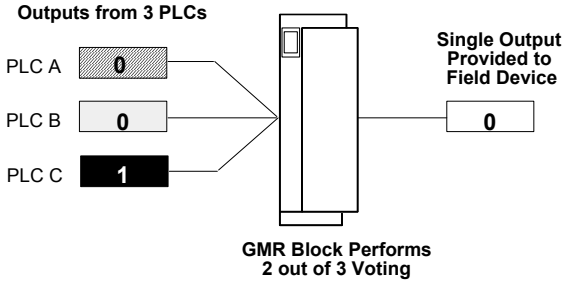
GMR Output Voting

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

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

24/48 VDC 16-Circuit Source block:	IC660BBD020
24/48 VDC 16-Circuit Sink block:	IC660BBD021
12/24 VDC 32-Circuit Source block.	IC660BBD024
5/12/24 VDC 32-Circuit Sink block:	IC660BBD025
24/48 VDC 16-Circuit Source block	IC660BRD020 (with internal blocking diodes)
24/48 VDC 16-Circuit Sink block	IC660BRD021 (with internal blocking diodes)
12/24 VDC 32-Circuit Source block	IC660BRD024 (with internal blocking diodes)
5/12/24 VDC 32-Circuit Sink block	IC660BRD025 (with internal blocking diodes)

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



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

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

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

If the Simplex Shutdown feature is enabled, a PLC will shut down if it determines that it is the only PLC still operating. The timeout period before it shuts down is

configurable. When the PLC shuts down and a block group is no longer receiving output data, outputs go to their default state or last state, as configured.

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

Duplex Default for Voted Outputs

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

Results of Block Group Voting with Three PLCs Online

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

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

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

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

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

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

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

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

Results of Block Group Voting with One PLC Online

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

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

PLC Logon Control

The purpose of PLC logon control is to prevent a CPU that is coming online from changing the state of a critical voted output. 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).

Automatic PLC logon should use the DUPLEX status bit to ensure 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.

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

Discrete Output Discrepancy Reporting

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

How Output Discrepancy Checking is Done

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

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

Discrete Output Discrepancy Reporting with Dynamic Outputs

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

Because of the asynchronous operation of CPUs in a GMR system, it is possible that output blocks, while voting the output from three separate CPUs, could "see" a discrepancy when an output is simply changing states. Versions 7.00 and higher of the GMR Configuration Utility allow one to adjust the Output Discrepancy Filter time to a value between 0 and 65535 seconds (See Chapter 6 System Configuration, the Options Tab). An output discrepancy must exist for the configured number of seconds before it is reported as a fault.

If the Output Discrepancy Filter time is set to 0 (the default), output discrepancy checking works with outputs that change state less frequently than approximately once per 10 PLC scans.

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

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

Discrete Output Autotest

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

Output Faults that Cause I/O Shutdown

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

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

Operation of the Output Autotest

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

For the test to be performed:

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

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

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

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

Output Autotest Faults When Outputs are Rapidly Changing State

In addition to causing output discrepancy faults (see previous page), normally-energized outputs that change frequently and are part of a redundant output group can also cause Output Autotest faults. If the output value changes while the Autotest overrides the output block's state to the de-energized state, the Autotest can fail, causing an Output Autotest fault message. In addition, the output remains overridden in the de-energized safe state. Increasing the Output Discrepancy Filter time often resolves prevents these auto-test faults from occurring (See Chapter 6 System Configuration, the Options Tab).

GMR Pulse Test Operation for 32-Circuit Blocks

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

GMR Pulse Test Operation for 16-Circuit Blocks

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

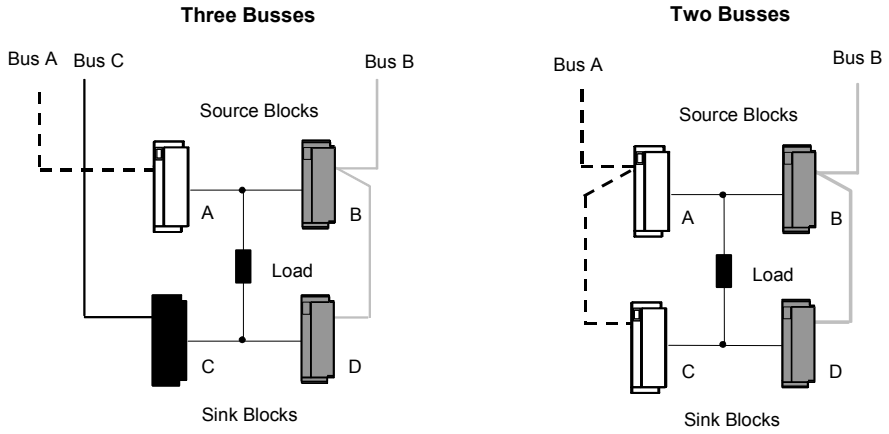
ON-OFF-ON Test: Similar activity occurs for this test. The initial time a point is Off is about 5mS. The only fault checked for in this case, however, is that the volts feedback agrees with the commanded state. If it does not, the point is pulsed Off again for about 7.5mS. A maximum of two pulses of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

The H-Block Output Group

All four blocks in an H-Block Output Group must be either 16-circuit or 32-circuit blocks. In this type of group, two source-type Genius blocks, preferably IC660BRD020 or IC660BRD024, are connected in parallel on one side of each load and two sink-type Genius blocks, preferably IC660BRD021 or IC660BRD025, are connected in parallel on the other side.

The IC660BRD020, BRD021, BRD024, and BRD025 blocks have built-in blocking diodes. Blocks with other catalog numbers (for example, block IC660BBD024) require external blocking diodes. The diodes prevent the possibility of system malfunction due to back-drive current through the common I/O point connected to the other block.

An H-Block Output Group requires either two or three Genius busses.



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