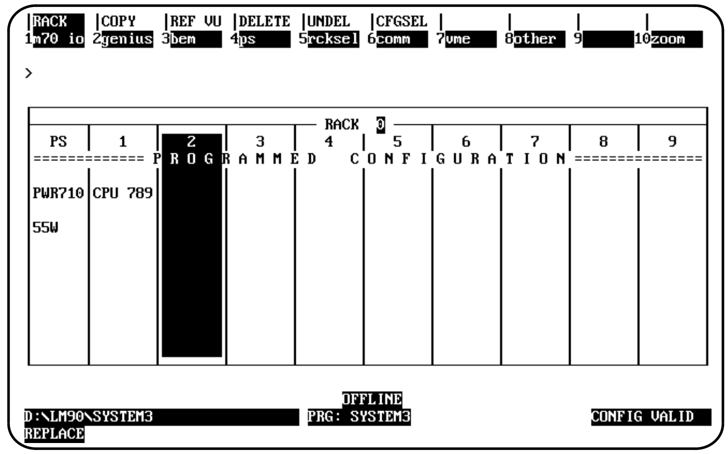
D. If there are three PLCs, repeat this for the other PLC.

E. Edit the configurations for PLC B and PLC C as necessary.

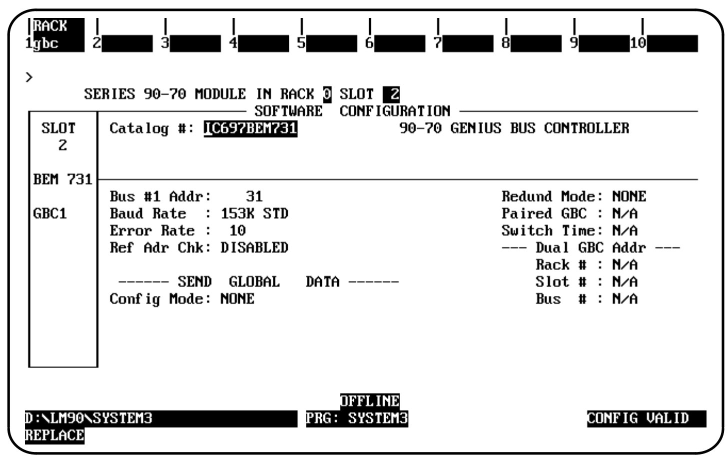
Logicmaster Configuration Summary

1. Change the CPU to the correct type (in this example, it is a CPU 789) and add appropriate memory.
2. Move the cursor to the rack and slot location for the first Bus Controller.

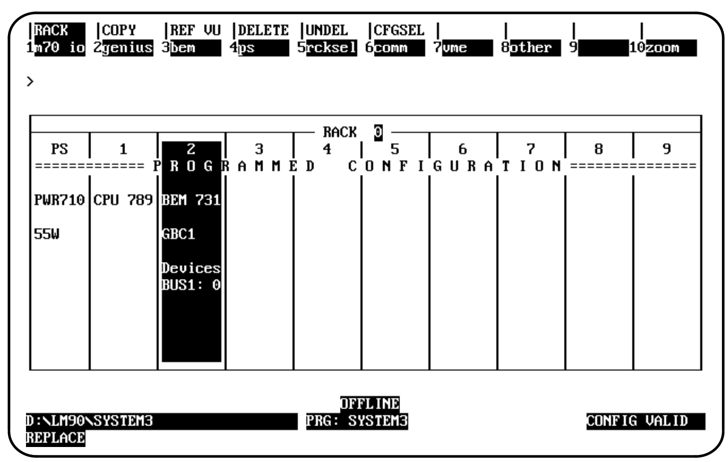
   Be sure the location matches the entry made with the GMR Configuration Software.
3. Press F2 (genius).
4. From the Catalog # screen, press F1 (gbc).
5. From the Description screen, press Enter.



6. Complete the entries on the left side of the screen. Remember that all of the bus controllers in the PLC must have the same serial bus address (31 in the illustration at right). Leave the **Ref Adr Chk** selection disabled (the default).
7. On the right side of the screen, leave **Redund mode** set to NONE. The entries below it cannot then be edited.

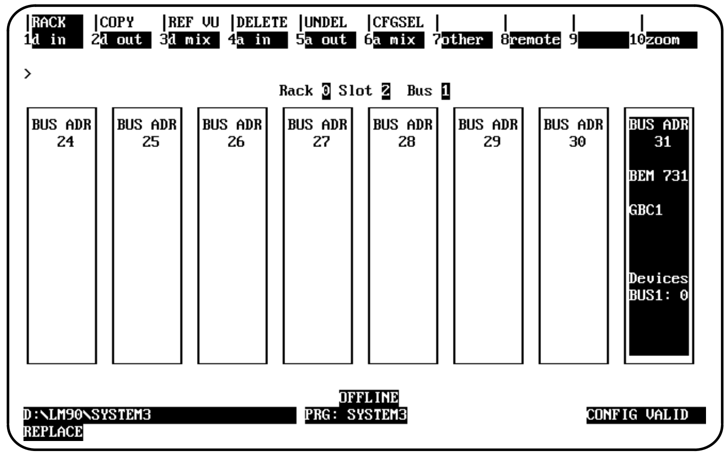


8. *If this Bus Controller was configured in the INIT DATA window of the Configuration utility*, for Global Data, set the field for **Config Mode** to MANUAL. Enter a beginning %R reference and length (64) for global data. See the Programming chapter of this book for more information about Global Data addressing.
9. Press the ESC key to return to the rack configuration screen.
10. The rack configuration screen now includes the Bus Controller.
11. Press F10 (zoom) to go to the bus configuration screen.



12. On the bus configuration screen, the Bus Controller appears at its configured Bus Address, 31 in this example.

13. 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. In addition, the bus controllers on a Global Data bus must be configured with an appropriate Global Data address and length.*



When configuring I/O blocks, be sure to match I/O address assignments and serial bus addresses of GMR blocks to those made using the GMR Configuration Software.

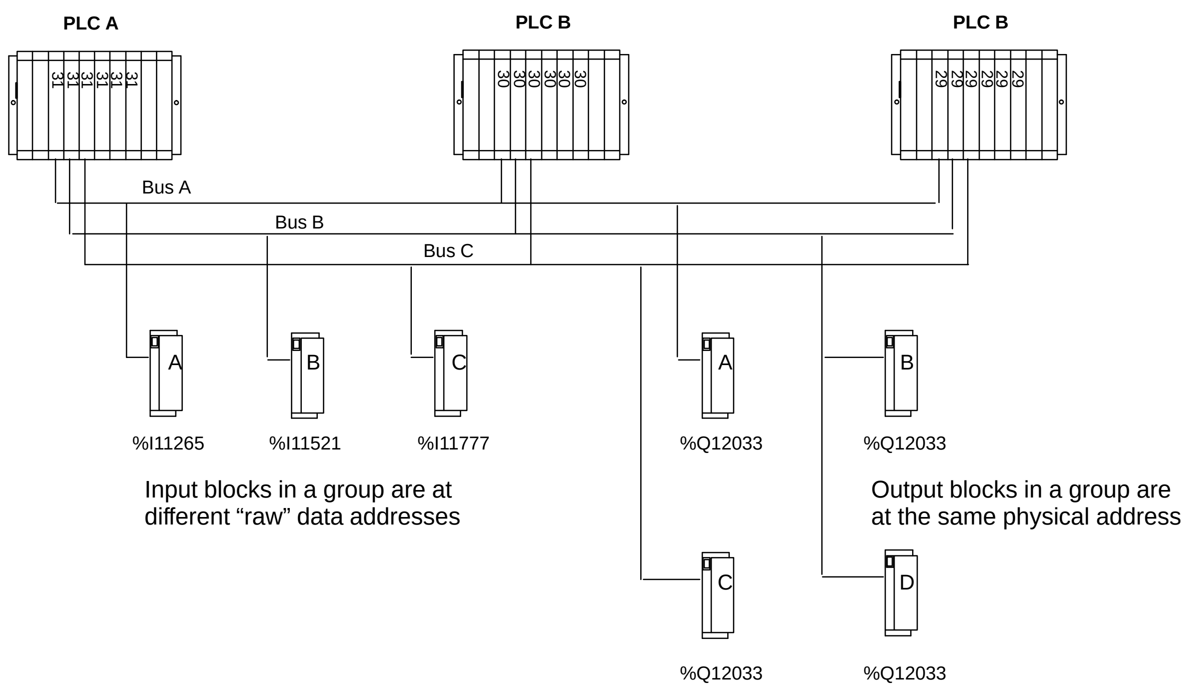
Note: For input blocks in GMR groups, the I/O addresses configured on these screens are for the “raw” input data received directly from the blocks (for the A, B, and C areas of the Table, as described in the Programming chapter. For output blocks in GMR groups, the output addresses configured on these screens 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.

Configuring GMR Bus Controllers and I/O Blocks

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 a 4-block output group.

GMR redundant *input* blocks in a group each have a unique “raw” data address on each bus in the same PLC. However, the blocks have the *same* reference addresses in another GMR PLC.

GMR redundant *outputs* in a group have the same reference addresses on each bus in the group.



Configuring Genius I/O Blocks

Genius I/O block configuration for a GMR system is similar to configuration for a non-GMR system. You should refer to the *Genius Discrete and Analog Blocks User's Manual* for specific configuration instructions.

A copy of the configuration prepared with the GMR Configuration Software should be used for reference during block configuration, to assure consistency.

Editing the Reference Addresses

For Genius blocks in a GMR system, blocks within a group use the same reference addresses in each of the redundant PLCs, so these are not changed.

Editing the Block I/O Type

Any discrete block that is part of a redundant input group (triplex, duplex, or simplex) must be configured as a "combination" I/O block.

Copying Configurations

Because the blocks in a redundant input or 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). Of course, it is possible to use the Copy Configuration feature between similar blocks on a bus that are not in the same group.

Setting Up Blocks for Fault Reporting

Configuring a block for CPU Redundancy = 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.

Setting Up Non-GMR Blocks 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.

Configuring 16-Circuit and 32-Circuit Discrete DC Blocks

The table below lists configuration parameters for 16-circuit and 32-circuit discrete blocks. Configuration options with special requirements in GMR systems are described after the table. Configuration options that are not changed for GMR systems are not described here. Note that blocks do not prevent selecting incorrect parameters for a GMR system. It is important to configure blocks appropriately for GMR use.

Feature	Circuit or Block	Factory Setting	Selections
Device Number	Block	null	0 to 31 (a number must be selected)
Reference Address	Block	none	Depends on host CPU type
Block I/O Type	Block	input	input, output, combination
Baud Rate	Block	153.6 std	153.6 std, 153.6 ext, 76.8, 38.4 Kbd
Pulse Test for Outputs	Block	enabled	enabled, disabled
Input Filter Time (16–ckt) (32 ckt)	Block	20mSec	 5–100mSec 1–100mSec
Circuit I/O Type	Circuit	input	input, output, tristate input*
Report Faults	Circuit	yes	yes, no
Hold Last State	Circuit	no	yes, no
Output Default State	Circuit	off	on, off
Detect No Load*	Circuit	yes	yes, no
Overload Shutdown*	Circuit	yes	yes, no
BSM Present	Block	no	yes, no
BSM Controller	Block	no	yes, no
Output Default Time	Block	3 bus scans	(for bus redundancy) 2.5 or 10 sec
Redundancy Mode	Block	none	none, hot standby, duplex, GMR
Duplex Default	Block	off	on, off

* Available only with 16–circuit blocks.

Device Number (serial bus address)

In a triple-redundancy GMR system, serial bus addresses 29 – 31 are reserved for the bus controllers. By convention, serial bus address 0 is often used for the Genius Hand-held Monitor. The serial bus addresses assigned to the blocks must match those entered using the GMR Configuration Software. Therefore 1–28 are available for blocks.

All the blocks in an *input* group must be configured to use the same serial bus address. In a 4-block output group, three of the blocks (one each on bus A, B, and C) use the same serial bus address. The fourth block, which must be located on either bus A or bus B, must be assigned a different serial bus address.

Reference Address

All blocks in the same output group must use the same reference address. However, blocks in an input group each have a unique address, as explained on page 6-37. Refer to the reference address assignments made using the GMR Configuration Software when assigning addresses to blocks. Reference addresses must be assigned on 8-bit boundaries.

The system may include individual blocks that are not set up for redundancy.

Block I/O Type Any discrete block that is part of a redundant input group (triplex, duplex, or simplex) must be configured as a "combination" (I/O) type block.

Any block that is part of an output group must be set up as an outputs-only block.

Baud Rate Baud rate should be selected on the basis of the calculations in the *Genius I/O System and Communications User's Manual* (GFK-90486). Note that for correct autotesting in a GMR system, the Genius bus scan time should not be be more than 60mS.

Pulse Test Pulse-testing should be enabled for all GMR output blocks. It should be disabled for all GMR input blocks, except for GMR input blocks that have output circuits that you wish to output pulse test.

Input Filter Time Input Filter Time should be set up according to the needs of the application. If an input block will also have outputs and those outputs will be pulse-tested, the Input Filter Time must be set at a minimum of 20mS. This is necessary because the power feed output (the output supplying power for autotesting input circuits) will also be pulse-tested, and could cause false inputs at filter times under than 20mS. On 16-circuit blocks, any circuits configured as tristate inputs *must* have an Input Filter Time of at least 30mS.

Circuit I/O Type On non-voted blocks in the system, circuits can be any mix of inputs and outputs.

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 blocks in input groups:

- GMR input circuits on 16-circuit blocks only can be configured as regular inputs or tristate inputs. They 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 page 2-7 for details.

- 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).

Report Faults Fault reporting must be enabled on all GMR block circuits. The 16-circuit and 32-circuit DC Genius blocks will automatically send three copies of all fault reports; one each to the bus controllers at serial bus addresses 29, 30, and 31.

Hold Last State

If the block will use Input Autotest, circuit 16 must be configured as an output, as explained above. **For circuit 16, Hold Last State must be configured to NO.**

Output Default

If the block will use Input Autotest, **circuit 16 must be configured with Output Default set to ON.**

Redundancy Mode

Portions of the overall system can be configured for no CPU redundancy, duplex redundancy, hot standby redundancy, or GMR mode. (See page 5-3 for information about how the configured Redundancy Mode affects Fault Reporting by blocks in the GMR system).

For 16-circuit and 32-circuit DC blocks, select **GMR** mode for blocks that will be part of input or output groups as described in this book. Individual circuits on the blocks can be configured (using the GMR Configuration Software) to utilize the special GMR features. GMR mode can be selected even if there is just one block in an input group, and 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.

The **duplex CPU redundancy** selection is 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. This is explained below.

The following three tables compare voting results for a block receiving outputs from all three PLCs with results, and with one of the three PLCs is offline.

Results of Block Voting with Three PLCs Online

For comparison, this table shows how a block votes on outputs received from three PLCs. In this case, the block 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 Voting with Only Two PLCs Online

In the two tables below, PLC C is shown as offline, but it could be either of the other two instead.

Using 0 as the Duplex Default state means that when only two PLCs are online, the voted output state will be 0 if either PLC sets it to 0. It will not be 1 unless both online PLCs set it to 1.

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

Similarly, using 1 as the Duplex Default state means that when only two PLCs are online, the voted output state will be 1 if either PLC sets it to 1. It will not be 0 unless both of the PLCs set it to 0..

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

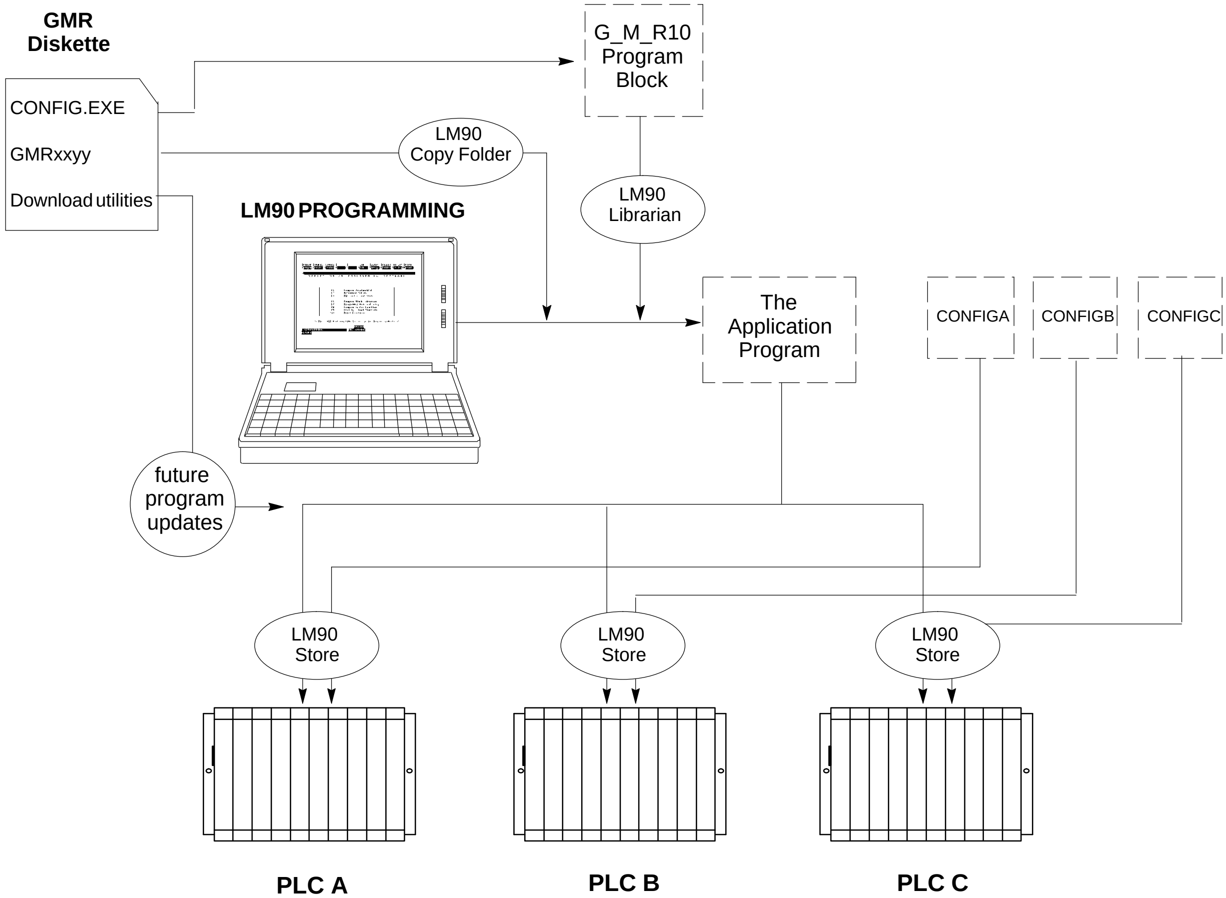
Chapter 7 Programming Information

This chapter describes the following aspects of the application program interface to the GMR software:

- Programming Overview
- Program Instruction Set for GMR
- Estimating Memory Usage
- Reserved References
- Input and Output Addressing for GMR
- Register (%R) Memory Assignment for GMR
- System Status (%S) References
- GMR Status and Control (%M) References
- Programming for Startup
- I/OPoint Faults
- Programming for Fault and Alarm Contacts
- Programming for I/O Shutdown
- Reading GMR Diagnostics
- Programming for Global Data
- Adding the GMR System Software to a New Application Program Folder
- Adding the GMR Configuration to the Application Program Folder
- Storing a Program to the PLC
  - Storing a Program to the PLC if the System is NOT Configured for Online Changes
  - Storing a Program to the PLC if the System IS Configured for Online Changes

Programming Overview

The following figure represents the basic GMR programming steps. As explained previously, the GMR configuration, which assigns I/O reference addresses and produces the G_M_R10 Program Block should be done first.



1. **Create a new Program Folder.** In the Logicmaster programmer, create a folder with a new name, such as GMRPROG.

2. **Add the GMR <u>system software</u> to the new program folder.** Using the Copy Folder feature of Logicmaster, copy the GMR system software folder GMRxxyy from the diskette to your new program folder. 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.

3. **Using the Logicmaster librarian feature, add the external program block containing the GMR configuration parameters (G_M_R10) to the LM90 library.** Then, use the Librarian to import G_M_R10 from the Library to the application program folder.

4. **After completing the application program and the configuration(s), store them to the PLCs.** Supplying the configuration and program as separate files, as shown above, makes it easier to perform program updates in the future.

Program Instruction Set for GMR

The CPUs used for GMR support the all of the following Series 90-70 ladder logic instructions:

<table>
<tr><td>Contacts
Any Contact
–| |–
–| / |–
–| ↑ |–
–| ↓ |–
–[FAULT]–
–[NOFLT]–
–[HIALR]–
–[LO ALR]–
<+>——</td><td>Coils
Any Coil
–( )–
–(/)–
–(↑)–
–(↓)–
–(S)–
–(R)–
–(SM)–
–(RM)–
–(M)–
–(/ M)–
——<+></td><td>BitOperation
AND
OR
XOR
NOT
SHL
SHR
ROL
ROR
BTST
BSET
BLCR
BPOS
MCMP</td><td>Conversion
to BCD–4
to BCD–8
to UINT
to INT
to DINT
BCD–4 to
UINT
BCD–4 to INT
BCD–8 to
DINT</td><td>Control
CALL
DOIO
SUSIO
MCR
ENDMCR
JUMP
LABEL
COMMENT
SVCREQ
PIDISA
PIDIND
FOR
END_FOR
EXIT</td><td rowspan="2">DataTable
TBLRD
TBLWR
LIFORD
LIFOWRT
FIFORD
FIFOWRT
SORT
ARRAY_MOVE
SRCH_EQ
SRCH_NE
SRCH_GT
SRCH_GE
SRCH_LT
SRCH_LE</td><td rowspan="2">DataMove
MOVE
BLKMOV
BLKCLR
SHFR
BITSEQ
SWAP
COMMREQ
VMERD
VMEWRT
VMERMW
VMETST
VME_CFG_RD
VME_CFG_WRT
DATA_INIT
DATA_INIT_COMM
DATA_INIT_ASCII</td></tr>
<tr><td>Timers
ONDTR
OFDT
TMR</td><td>Counters
UPCTR
DNCTR</td><td>Links
Horizontal
Vertical</td><td>Relational
EQ
NE
GT
GE
LT
LE
CMP</td><td>Math
ADD
SUB
MUL
DIV
MOD
SQRT
ABS</td></tr>
</table>

Use of 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.

Programming Restrictions for TÜV Applications

Some of the program instructions listed above can not be used for a GMR system that will be applied in an Emergency Shut Down (ESD) application for which for a TÜV site application approval will be sought. See Appendix A for details.

Estimating Memory Usage

The GMR system software version 2.06 uses approximately 318,688 bytes of the CPU's memory. 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:

Max. User Ladder Logic Application Program Size = 524,288 bytes – 318,688 bytes – User Reference Tables

The size of the User Reference Tables depends on your configuration and actual application program. See the *LM90–70 Programming Software User's Manual* (GFK–0263) for more information.

Estimating Bus Scan Time

If you want to estimate the bus scan time, see page 4-6 for instructions.

Reserved References

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

References	Reserved For:
%I0001 to %I1024 (788 CPU) %I00001 to %I12288 (789 CPU)	Input Table. Some references are automatically assigned by the GMR Configuration Software. Others are available for use, as explained in this chapter.
%Q0001 to %Q1024 (788 CPU) %Q00001 to %Q12288 (789 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 bus controllers on the bus. 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 this chapter.
%M12225 to %M12256	System status bits
%M12257 to %M12288	System control flags
%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

With the exceptions noted above, the following memory areas can be written to if Write Access is enabled during GMR configuration:

%R	Registers
%AI	Analog Input Table
%AQ	Analog Output Table
%I	Discrete Input Table
%Q	Discrete Output Table
%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 above), and cannot be accessed directly.

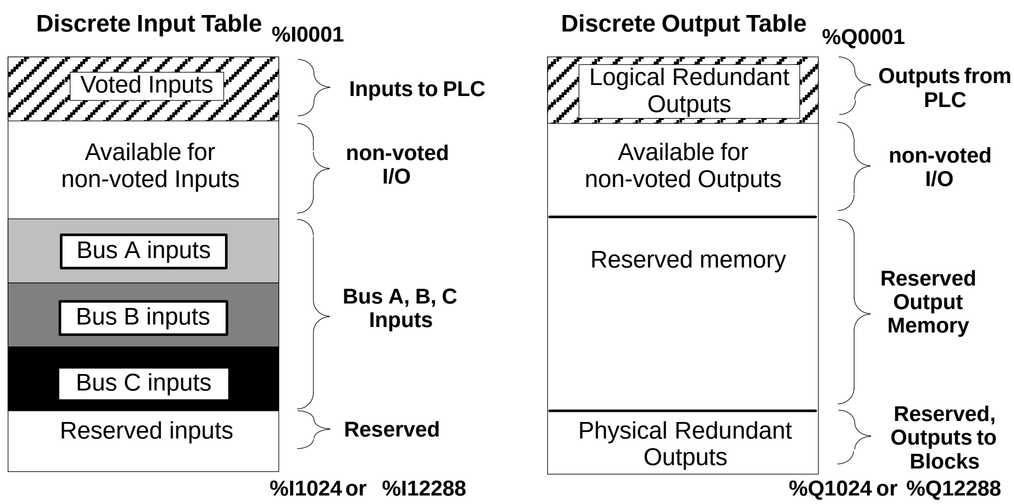
Page 6-23 describes configuration for setting up Write Access.

Input and Output Addressing for GMR

I/O addressing for GMR is unlike a that of conventional Series 90-70 application. In a conventional application, input and output addresses are assigned sequentially, starting at the beginning of the Input Table and Output Table. In a GMR application, the GMR software automatically divides the Discrete Input and Output Tables and the Analog Input Table into special-purpose areas.

Discrete I/O Addressing

The discrete Input Table and Output Table are divided up into separate areas for redundant and non-voted data, as shown below.



- Voted inputs and logical redundant outputs occupy the beginning of the discrete I/O tables. Normally, the application program utilizes these inputs and outputs, although it can also access the rest of the I/O table data if necessary.
- Non-voted inputs and outputs occupy the next portions of the Input and Output Tables. These are the inputs and outputs of blocks that are present in the system either as non-voted blocks on GMR busses, or on other busses.

  The starting address for non-voted data depends on the amount of redundant data, as explained above. In the same example, if there were 64 voted inputs and 48 logic outputs, non-voted I/O data would begin at addresses %I0065 and %Q049.
- The area of Output Table memory that corresponds to the bus A, B, and C input data in the Input Table is reserved. The reason this area is reserved is that input blocks used in redundancy 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 that is actually sent to the Genius blocks that are 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.
- The total amount of I/O data available depends on the CPU type. For the model 788 CPU, there can be a total of 352 physical inputs and outputs or approximately 100 redundant I/O points. For the model 789, there can be a total of 12288 physical inputs and outputs (or a maximum of 4096 redundant I/O points).

Discrete I/O Tables: Example

In this very simple example, there are:

- a model 788 CPU (with 352 physical I/O).
- One output group of four discrete 16-circuit blocks. The application program will use 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:

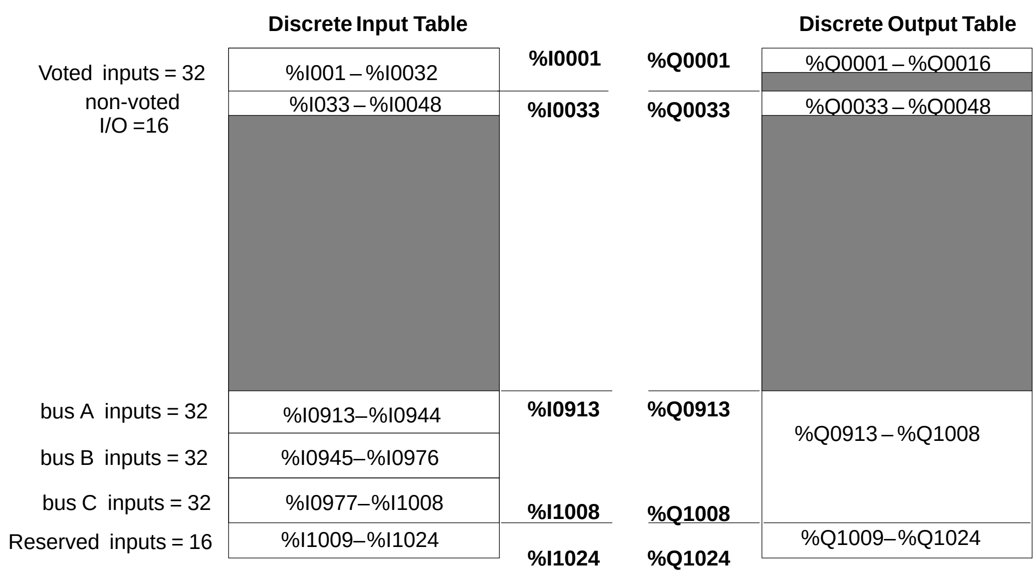
    I/O Table length – reserved inputs – (3 X input data length for one group) +1

    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.

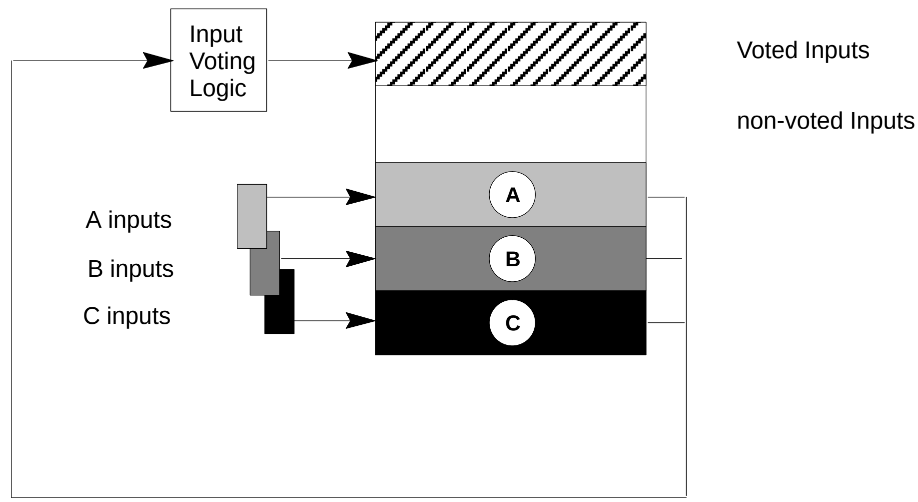
The illustration shows where these inputs and outputs would be located in the I/O tables. Shaded portions represent unused I/O table memory.



Analog I/O Addressing

The size of the Analog Input Table is defined during 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 labelled 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.

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

Addresses	Contents
%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.

Analog Output Addressing

Analog blocks with outputs can be used in a GMR system, but they do not operate in GMR mode.

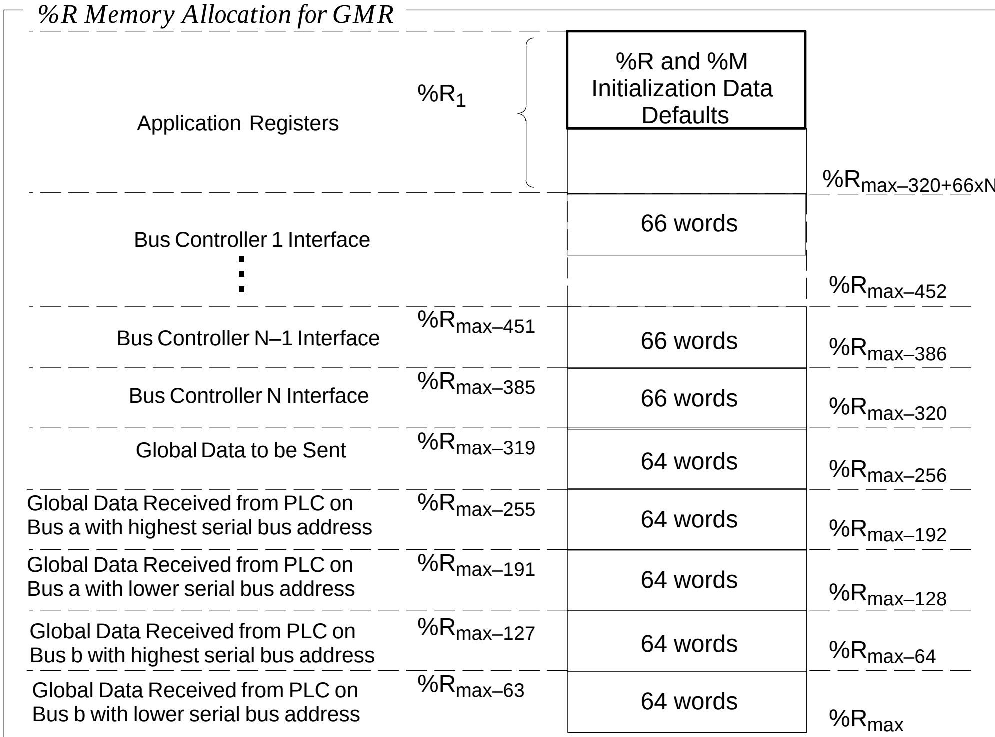
They can be configured for Hot Standby CPU redundancy operation. In Hot Standby mode, an analog block accepts outputs from a bus controller at serial bus addresses 31. If that bus controller stops sending output data, the block accepts outputs from bus controller 30.

Remember that each PLC in the GMR system normally executes the same application program.

Register (%R) Memory Assignment for GMR

The GMR software uses several areas of %R memory for specific functions, as diagrammed below. Only the area labelled “Application Registers” should be used by the application program. Within that area, a portion is reserved for initialization data, as explained below.

%R Memory Allocation for GMR



Each PLC receives two sets of incoming Global Data from the other PLC(s). Both of these are placed into %R memory, as can be seen in the diagram. Only one set is copied to %G memory for access by the application program, however.

Directly ahead of the incoming Global Data in %R memory is a copy of the outgoing Global Data. This data should be programmed using %G memory, not %R memory. The GMR software automatically moves the data to the appropriate %R location prior to the Global Data being sent.

Ahead of the Global Data areas of %R memory are additional areas used by the GMR software for communications with I/O blocks (for functions such as autotesting and diagnostics) and with other bus controllers on the bus. The overall length of this area depends on the number of other bus controllers in the system.

%R Memory Required for Startup Initialization Data

%R and %M initialization data that may be received during startup are stored in %R memory (the second set of incoming %M initialization data is stored there temporarily at startup).

The GMR Configuration Software default for the beginning of the initialization data is %R0001.

In addition, by default, the configuration software assigns %R0257 as the beginning location for %M initialization data which is directly after the %R initialization data.

System Status (%S) References

System status references are pre-defined locations and nicknames. They can be included in the application program to check for fault-related conditions. For example, status references can be used to:

- Detect forces and overrides.
- Monitor the fault tables.

For a complete listing of %S references, see the *Series 90-70 PLC Reference Manual*.

Monitoring Forces and Overrides

The GMR software cannot detect point forces and overrides, and their use is not recommended and may affect the results of autotesting. Forces and/or overrides can also affect GMR voting of inputs and outputs. Therefore, if the system will include the use of forces and/or overrides, it is important to include application program logic to detect them.

These system status references detect forces and overrides *in an individual PLC*:

%S0011	**OVR_PRE**	when set, indicates an override in %I, %Q, %M, or %G memory.
%S0012	**FRC_PRE**	when set, indicates a force on a Genius point.

Monitoring the Fault Tables

These system status references are associated with the fault tables *in an individual PLC*:

%S0009	**SY_FULL**	when set, indicates that the PLC Fault Table is full.
%S0010	**IO_FULL**	when set, indicates that the I/O Fault Table is full.
%SC0010	**SY_FLT**	when set, indicates that an entry has been placed in the PLC Fault Table.
%SC0011	**IO_FLT**	when set, indicates that an entry has been placed in the I/O Fault Table.
%SC0012	**SY_PRES**	when set, indicates that there is presently at least one entry in the PLC Fault Table.
%SC0013	**IO_PRES**	when set, indicates that there is presently at least one entry in the I/O Fault Table.

GMR Status and Control (%M) References

The GMR system software uses several %M references as status or control bits. Status bits are used by the GMR software to provide information about GMR operations. These references can be read as needed by the application program. The control bits can be used by the application program to provide information to the GMR software.

%M Status References

The following table lists the GMR system status flags.

Reference	Nickname	Name	Meaning
%M12225	PLCA	PLC Ident is A	This is PLC A (all GMR bus controllers =31). For references %M12225, 26, and 27, only one will be set in each PLC.
%M12226	PLCB	PLC Ident is B	This is PLC A (all GMR bus controllers =30).
%M12227	PLCC	PLC Ident is C	This is PLC A (all GMR bus controllers =29).
%M12228	PLCAOK	PLC A is online	Meaning depends on the PLC where the flag is set. See the table on the next page.
%M12229	PLCBOK	PLC B is online	”
%M12230	PLCCOK	PLC C is online	”
%M12231	INHIBIT	Inhibit user application	Set by the GMR software at startup, to prevent execution of the application program until data initialization is complete.
%M12232	MISCMP#*	Init. miscompare at startup	Initializing PLC detects miscompare between %M (bit) init. data from two online PLCs.
%M12234	SYSFLT#*	System fault at startup	At startup, communications failure with a GMR bus controller.
%M12235	SYSFLT	System fault	Communications failure with a GMR bus controller. This reference is cleared when PLC Fault Reset is issued.
%M12236	OPDISC	O/P discrepancy	Output discrepancy. This reference is cleared when PLC Fault Reset is issued.
%M12237	COLDST*	Cold start performed	At startup, the 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.
%M12238	IORESIP	I/O reset in progress	An I/O fault reset is in progress. Bit is On for one scan when the internal GMR fault tables are cleared.
%M12239	ATINPRG	Autotest in progress	An input or output autotest is in progress (not necessarily initiated by this PLC) the state of this bit will be the same in all running PLCs.
%M12240	LOGONFT	Block logon fault	See page 7-17.
%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	At least one of the PLCs has begun timing an I/O Shutdown.
%M12245 through %M12256, %M12233			Reserved for future GMR use.

* Will only be set at startup if condition occurs.

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

PLC OK Flags

The meanings associated with the three PLCOK flags are listed below:

At PLC A	PLCAOK	PLC A outputs enabled
	PLCBOK	PLC B communications with PLC A healthy and PLC B outputs enabled
	PLCCOK	PLC C communications with PLC A healthy and PLC C outputs enabled.
At PLC B	PLCAOK	PLC A communications with PLC B healthy and PLC A outputs enabled
	PLCBOK	PLC B outputs enabled
	PLCCOK	PLC C communications with PLC B healthy and PLC C outputs enabled.
At PLC C	PLCAOK	PLC A communications with PLC C healthy and PLC A outputs enabled
	PLCBOK	PLC B communications with PLC C healthy and PLC B outputs enabled
	PLCCOK	PLC C outputs enabled.

Resetting Status Flags

Startup status flags (with asterisks in the table on the previous page) 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 Control References

The application program can use the following %M references to provide information to the GMR software. The references are located at %M12257 – %M12288.

Reference	Nickname	Description	Meaning
%M12257	CONTINU	Continue with initialization & enable outputs	
%M12258	IORES	Perform I/O Fault Table clear.	See next page.
%M12259	PLCRES	Perform PLC Fault Table clear.	At an individual PLC
%M12260	ATMANIN	Autotest Manual Initiate	Initiates a single autotest (both input and outout) any time it is turned on, even if the Autotest Inhibit bit is on.
%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 On. Note: it does not prevent an Autotest Manual Initate.
%M12262	REPORT	Report GMR version / status	See description of %M12262 (Report) on page 7-14.
%M12263	FORCLOG	Force block(s) to log on	See the description of PLC Logon Control on page 7-17.
%M12264	PLCRESG	Clear PLC Fault Tables in all PLCs.	See next page.
%M12265	SDCAN	Cancel I/O Shutdown	If an I/O Shutdown was initiated by any PLC, turning this bit On cancels it and prevents the shutdown from occurring. If this bit is set continuously, no I/O Shutdown will be initiated.
%M12266 to %M12288		Reserved for future GMR use.	

%M12257 (Continue)

When the application program has computed valid outputs that can be sent to output blocks, the application program must set control bit %M12257 (CONTINUE) to 1. When this is done, outputs to the blocks are enabled.

%M12262 (Report)

When this control bit is turned on, it causes the GMR software to report and record the following into the PLC Fault Table of the PLC(s) that turned it on:

- The **GMR Software Version** currently running in the PLC. Example:
  Application message (10840): GMR Ver:02.06
- The **GMR Configuration Utility Version** used to create the G_M_R10 Program Block. Example:
  Application message (10841): Config Util Ver:04.01
- 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 that is created, so it can be used to determine exactly what configuration file is in a GMR PLC. The GMR configuration checksum is also recorded in the GMR configuration utility printout of a configuration.
- The 40-character **Configuration File Description**.

  This GMR control bit is infrequently used. It is typical to turn it on manually using the Logicmaster 90-70 software, although it can also be turned on by the application program if desired.

Clearing the PLC Fault Tables

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.

Caution

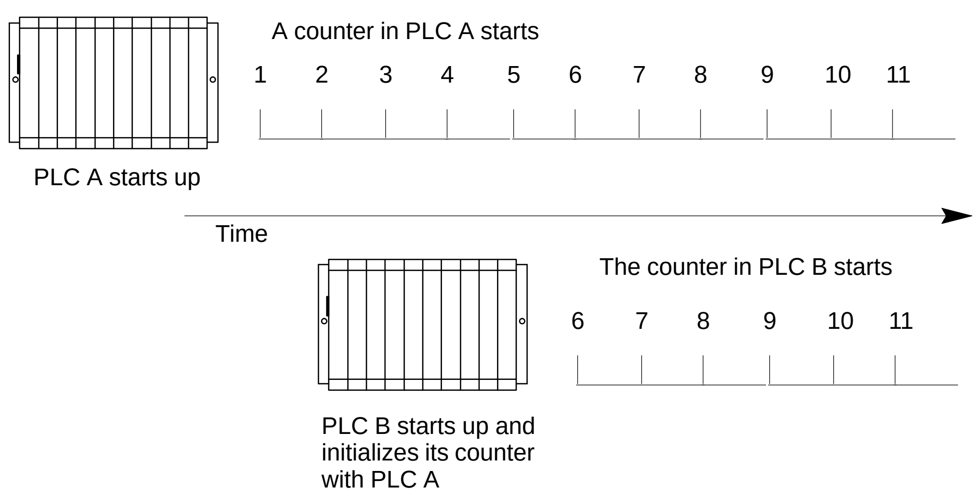
Do not use the Logicmaster F9 key to clear the Fault Tables.
Fault Table Clearing from the Logicmaster software can be prevented by keeping it in Monitor mode.

Although the Fault Tables seem to operate as they would in a non-GMR system, they are actually controlled by the GMR software, *not* the Logicmaster software. Instead, in a GMR application, the fault tables must be monitored and cleared from the application program logic.

Programming for Startup

The *PLC Subsystem* chapter of this book describes the sequence of actions that occur when the PLCs in a GMR system are started up.

- 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 (see page 7-11): %M12225 for PLC A or %M12226 for PLC B, or %M12227 for PLC C.
- While a PLC is initializing, the GMR software sets the Inhibit status flag (%M12231). This Inhibit flag should be used to prevent the application program from executing until initialization is complete. Example ladder logic that provides this functionality is shown on page 7-18. In addition, the PLC's outputs are disabled. If outputs do not disable successfully, the GMR software halts 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 also communicates with the GMR I/O blocks and with Bus Controllers in other PLCs. If any of these communications fails, status bit %M12234, which indicates System Failure at Powerup, is turned on. The application program can use this bit 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 this flag to initialize the application program data.
  - If one other PLC is already online, the initializing PLC reads that PLC's initialization data (%M and %R). 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.

  Word type data that will be included in the initialization data exchanged among the PLCs at startup, such as timer and counter accumulators, should be located at the top of the configured %R memory space. This is because the last portion (top) of the configured %R initialization data is copied last. Locating changeable data at the top of the %R data assures that the most recent values will be 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 they don't match, the initializing PLC sets the Miscompare status reference (%M12232) to 1.

- When the PLC completes its data initialization, the GMR software clears the Inhibit status flag (%M12231). At that point, the application program can monitor the startup status flags, as suggested on the next page, before continuing startup.
- When the application program has computed a set of outputs, it must enable sending outputs to Genius blocks.
- The application program enables outputs to the I/O blocks by turning on control bit %M12257 (the Continue bit). As the example shows, it is important to have this occur at the *end* of the program, so the outputs have been solved at least once before being enabled.

Monitoring Startup Status

The application program should include logic to cause it to begin executing when the Inhibit flag is cleared to 0. Depending on the needs of the application, the application program can begin by checking the startup status flags to determine whether, or how, to proceed with the rest of the logic. See page 7-11. for a complete list of status flags.

The GMR software provides several initialization flags. It can also monitor the application program %M data for miscompares, and make program execution conditional upon voting of the data. See below.

The following flags are of particular interest immediately following startup:

%M12237	**COLDST**: If this reference has been set to 1, it means the PLC detected no other PLC(s) online when it started up. The application program must initialize its own %M and %R initialization data.
%M12232	**MISCMP#:** If set to 1, this flag indicates that 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.
%M12234	**SYSFLT#** : If set to 1, this flag indicates that when the PLC started up, it experienced a problem trying to communicate with one of the bus controllers or a Genius I/O block.

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.

Prior to sending the outputs, the application program may check the status flags. If any are found to be 1, the application program may decide to process the initialized data before continuing.

When the application program has computed valid outputs that can be sent to output blocks, the application program must set control bit %M12257 (CONTINUE) to 1. When this is done, outputs to the blocks are enabled.

If outputs fail to be enabled successfully, the GMR Software sets the System Fault status flag (%M12235) to 1.

PLC Logon Control

PLC Logon Control prevents output states from inadvertently changing state when a newly-initialized PLC is put online by the application program. (The application program turns on the Continue bit: %M12257). Without PLC Logon Control, outputs have the potential to change state if a PLC just coming online has output states that differ from those of other PLCs that are already online, due to the output voting done by each Genius output block group.

PLC Logon Control causes the output states from a PLC that has just come online to be compared with the voted output states at each output block group. If the states do not agree for any output block, the block ignores the new output data and effectively keeps the new PLC offline with respect to that output block. This condition continues until either the voted output states match for the complete output block or until the Force PLC Logon control bit (%M12263, FORCLOG) is turned on. A GMR status bit (%M12240, LOGONFT) is available. That bit indicates if this condition exists with one ore more output blocks. It is the responsibility of the application program to monitor the LOGONFT status bit and to turn on the FORCLOG control bit if desired, to cause output block groups to vote on and respond to output data from all online PLCs.

Note that, if set, the LOGONFT status bit remains set until the I/O fault table is cleared, by using the IORES control but (%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.

Powerup Note

PLC Logon Control is also in effect for the first PLC in the GMR system to come online. The first PLC to come online has its output states compared with the voted outputs currently present at the output block groups. Remember that the output states of each output block, with no PLCs online, are determined by the output default configuration (0, 1, or hold last state) for each individual output circuit at each output block. For example, if output defaults are set to Off (0) and a PLC is put online with the same outputs already driven to On (1) states, the output block keeps the PLC offline until the driven output states agree or until the FORCLOG control bit is set, to force the PLC online with respect to the output block.

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.

Example Ladder Logic:

The following example shows some typical program startup logic. This is only an example. You will probably need to modify the logic shown for your application.

```
|[  START OF LD PROGRAM  EXAMPLE    ]     (*                                *)
|
|[     VARIABLE DECLARATIONS        ]     (*                                *)
|
|[  PROGRAM BLOCK DECLARATIONS      ]     (*                                *)
|
|[    START OF PROGRAM LOGIC        ]
|
| << RUNG 5 >>
|
|INHIBIT
|--| |-------------------------------------------------------------->>  END
|
| << RUNG 6 >>
|
|-[CALL     IN_CO]-
|
| << RUNG 7 >>
|
|-[CALL    FILTER]-
|
| << RUNG 8 >>
|
|-[CALL    HR_344]-
|
| << RUNG 9 >>
|
|-[CALL     ANNUN]-
|
| << RUNG 10 >>
|
|-[CALL    DIAGNO]-
|
| << RUNG 11 >>
|
|MISCOMP  SYSFLT                                                      CONTINU
|--|/|----|/|-+-------------------------------------------------------( )--
|             |
|MAN_COM      |
|--|/|--------+
|
```

These Program Blocks represent logic routines that are appropriate for the application.

In rung 11, the logic tests for Miscompare and System Fault. If both are not 1, initialization continues.

An optional parallel input (MAN_COM in this example) can be used to allow a "manual continue" input to be supplied by an operator.

```
|
| << 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 on line) 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.

I/O Point Faults

The GMR system can optionally use 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.

Enabling I/O Point Faults

The use of I/O point faults requires the following setup during Logicmaster 90 configuration:

A. During CPU configuration, select Memory Allocation and Point Fault Enable (F4) from the CPU Configuration menu.

B. Change the Point Fault Reference setting from DISABLED to ENABLED.

Programming for I/O Shutdown

When the GMR system diagnoses a discrete I/O fault, it logs the appropriate faults in its fault tables and set the appropriate fault contacts. For certain types of discrete I/O faults, the system allows a predefined amount of time for the problem which has caused the fault to be repaired. If it is not rectified within this period of time, an I/O shutdown of the I/O which corresponds to the block(s) occurs, unless I/O shutdown is disabled by the cancel I/O Shutdown control bit (%M12265). I/O shutdown is defined as setting the affected I/O to its safe state. For more information about I/O Shutdown, please refer to page 4-18.

To be aware of a pending I/O Shutdown, monitor Status Bit %M12244 (IO_SD).

To completely prevent an I/O Shut Down from occurring set Control Bit %M12265 (SD_CAN).

Programming for Fault and Alarm Contacts

The GMR system software can optionally utilize the Fault and Alarm contacts capability of the Series 90-70 PLC to make fault and alarm information available to the application program logic. Conditions that cause Fault and Alarm contacts to be set are described in the Diagnostics chapter. Programming for Fault and Alarm contacts is explained on the following pages.

Fault and No Fault Contacts

Fault and No Fault contacts can be used to detect fault or lack of fault conditions on a discrete (%I or %Q) or analog (%AI or %AQ) reference. They can also be programmed with the Series 90-70's built-in fault-locating references (see below). 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.

A Fault contact is programmed as shown below, using the reference address to be monitored (here, %I0014):

```
|    %I0014                                              %Q0056
|----[FAULT]-----------------------------------------------( )----
|
```

A Fault contact passes power flow if the associated reference has a fault. (Fault contacts are also set if a block logs off the bus.)

A similar contact, called the No Fault contact passes power flow while the associated reference has no fault.

```
|    %I0167                                              %Q0168
|----[NOFLT]-----------------------------------------------( )----
|
```

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. Fault contacts are cleared by being reset from the application program, by sending a command to the GMR software using 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.*

Fault-Locating References

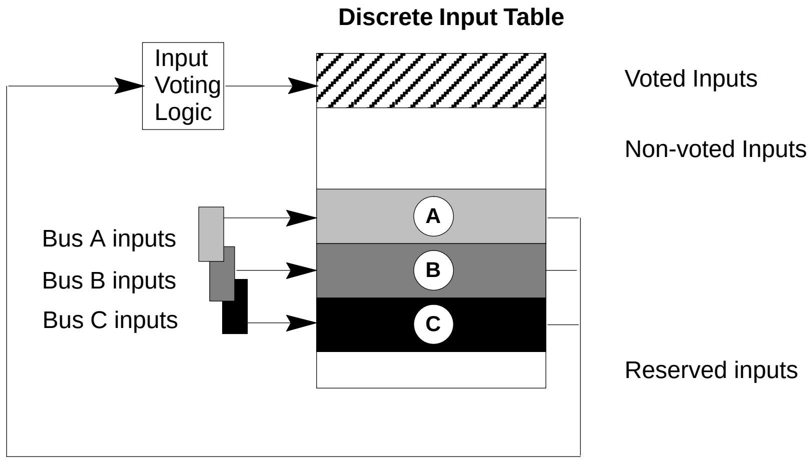
Both Fault and No-Fault contacts can be programmed with fault-locating references to identify faults associated with the system hardware. These fault references are for informational purposes only. The PLC does not halt execution if one of these reference faults occurs. For a Genius device, the format of the fault-locating reference is:

M_rsbmm

Where **r** is the rack number 0 to 7, **s** is the slot number of the bus controller; **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.*

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:



Fault contacts are set for:

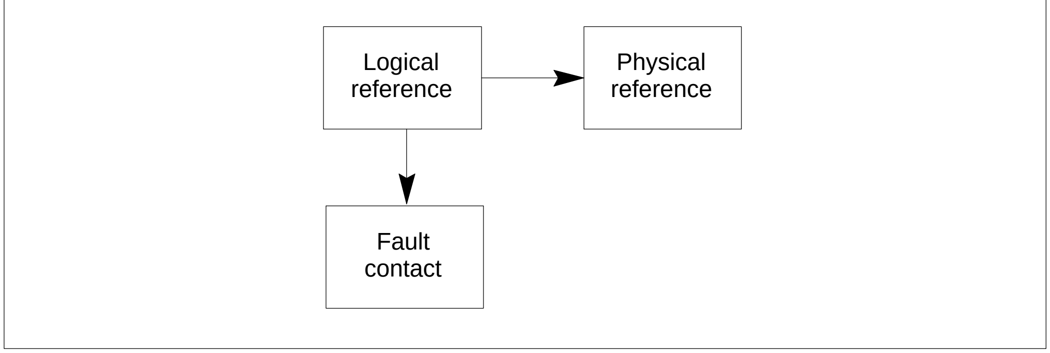
- Input Genius faults
- Input discrepancy faults for A, B, and C inputs
- Input autotest faults
- Line faults

See page 5-25 for detailed information on conditions that cause fault contacts to be set.

Discrete Output Fault Contacts for GMR

For discrete outputs, fault contacts are associated with 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.

Contact References Associated with an Output



Fault contacts are set for:

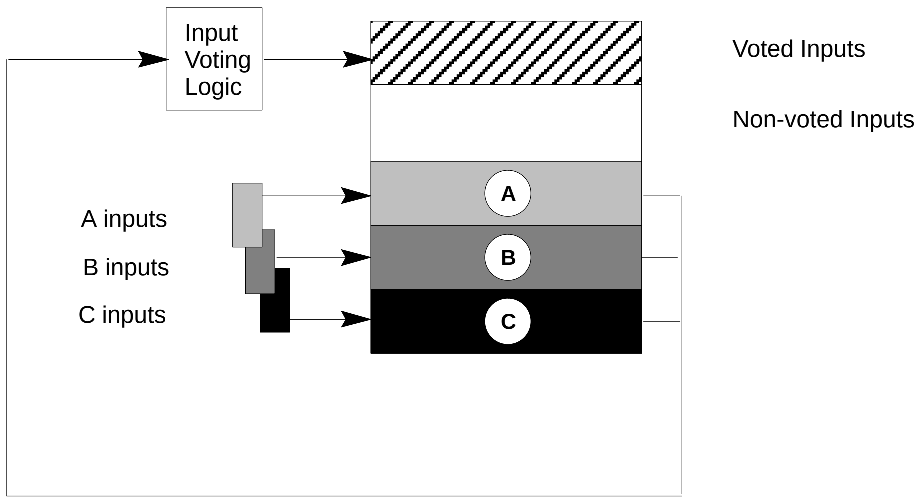
- Genius faults
- Discrepancy faults
- Autotest faults

See page 5-26 for detailed information on conditions that cause fault contacts to be set.

Analog Fault Contacts for GMR

As for 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.

Analog Input Table



For analog inputs, fault contacts are set for:

- Genius faults
- Discrepancy faults

For analog outputs, a fault contact is set for any Genius fault, including Loss of Block.

See page 5-28 for detailed information on conditions that cause analog fault contacts to be set.

Analog Alarm Contacts for GMR

For analog data, there are two additional types of diagnostic contacts that can be used in the application program, the High Alarm and Low Alarm contacts. These 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.

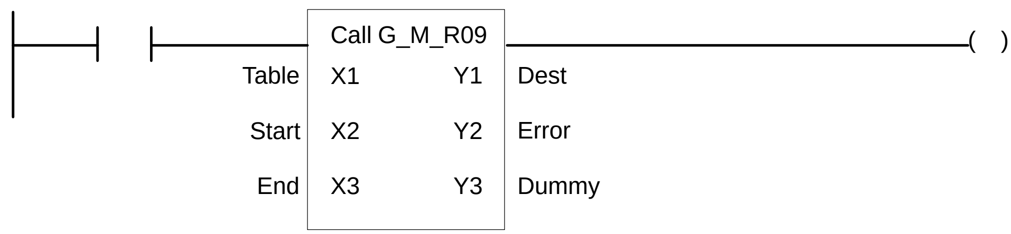
Reading GMR Diagnostics

The application program can obtain the following diagnostic information from the GMR system software:

- Autotest faults
- Discrepancy faults
- Genius faults
- Point faults
- Analog alarms

This information is described in detail in the *Diagnostics* chapter.

To obtain this information, the application program should CALL an external Program Block named **G_M_R09.** Information is read-only; it cannot be written to.



Each call to G_M_R09 can access one type of data, as listed in the table on the next page. Data is returned in bit format. The data length is selected by the Start and End entries.

Parameters for the Call Function

You must specify the following information:

X1: Table a number representing the type of data to be read. For example, to read Digital Input Discrepancy faults, you would specify item 11.

X2: Start the start offset within the area of information specified in the table.

For discrete point faults (input or output faults of any of the types listed), this is the actual address of the start 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 the location where the requested information will be placed after it has been obtained.

Y2: Error the location where the error code will be placed. The error code is generated if the CALL function fails to execute successfully.

The table on page 7-26 lists error codes may be be read in this location.

Y3: (dummy) not used.

Data Table Numbers

Table	Contains	Range for Start Value	Range for End Value
11	Digital Input Discrepancy faults	Greater than or equal to the first digital input address for A, B, or C.	Less than the start plus the maximum digital input address for A, B, or C.
14	Digital Input Autotest faults	start>=1	end<=12228, end<=start
15	Digital Input Genius faults	start>=1	end<=12228, end<=start
16	Digital Input Point faults	start>=1	end<=12228, end<=start
21	Digital Output Discrepancy faults: PLC A	start>=1	end<=12228, end<=start
22	Digital Output Discrepancy faults: PLC B	start>=1	end<=12228, end<=start
23	Digital Output Discrepancy faults: PLC C	start>=1	end<=12228, end<=start
24	Digital Output Autotest faults	start>=1	end<=12228, end<=start
25	Digital Output Genius faults	start>=1	end<=12228, end<=start
26	Digital Output Point faults	start>=1	end<=12228, end<=start
27	Digital Logon faults (PLC A)	First group number required	Last group number required
28	Digital Logon faults (PLC B)	First group number required	Last group number required
29	Digital Logon faults (PLC C)	First group number required	Last group number required
31	Analog Input Discrepancy faults	Greater than or equal to the first digital input address for A, B, or C.	Less than the start plus the maximum digital input address for A, B, or C.
35	Analog Input Genius faults	start>=1	end<=8192, end<=start
36	Analog Input Point faults	start>=1	end<=8192, end>=start
37	Analog Input Low Alarms	start>=1	end<=8192, end>=start
38	Analog Input High Alarms	start>=1	end<=8192, end>=start
45	Analog Output Genius faults	start>=1	end<=8192, end>=start
46	Analog Output Point faults	start>=1	end<=8192, end>=start
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 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 desired block you want shutdown information from (0–28)
48	Output 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 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 desired block you want shutdown information from (0–28)
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 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) 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 input blocks return the value 0.	High byte contains rack number (0–7) and low byte contains slot number (1–9) where the desired Bus Controller is located.	unused
1000h	Configuration text description	unused	unused

Error Codes for GMR Diagnostics

The following error codes may be generated by the GMR diagnostics routine (see page 7-24):

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

Programming for Global Data

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

The GMR software uses this Global Data capability as the vehicle for exchanging system information between the PLCs. Each PLC provides 8 words of system data to the other PLCs as Global Data. Because Global Data messages can be up to 64 words in length, up to 56 additional words of Global Data capacity are available for use by the application program. Since each PLC can broadcast just one Global Data message per bus scan, the system Global Data and the application Global Data are a sent in the same message.

Global Data for the Application Program

The application program can send Global Data by placing it into %G memory, as detailed below. Each PLC uses %G0001 through %G0896 to send "application" Global Data. It is not necessary to use all of the references.

The application program can read Global Data received from the other PLCs from %GA, %GB, and %GC memory. In addition, each PLC can also read a copy of its own Global Data. As explained in the PLC chapter of this book, each PLC actually 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, a PLC uses Global Data received from the bus designated bus b. Under ordinary circumstances, these two sets of data would match. The use of two busses provides redundant operation in case a bus or bus controller is not available.

The incoming Global Data is 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.

All PLCs	%G0001 –%G0896	Global data to be transmitted.

PLC A	%GA0001–%G A0896	Copy of transmitted global data.
	%GB0001–%GB0896	Data received from PLC B
	%GC0001–%GC0896	Data received from PLC C

PLC B	%GA0001–%G A0896	Data received from PLC A
	%GB0001–%GB0896	Copy of transmitted global data.
	%GC0001–%GC0896	Data received from PLC C

PLC C	%GA0001–%G A0896	Data received from PLC A
	%GB0001–%GB0896	Data received from PLC B
	%GC0001–%GC0896	Copy of transmitted global data.

Adding the GMR System Software to a New Application Program Folder

The GMR system software provided on the diskette must be added to the folder containing the application program.

Follow the steps below to add the GMR system software to a new application program folder.

1. **Place the GMR software diskette in a drive where it can be accessed by the Logicmaster programming software.**
2. **Enter the Logicmaster programming software and go to the folder functions (F8).**
3. **Create a new Program Folder (F1).**
4. **Enter a name for the new folder.** Press the Enter key.
5. **When prompted that the new name is not that of the current folder, respond "yes".**
6. **In the Program Folder functions menu, select F10, Copy Contents of Program Folder to Current Program Folder.**
7. **Copy the GMR directory containing the GMR system software to the new folder.**

   A. For **Source Folder**, enter the actual name of your GMRxxyy file (for example, GMR0206).

   B. **Current Folder** should already be selected.

   C. For **Information to be copied:** set **Program Logic** and **Reference Tables** only to yes.

```
C O P Y   P R O G R A M   F O L D E R   T O   C U R R E N T   F O L D E R

 Source Folder : a:\GMR0206
Current Folder : GMRPROG

Current drawer is D:\LM90

Information to be copied:
____________________________
ENTIRE FOLDER       N (Y/N)      The "ENTIRE FOLDER" selection
PROGRAM LOGIC       Y (Y/N)      will copy everything from the
CONFIGURATION       N (Y/N)      source folder (logic, config,
REFERENCE TABLES    Y (Y/N)      reference data,  teach files,
                                 and any  other files)  to the
                                 current folder.
```

Adding the GMR Configuration to the Application Program Folder

The GMR configuration software outputs a program block file named G_M_R10.EXE, which must be added to the folder containing the application program. By default, this file is located in the GMR Configuration Utility subdirectory.

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 to complete:

- 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 programming 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

 ANNUN    DIAGNO   FIX      G10516   G_M_R10  H2_FLOW  N_SIG    J1024
 MR513

<< 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.

Important ☞ 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

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

ANNUN    DIAGNO   FIX      G10516   G_M_R10  H2_FLOW  N_SIG    J1024    MR513

CURRENT FOLDER:  D:\LM90\GMRPROG

AI       FLT_CON  MOV      SID      TABLST   USER_IF
G_M_R01  G_M_R02  G_M_R03  G_M_R06  G_M_R08  G_M_R09  G_M_R10  G_M_R11  G_M_R12
G_M_R14  G_M_R15  G_M_R__

<< 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.

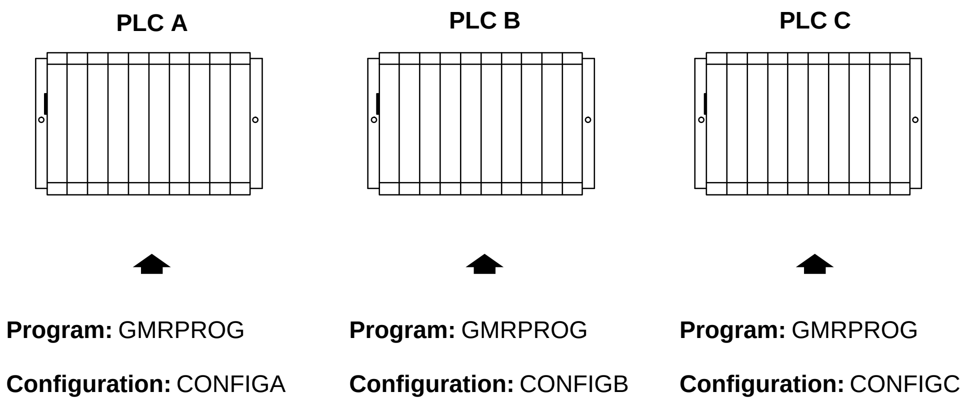
3. **DO NOT RENAME G_M_R10.**

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.

Storing a Program to the PLC

All redundant PLCs in the GMR system must use the same application program, but different configurations:



Supplying the configuration and program as separate files, as shown above, makes it easier to perform program updates in the future.

Note: 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. Configuration for online changes is described on page 6-15.

Things to Consider when Storing to the PLC from the Programmer

Use the Store function to copy program logic, configuration data, and /or reference tables from the programmer 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.

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.

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 will be cleared and replaced by the new logic in the current folder. The current configuration data and reference tables in the PLC are left intact.
3. 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.

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
ProgramLogic	The ladder logic program and %L and %P data.
Reference Tables	The reference tables for the program. except %L and %P data.
Configuration	The currentconfiguration.

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 which 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 which 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.

Storing a Program to the PLC: 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 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 diskette includes a special utility that can be used to facilitate storing an updated application program in a system that includes SNP (serial network protocol) communications between PLCs. This utility is described on the following pages.

If the system does not include SNP communications, then the update must be done manually.

Using the Program Download Utility

If the redundant PLCs are linked by an SNP network, you can use the Download utility provided on the GMR software diskette 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. Using DOS, 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

4. When you press the Space Bar, the PLC is put into Stop mode with its outputs disabled.
5. With all PLCs stopped, the software again prompts:

   Press the Space Bar to Continue

6. 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.
7. 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 diskette in your computer's diskette drive.
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.

Storing a Program to the PLC: 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, 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 Programing 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.

Chapter 8 Installation Information

- Genius Bus Connections
- Termination Boards
- Input Wiring
  - Single Sensor to Three Blocks (Triple Bus)
  - Three Sensors to Three Blocks (Triple Bus)
  - Block Wiring for a 16-Circuit Block in an Input Group
  - Block Wiring for a 32-Circuit Block in an Input Group
- Output Wiring
  - Block Wiring for a 16-Circuit, Four-block Output Group
  - Block Wiring for a 32-Circuit, Four-block Output Group

Note

The information in this chapter is intended only to supplement the installation instructions in the Series 90-70 PLC and Genius I/O Manuals and datasheets.

Those documents should be the primary references for installation of any GMR system.

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.

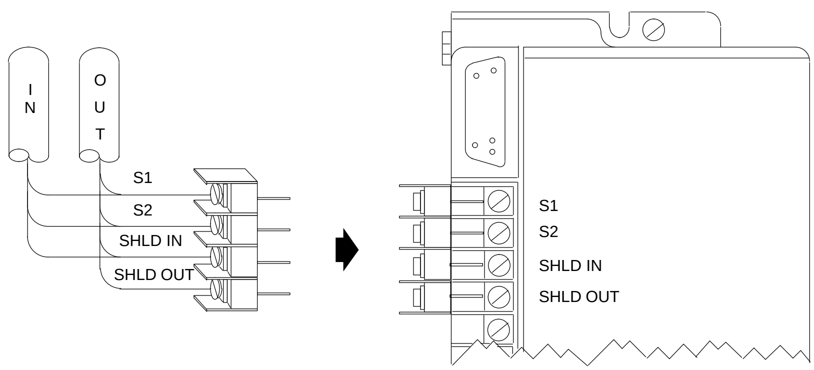
In GMR system, "GMR busses" can operate at any baud rate with the following restrictions:

D. All busses in a group must use the same baud rate.

E. 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.



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.

Termination Boards

Termination boards that will make it easier to integrate Genius blocks into redundant groups (4-block output groups or 3 or 2 block input groups) are currently being developed by a third-party supplier. Please contact your GE Fanuc Sales representative for more information about these GMR Termination Boards.

Input Wiring

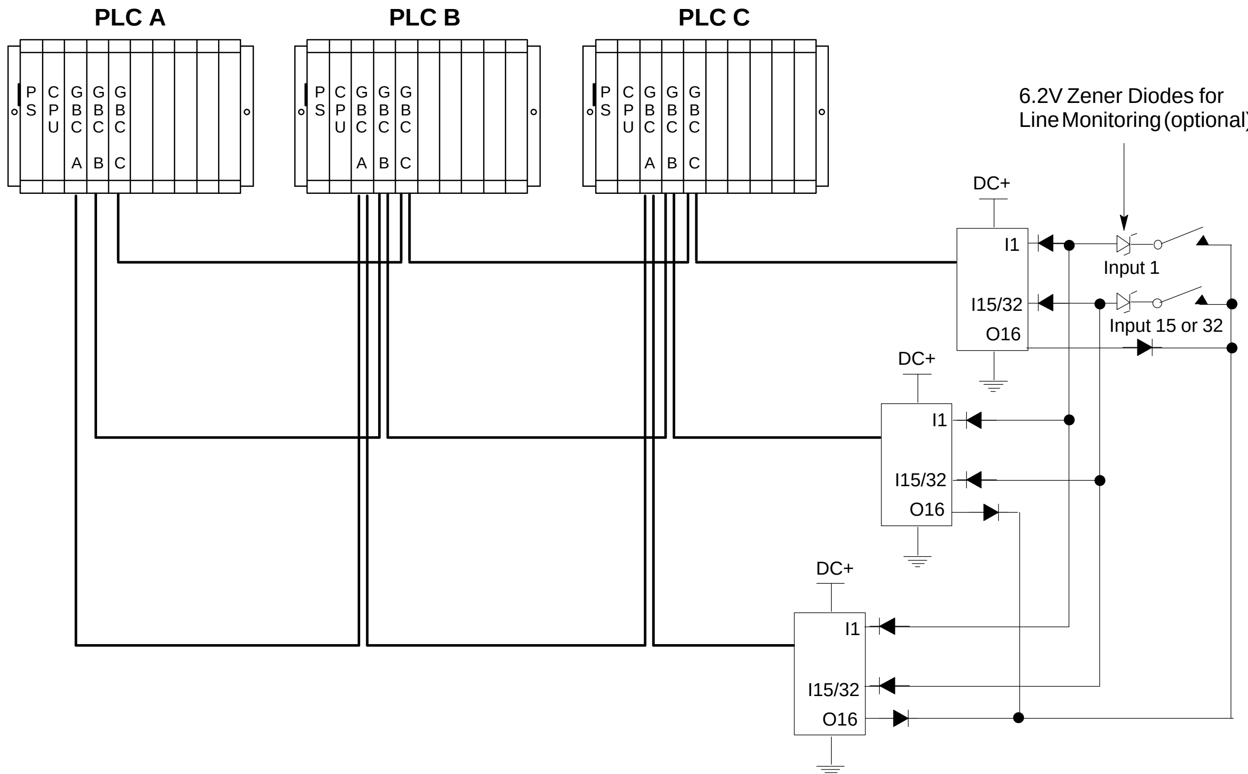
Calculating Voltage Drops on Tristate Inputs

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 inserted at the field device to provide an input threshold range for three states. The table on page 2-7 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 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).

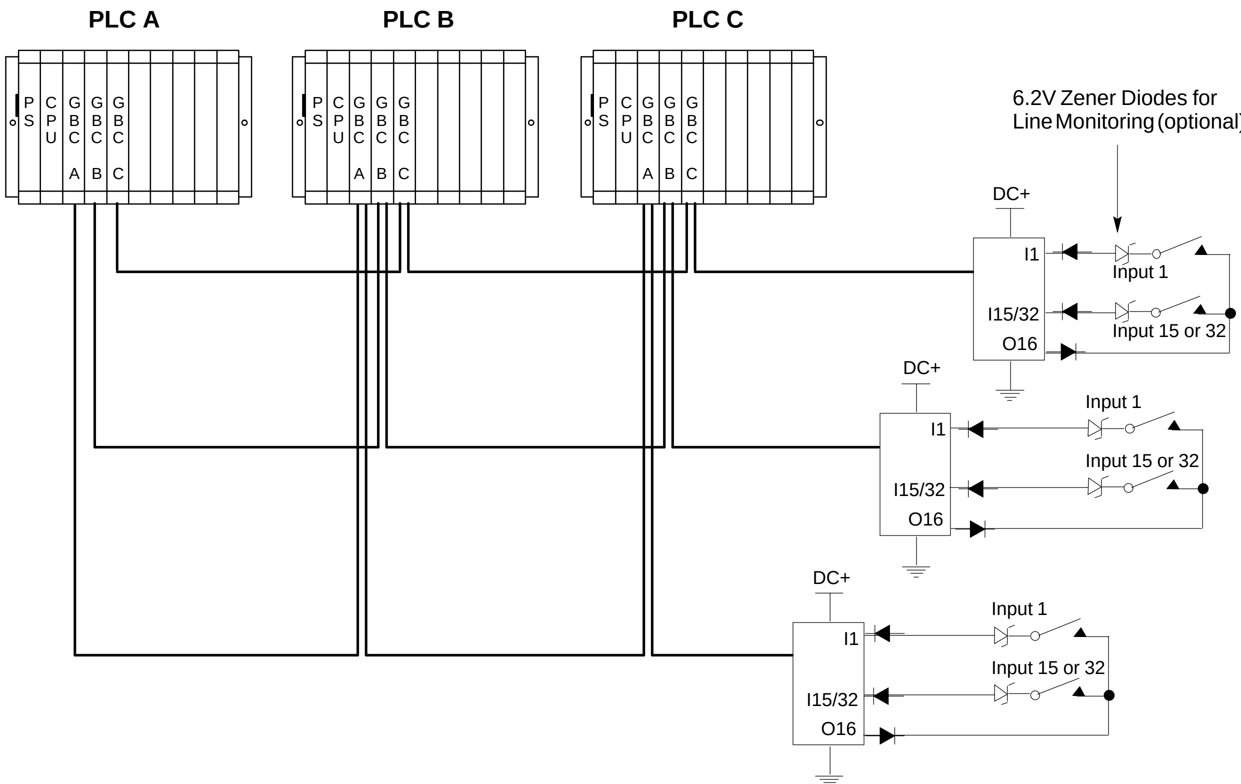
Single Sensor to Three Blocks (Triple Bus)



- 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.
- On any block, circuits that are not configured as part of the GMR input group can be used as non-redundant inputs or outputs.
- 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. Different groups may use different power sources.
- All blocks in the input group must be assigned the same serial bus address.
- 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 not be wired to the power feed output.
- Isolation diodes must also be wired as shown above for any input to be autotested. The suggested diode is 1N5400 or equivalent.

Input Wiring (continued)

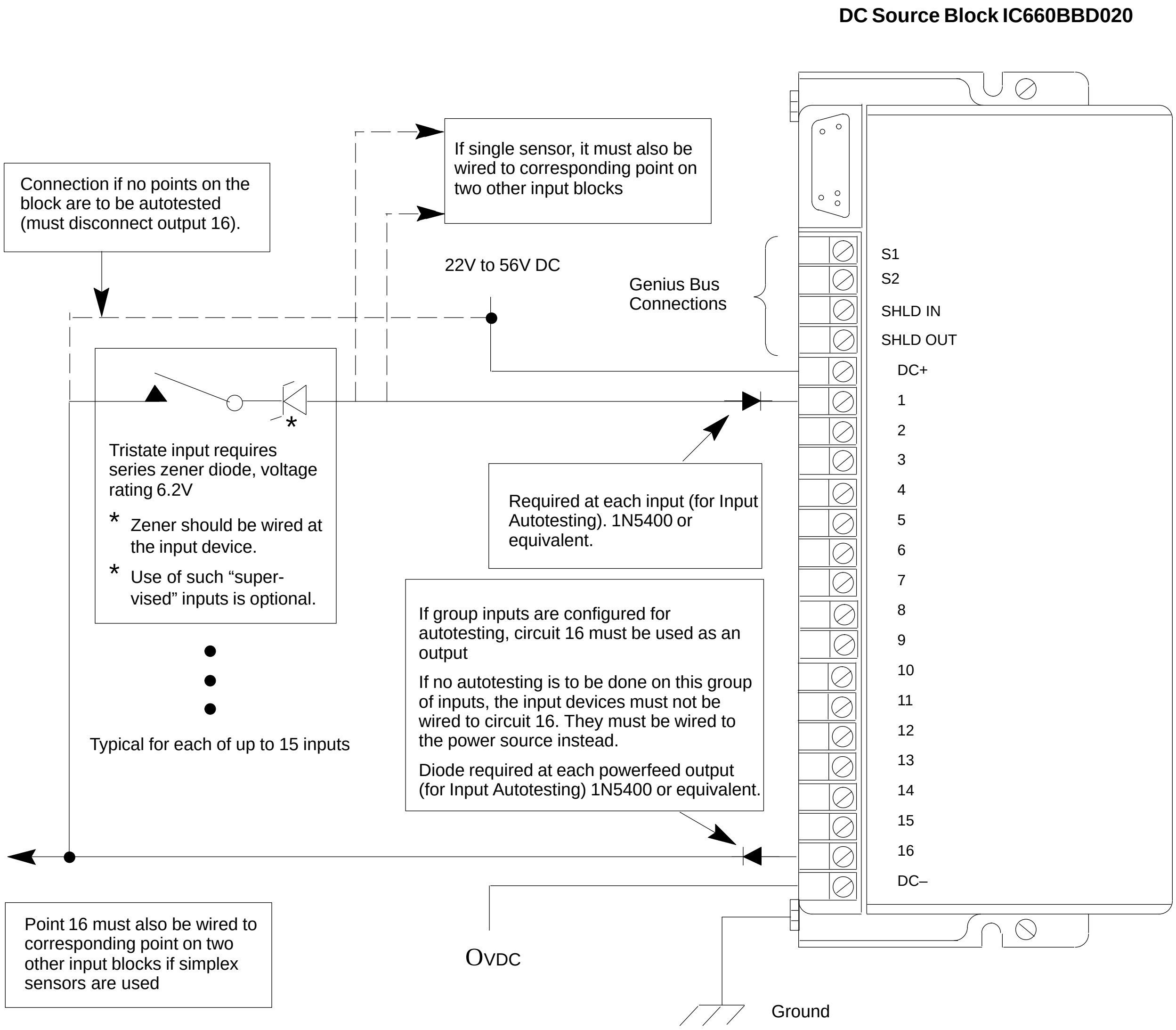
Three Sensors to Three Blocks (Triple Bus)



- 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.
- On any block, circuits that are not configured as part of the GMR input group can be used as non-redundant inputs or outputs.
- All blocks in the input group must be assigned the same serial bus address.
- 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. The suggested diode is 1N5400 or equivalent.

Input Wiring *(continued)*

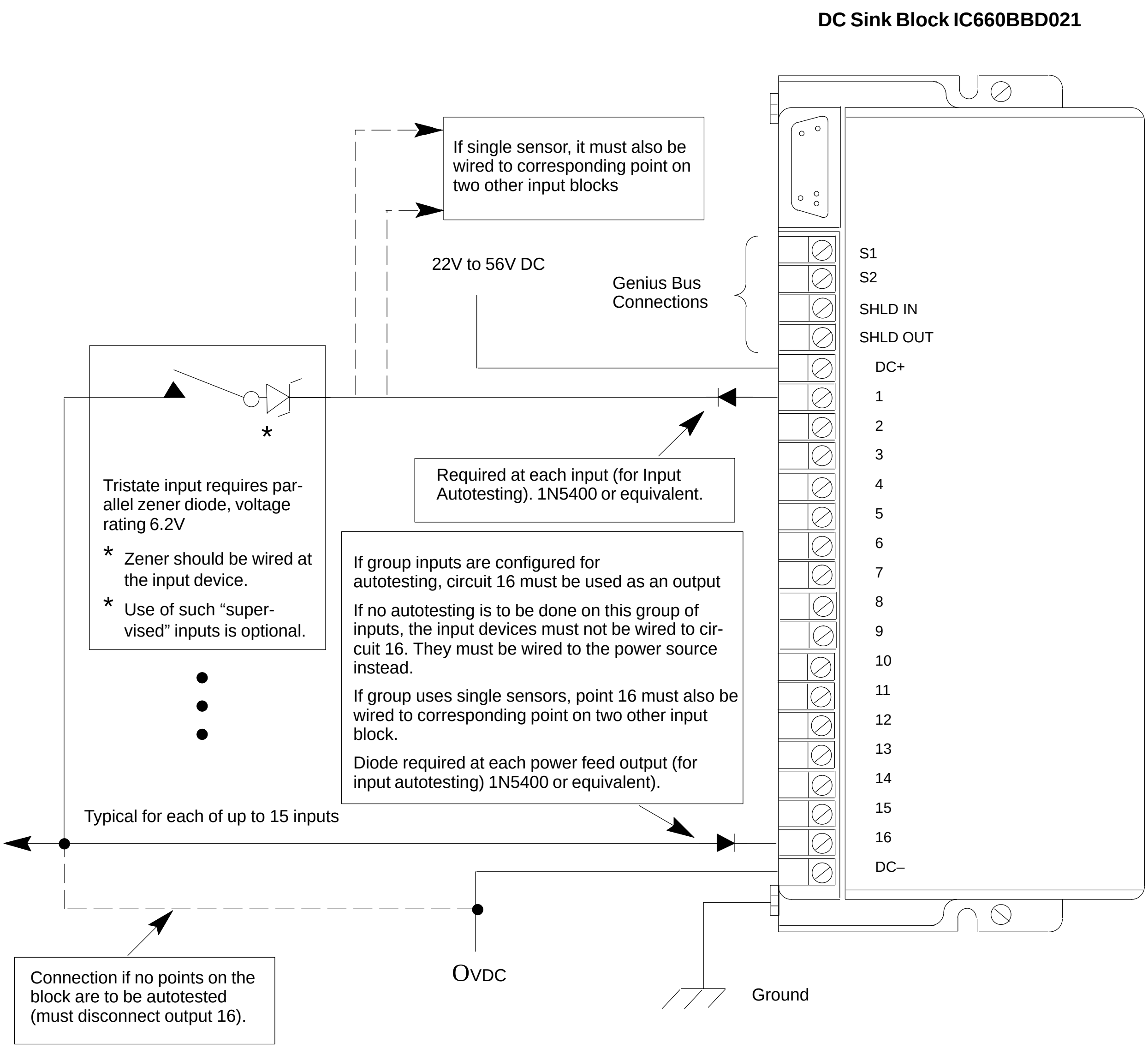
Block Wiring for 16-Circuit Source Block in an Input Group



- In 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. Different groups may use different power sources.

Input Wiring *(continued)*

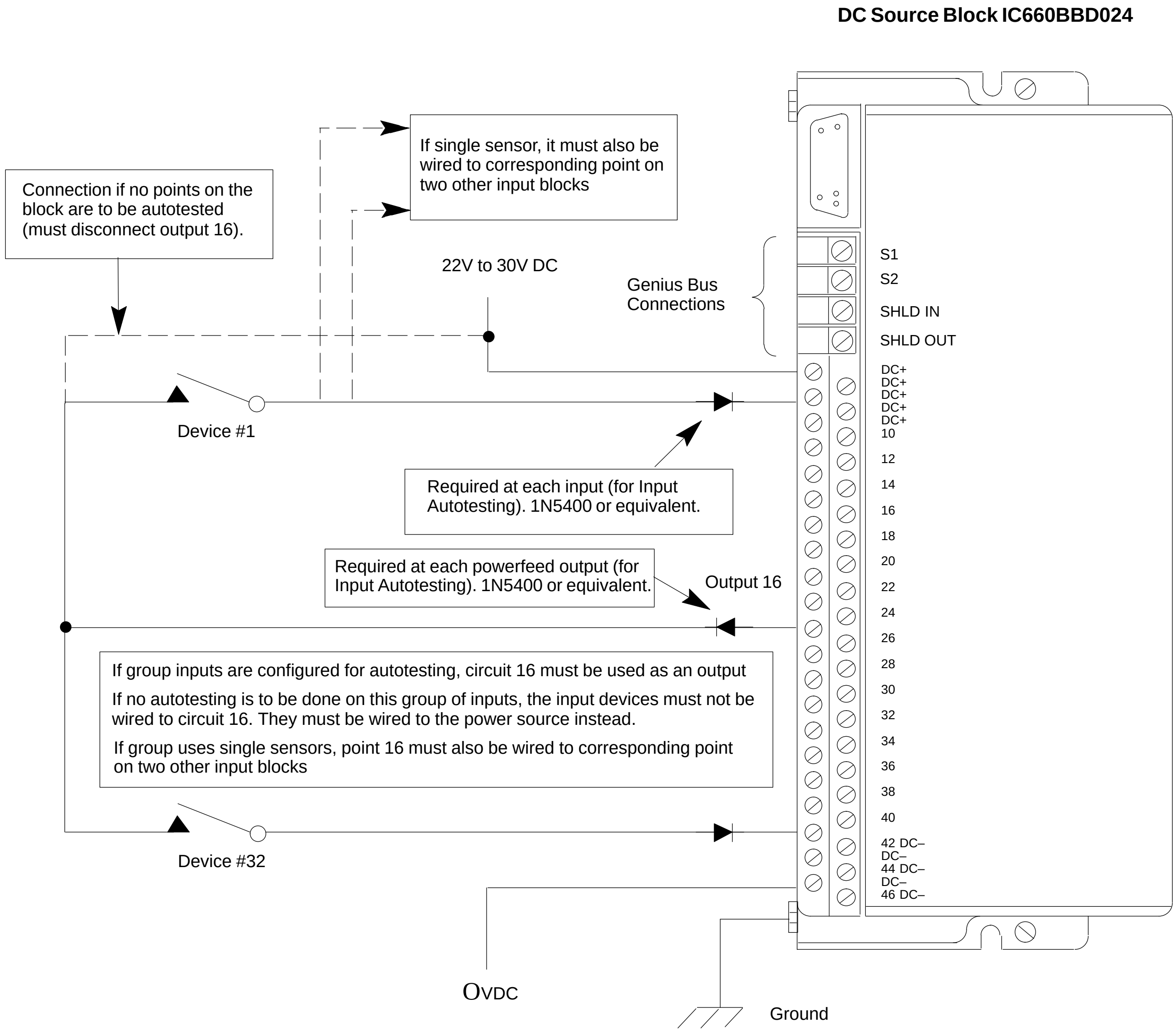
Block Wiring for 16-Circuit Sink Block in an Input Group



- In 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. Different groups may use different power sources.

Input Wiring *(continued)*

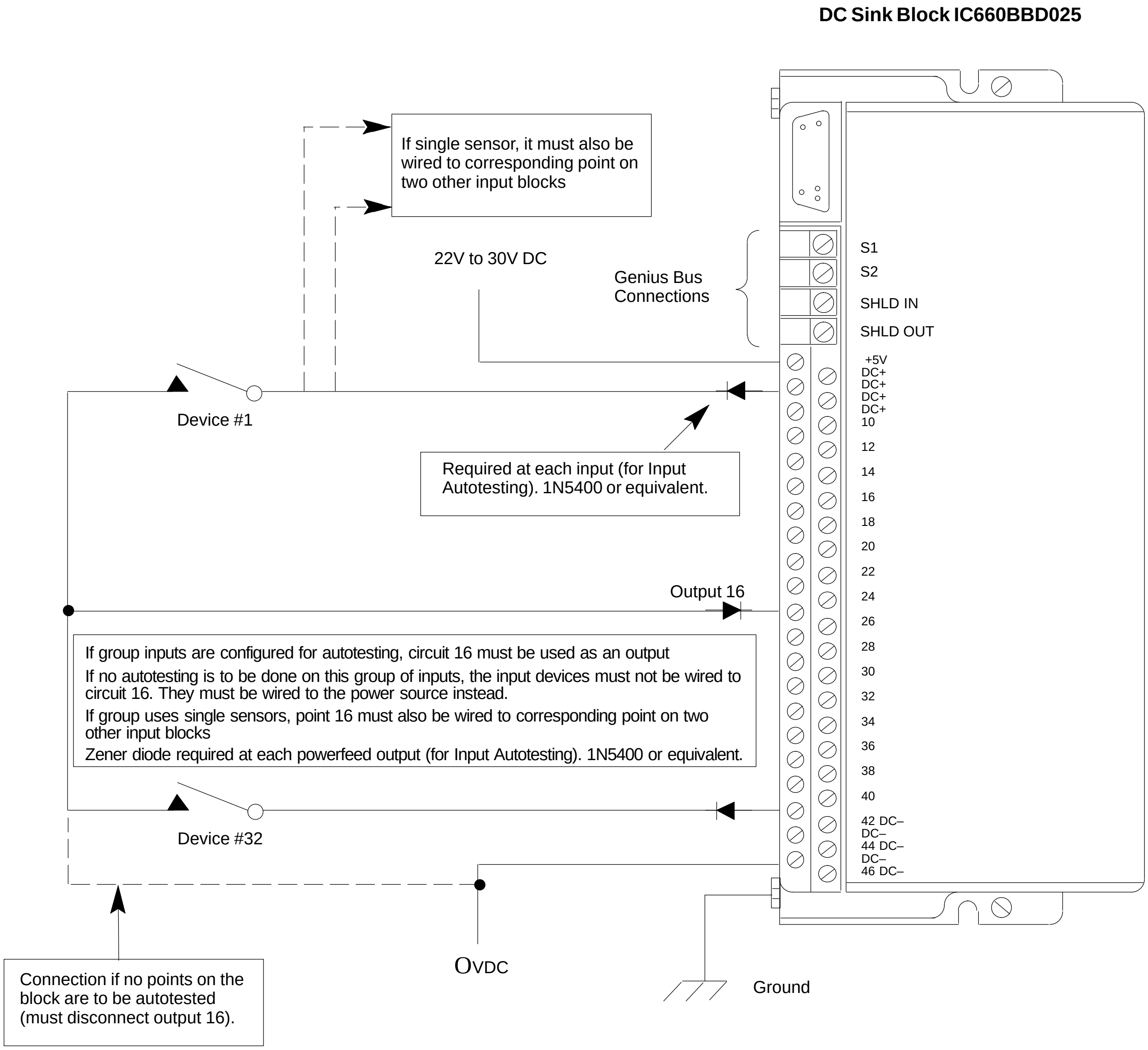
Block Wiring for 32-Circuit Source Block in an Input Group



- In three-block input group, each block is connected to one bus of three.
- 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.

Input Wiring (continued)

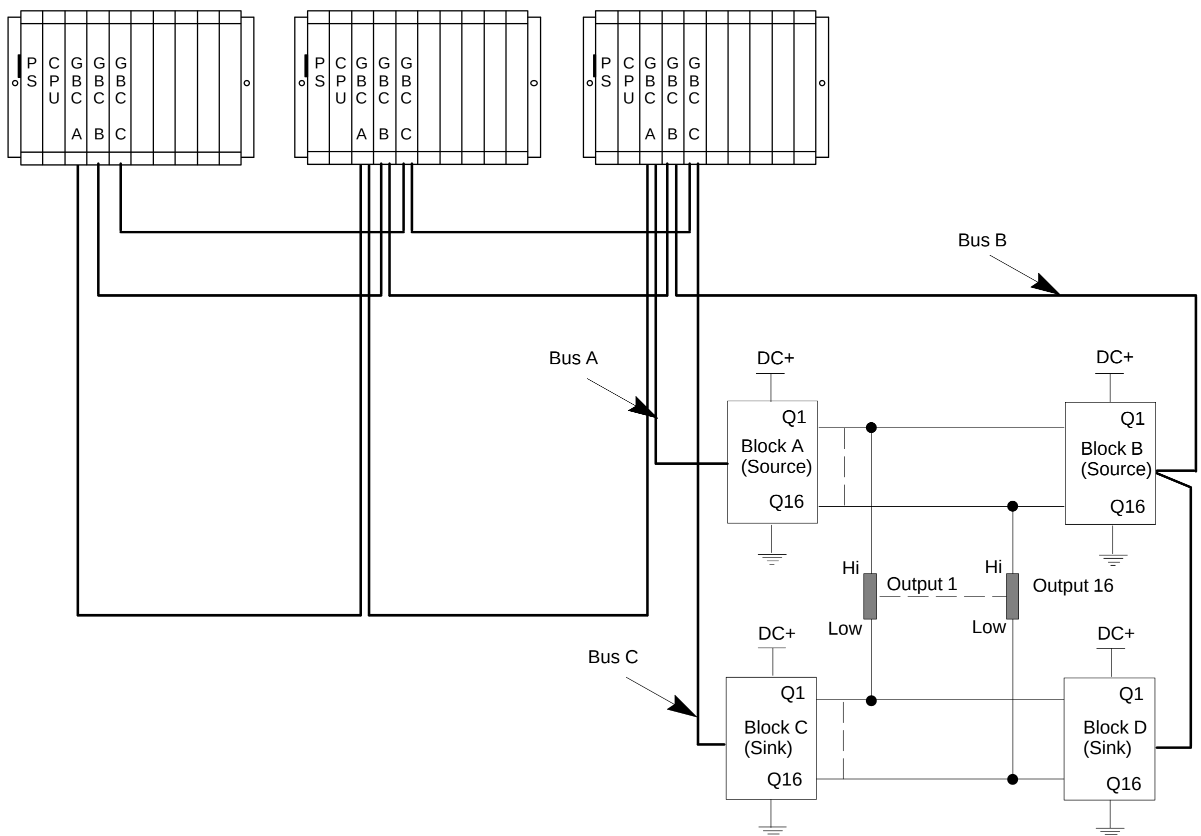
Block Wiring for 32-Circuit Sink Block in an Input Group



- In three-block input group, each block is connected to one bus of three.
- 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.

Output Wiring for a 16-Circuit, 4-Block Group

16- Circuit, 4-Block Output Group

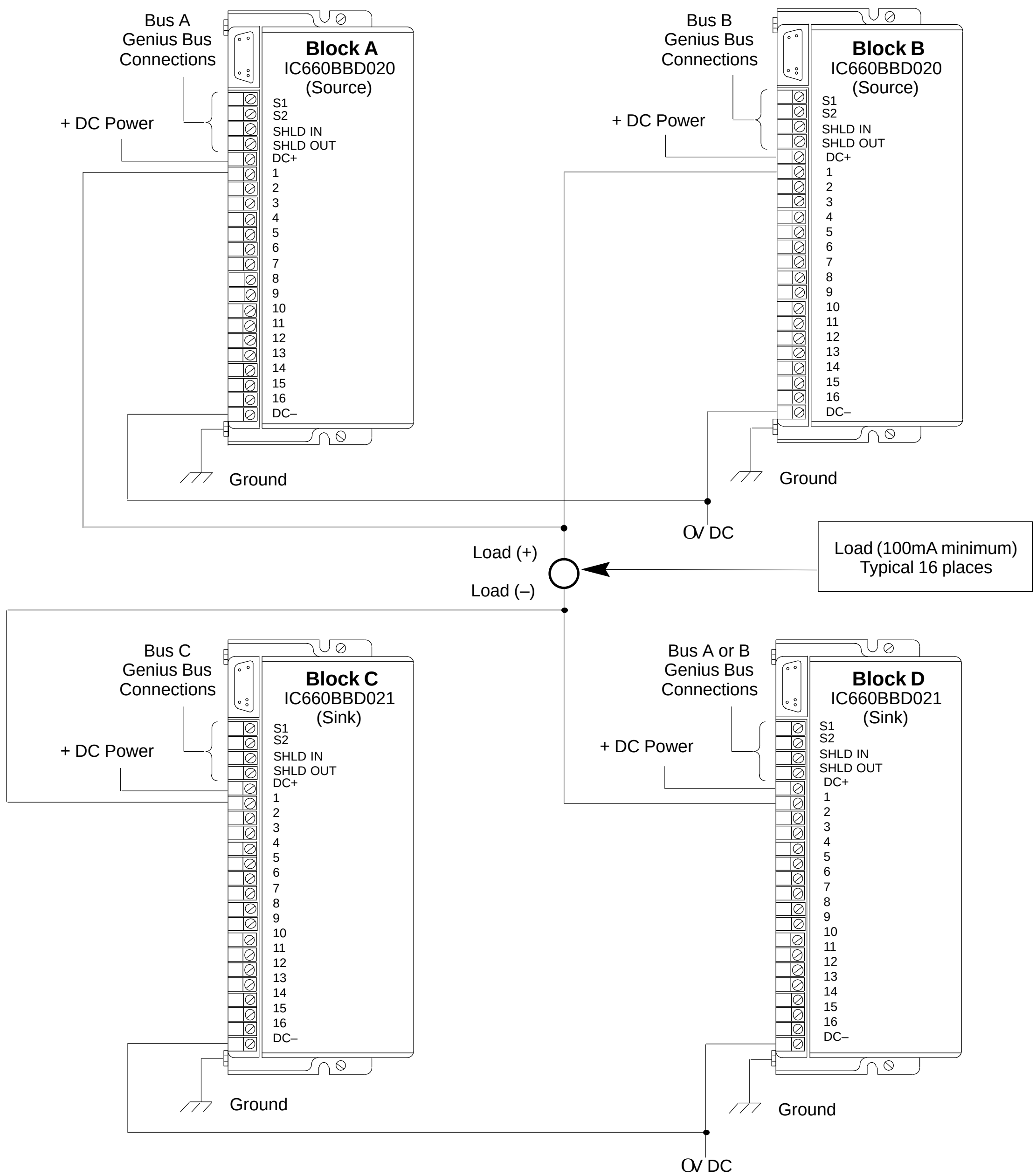


- All blocks in an output group must have the same number of circuits (16 or 32).
- Block "D" must be connected to the system through bus A or bus B (not bus C). The bus selected must be the one specified in the GMR configuration.
- Unused voted outputs cannot be used as non-voted I/O points.

Output Wiring for a 16-Circuit, 4-Block Group (continued)

Block Wiring for a 16-Circuit 4-Block Output 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.

Output Wiring for a 16-Circuit, 4-Block Group *(continued)*

Output Load Considerations for 16-Circuit 4-Block "H" Pattern Redundant Output Groups

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

Caution

Check the characteristics of each output device against the list above to verify that it can be autotested and/or used in the 4-block 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. The actual pulse width and the number of times a point is tested depend greatly on its configuration, state (ON or OFF) and the type of load (or absence of load) on the point. So, output circuits that are to be autotested must be able to withstand On and Off pulse times that are discussed below. Each output device's characteristics should be checked against the list above to verify that it can be autotested and / or used in the 4-block output group. The following Pulse Test descriptions refer to Pulse Test operation of a block configured in the GMR mode only.

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, these is a delay of approximately 5 to 15 mS 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.

Each output device's characteristics should be checked against the list above to verify that it can be autotested and / or used in the 4-block output group. 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 4-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 4-block output group. The following are two examples.

GE Catalog Number CR120BDXXX48 Series A 600–Volt Industrial Relay

XXX represents a 3-digit number identifying the type and number of contacts.

This relay has a NEMA A600 rating: Maximum AC Voltage = 600
Maximum continuous current: = 10A

The 24 VDC coil typically draws 117 milliamps at 24 VDC when the relay is picked up. This meets the GMR requirement of a minimum of 100 milliamps to be able to use the No Load diagnostic without using additional external components to increase the load. However, the 24 VDC coil is a dual winding type which draws a higher current during the first part of the armature stroke. Its inrush current is approximately 9.8 Amps at 24 VDC, which causes an Overload diagnostic (overload=more than 2.8 Amps) to be generated by the Genius output circuits. To overcome the high inrush current, the Overload diagnostic must be set to NO for those outputs that would be wired to this type or relay. This relay, with no external components, does not exhibit any chatter during the output autotesting, although a flyback diode is still recommended to reduce noise on the 24VDC power lines.

GE Catalog Number CR7RBXXEL Spectra 700 IEC Control Relay

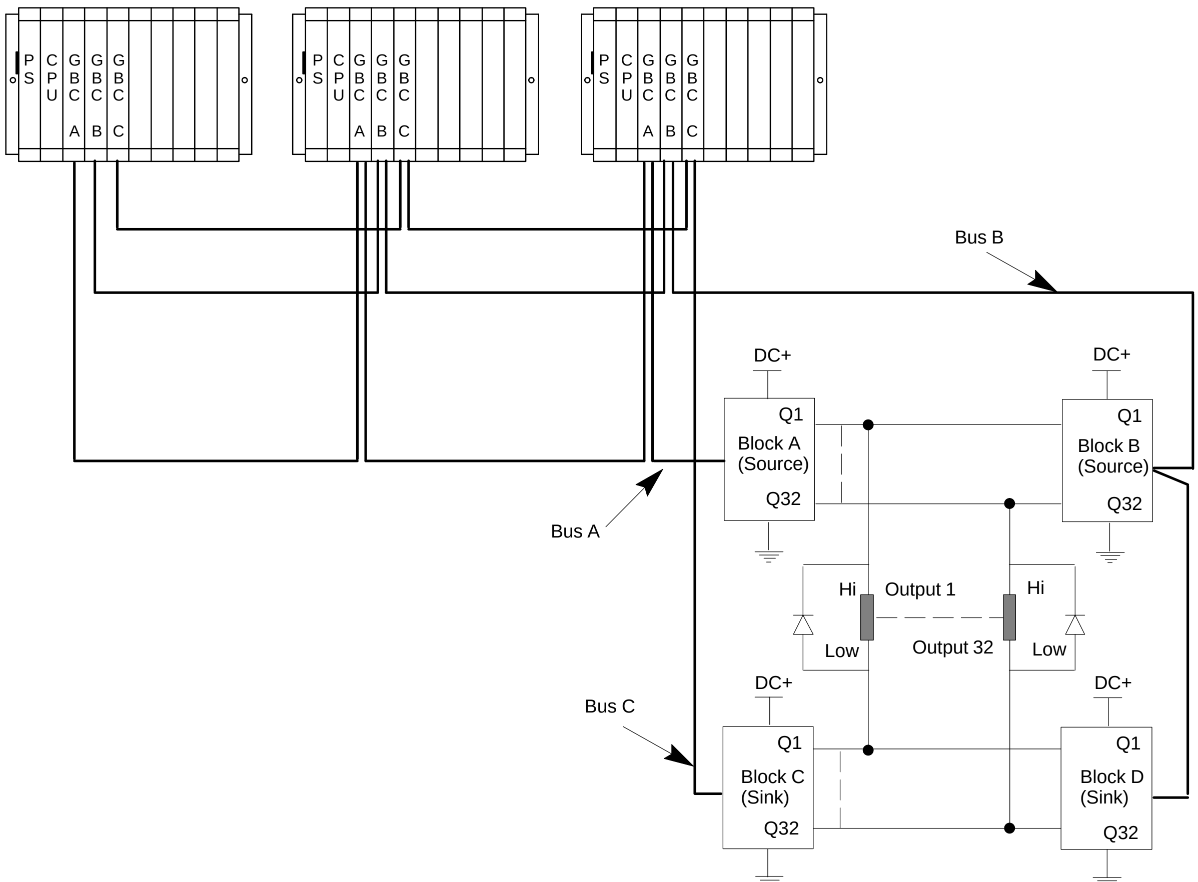
XX represents a 2-digit number identifying the type and number of contacts.

This relay has a NEMA A600 rating: Maximum AC Voltage = 600
Maximum continuous current: = 10 A

The 24 VDC coil typically draws 230 milliamps at 24 VDC when the relay is picked up. This also meets the GMR requirement of a minimum of 100 milliamps to be able to use the No Load diagnostic without using additional external components to increase the load. The inrush current for this relay is low enough that the Overload can be left enabled. However, this relay, with no external components, does exhibit very minor chatter during the output autotesting, although its contacts do not begin to open. A flyback diode wired across the coil eliminates all the chatter and is also recommended to reduce noise on the 24VDC power lines.

Output Wiring for a 32-Circuit, 4-Block Group

32- Circuit, 4-Block Output Group

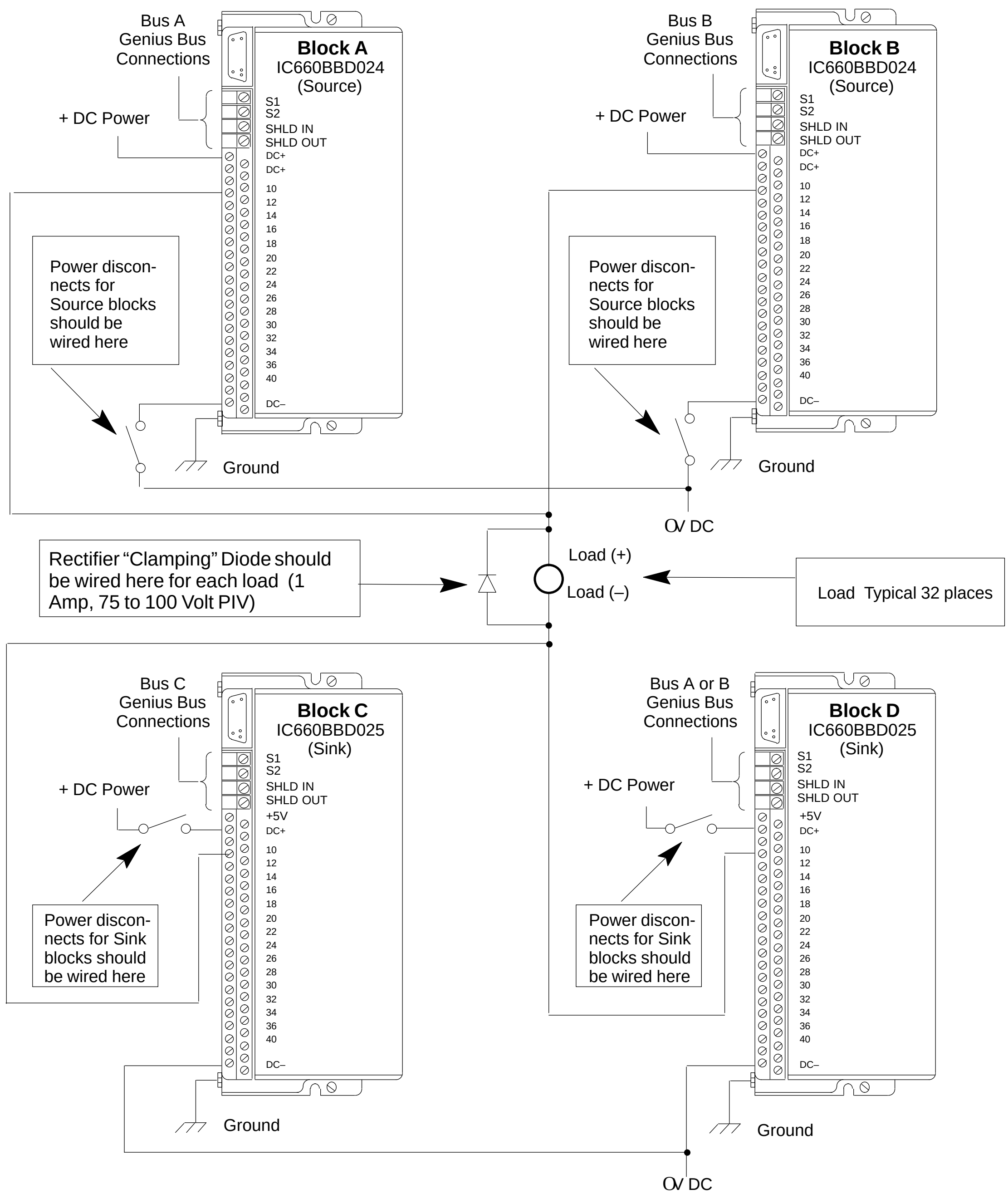


- All blocks in an output group must have 32 circuits.
- Block "D" must be connected to the system through bus A or bus B (not bus C). The bus selected must be the one specified in the GMR configuration.
- Unused voted outputs cannot be used as non-voted I/O points.

Output Wiring for a 32-Circuit, 4-Block Group *(continued)*

Block Wiring for a 32-Circuit 4-Block Output 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.



Warning

In certain cases, removing the DC power source from an output block or blocks which are part of a 32-circuit 4-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 adversly affect the output devices being controlled, the following 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.

Caution

When a 32-circuit 4-block output group is wired according to the instructions above and a single block is powered down for maintenance purposes, the following normal procedures should be followed.

- A PLC Force Logon may be required as always when an output block has power restored to it to cause the output 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. To execute a PLC Force Logon, turn on the GMR control bit %M12263 (FORCLOG – Force Block(s) to Log on).
- An I/O fault reset should executed after restoring power to a block in an ouput group. This is done by turning on the GMR control bit %M12258 (IORES – Perform I/OFault Table Clear).

Output Wiring for a 32-Circuit, 4-Block Group *(continued)*

Output Load Considerations for 32-Circuit 4-Block "H" Pattern Redundant Output Groups

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 4-block 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.

Appendix A TÜV 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 applications such as Emergency Shut Down (ESD), according to class 1 through 5 of DIN VDE 0801 standards and requirements. The type approval certificate is 945/EL 273/95. TÜV type approval for the GMR system for use in Fire and Gas applications is pending. The GMR system may be used in the following configuration for class 4 or 5 applications respectively:

Class 5 – Triplex (2v3) – Fail Safe and Fault Tolerant
Class 5 – Duplex (2v2) – Fail Safe
Class 4 – Duplex (1v2) – Fail Safe and Fault Tolerant

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 and Genius I/O 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 restrictions as described in this appendix. The subset of components that are approved are also listed in this appendix. In addition, this appendix describes restrictions placed on the design, configuration, installation and use of a GMR system that will be applied in an Emergency Shut Down (ESD) application, for which for a TÜV site application approval will be sought.

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 restrictions.

TÜV Restrictions

For all safety relevant applications the safe state must be the de-energized (0) state.

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 type 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. Specifically approved hardware components for the safety relevant portion are:

Catalog Number	Firmware Revision Level	Description
IC697BEM711J	n/a	Bus Receiver
IC697BEM713F	n/a	Bus Transmitter
IC697BEM731N	4.8	Genius Bus Controller
IC697CHS790D	n/a	9–Slot Rack
IC697CPU788DA	5.50	GMR CPU – 100 Triplex (voted) I/O
IC697CPU789DA	5.50	GMR CPU – 2K Triplex (voted) I/O
IC697MEM735D	n/a	Expansion memory module 512KB
IC697PWR711CX	n/a	Power Supply 120/240Vac, 100 Watts
IC660BBA023K	1.4	Genius Thermocouple Input Block, 24/48Vdc Power, 6 in
IC660BBA021K	1.1	Genius RTD Input Block, 24/48Vdc Power, 6 in
IC660BBA106K	1.0	Genius Current Source Analog Input Block, 115Vac/125Vdc, 6in
IC660BBA026K	1.0	Genius Current Source Analog Input Block, 24Vdc, 6 in
IC660BBA024K	1.8	Genius Current Source Analog I/O Block, 24/48Vdc, 4in/2out
IC660BBD020M	3.6	Genius Source I/O Block, 16 circuit, 24/48Vdc
IC660BBD021M	3.6	Genius Sink I/O Block, 16 circuit, 24/48Vdc
IC660BBD024N	3.7	Genius Source I/O Block, 32 circuit, 12/24Vdc
IC660BBD025N	3.7	Genius Sink I/O Block, 32 circuit, 5/12/24Vdc

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.

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 on each side of the load.

If Power Supply IC697PWR711CX is used with a 230 Volt AC power source, a surge protector/filter device is required. Any incoming overvoltage 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 overvoltage 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-0262D) and this *GMR User's Manual* (GFK-0787A) 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-0262D).

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, no RFI gasketing and all enclosure sides grounded to a common point with grounding straps equal to or larger than #14 AWG. 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.

The on-line programming option must be set to DISABLED in the configuration.

The simplex shutdown option must be set to be enabled at 60 seconds.

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 Appendix B of this manual.

Autotesting must be set to ENABLED for all used circuits of each discrete input group.

Vote Adaptation must be set to 3–2–0 for all used circuits of each discrete input group.

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.

Autotesting must be set to ENABLED for all used circuits of each discrete output group.

Normal State must be set to ON for all used circuits of each discrete output group.

Vote Adaptation must be set to 3–2–0 for each analog input group.

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.

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 worksheets are available for all 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.

Configuration Protect must be Enabled in each block.

The HHM must be configured to use serial bus address 0 (the default).

The following configuration options must be disabled and the 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, CALLEXTERNAL.

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.

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 three PLCs.

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).

A status report must be produced by setting the GMR REPORT bit (%M12262). The resultant information must be checked verified against the configuration printout.

Two backup copies of the system configuration and application program must be made for documentation and backup purposes. These backups must be verified to be identical to what resides in the PLCs by use of the Logicmaster 90–70 software.

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–0787B.

The Force Logon control bit must be set via a hard wired input device, as described in chapter 7 of GFK–0787B. 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 GFK–0787B.

The Cancel I/O Shut Down control bit (%M12265 – SD_CAN) must left in the off (0) state and must not used in any portion of the application program.

When the final commissioned application program is stored to the PLCs, all program data including reference tables must be stored. The procedures in document GFK-0787B starting at page 7-31 should be observed.

Appendix B Maintenance 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.

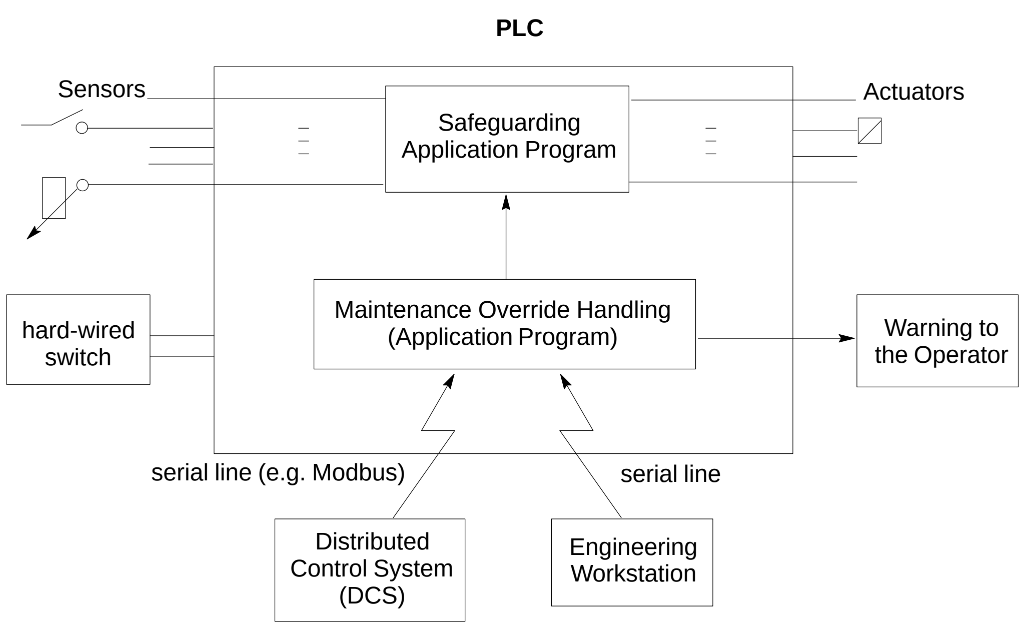
The following table shows common requirements. The differences between solution A and B are shown by typeface italic.

Requirements for maintenance override handling	Responsibility
Alreadyduring 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 correctconfiguration.
The configuration may also specify by a table, whether simultaneousoverriding in independent parts of the application is acceptable.	A. *Project engineer* B. *Projectengineer, Typeapproval*
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 Maintenanceengineer.* B. *Typeapproval*
A. *The override is activated via DCS.* B. *The maintenance engineer activates the override via the programmingenvironment.* As an organizational measure, the operator should confirm the overridecondition.	A. *Operator, Maintenanceengineer* B. *Typeapproval, Maintenance 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. *Projectengineer, Typeapproval*
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 programmingenvironment.*	A. *Operator, Maintenanceengineer* B. *Maintenanceengineer*
A. *There should be a second way to remove the maintenance overrodecondition.* B. *If urgent, the maintenance engineer can remove the override by the hard-wiredswitch.*	A. *Project engineer* B. *Maintenanceengineer, 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

A

B

C

D