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Programmable Control Products

PACSystems*

Hot Standby CPU Redundancy

User's Manual, GFK-2308G

December 2013

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Contents

Chapter 1 Introduction

This manual is a reference to the hardware components, configuration, programming and operation of Hot Standby CPU redundancy for the PACSystems RX3i and RX7i Controllers. The information in this manual is intended to supplement the system installation, programming, and configuration information contained in the manuals listed under "Related Publications" on page 1-6.

Hot Standby CPU Redundancy

Hot Standby CPU Redundancy allows a critical application or process to continue operating if a failure occurs in any single component. A Hot Standby system uses two CPUs; an active unit that actively controls the process, and a backup unit that is synchronized with the active unit and can take over the process if it becomes necessary. The two units are synchronized when both are in Run Mode, the backup unit has received the latest status and synchronization information from the active unit via a redundancy link, and both are running their logic solution in parallel.

Each unit must have a redundancy CPU and one or two Redundancy Memory Xchange (RMX) modules. The redundancy communication paths are provided by one or two pairs of RMX modules.

Note: We **strongly recommend** using two pairs of RMX modules configured as dual redundancy links. This practice eliminates the possibility of a single point of failure that using only one pair of RMX modules presents.

Control automatically switches to the backup unit when a failure is detected in the active unit. You can initiate a switch of control by activating a toggle switch on the RMX module or activating a service request in the application program. When a user-initiated switch of control occurs, the CPUs switch roles; the active unit becomes the backup unit and the backup unit becomes active.

The system runs synchronously with a transfer of all control data that defines machine status and any internal data needed to keep the two CPUs operating in sync. Critical control data plus all redundant outputs must be included in the output data transfer. The transfer of data from the active unit to the backup unit occurs twice per sweep, once before the logic is solved and once after the logic is solved. These CPU-to-CPU transfers are checked for data integrity.

The Primary and Secondary units in a redundancy system must be in the same Controller family. An RX3i and an RX7i Controller can ***not*** function as a redundant pair.

PACSystems HSB Redundancy Feature Summary

Feature	***RX3i Redundancy System***	***RX7i Redundancy System***
Redundancy CPU	IC695CRU320	IC698CRE020, CRE030 or CRE040
Redundancy links	Two IC695RMX128 modules per link Two links (four RMX modules) recommended per system	Two IC698RMX016 modules per link Two links (four RMX modules) recommended per system
Redundancy I/O systems supported	PROFINET I/O using single ring and star network topologies Single and redundant Ethernet remote I/O LANs through ENIU Single Bus and Dual Bus Genius networks	Single and redundant Ethernet remote I/O LANs through ENIU Single Bus and Dual Bus Genius networks
Expansion and remote racks	Supported	Supported
Failure recovery	Survives any one single point of failure (excluding failures of Genius devices and bus stubs) Online repair of failed component	Survives any one single point of failure (excluding failures of Genius devices and bus stubs) Online repair of failed component
Role switching	Manual toggle switch for switching control between active and backup units Application-initiated role switching	Manual toggle switch for switching control between active and backup units Application-initiated role switching
Bumpless switching from active unit to backup unit	Synchronized CPUs One-scan switching Configurable transfer data size up to 2Mbytes	Synchronized CPUs One scan-switching Configurable transfer data size up to 2Mbytes
Redundancy status monitoring	RMX128 module has five redundancy status LEDs (Link OK, Local Ready, Local Active, Remote Ready, Remote Active) Redundancy status bits and message logging	RMX016 module has five redundancy status LEDs (Link OK, Local Ready, Local Active, Remote Ready, Remote Active) Redundancy status bits and message logging
Online programming	Supported	Supported
Diagnostics	Background diagnostics Memory error checking and correction (ECC) with single bit corrections and multiple bit checking	Background diagnostics Memory error checking and correction (ECC) with single bit corrections and multiple bit checking
Maximum fiber optic cable distance supported between two RMX modules used in redundancy link	1000 feet (304.8 meters)	1000 feet (304.8 meters)

Online Programming

On-line changes to the application program are permitted in both the active unit and the backup unit. The programming device must be connected to the unit in which changes are to be made in order to make any on-line changes.

PACSystems releases 5.5 and later support run mode store (RMS) of the redundancy transfer list. This capability allows you to add, delete or modify transfer list entries without stopping the controllers.

Run mode stores are performed independently on both controllers. However, in a synchronized system, the optional *Dual RMS with Simultaneous Activation* feature can be used to defer activation of the newly stored application data until an RMS has been performed on both units. Because the controller sweeps are synchronized, both units will activate the new logic and transfer lists on the same sweep. For additional information about the use of this feature, refer to “Run Mode Stores” in Chapter 5.

On-Line Repair and System Upgrade

A Hot Standby CPU Redundancy system permits online repair of failed components without disrupting the control application. A failed component can be replaced in either unit after first removing power from the rack in which it is installed.

After replacing the component, returning power to the rack, and placing the CPU in Run mode, the repaired unit synchronizes with the currently active unit. Upon successful synchronization, the repaired unit becomes the backup unit.

RX7i Systems Only

The Redundancy CPU in each unit can be replaced with a different model in a similar manner. For example, you might want to replace the CRE020 models with CRE030 or CRE040 models, or CRE030 models with CRE040 models.

Caution

During normal operation, the primary and secondary units in an HSB redundancy system must have the same CPU model type. Extended operation with dissimilar CPU types is not allowed. Continued use of dissimilar CPU types can result in timing issues during synchronization.

The primary and secondary units with dissimilar CPU model types can be synchronized for a limited time, for the purpose of system upgrade only. Fail wait times for the higher performance CPU in a dissimilar redundant pair might need to be increased to allow synchronization. Either model can be in the primary or secondary unit.

Online repair and system CPU upgrade are described in more detail in chapter 7.

Definitions

Active Unit	The unit that is currently controlling the process.
Backup Unit	The unit that is synchronized with the active unit and able to take over the process.
CPU Redundancy	A system with two controller CPU units cooperating to control the same process.
Critical Component	Components that acquire or distribute I/O data or that are involved in execution of the control logic solution.
Genius Dual Bus	The use of two Genius busses to control the same I/O devices. The busses are linked to the I/O devices by one or more Bus Switching Modules (BSMs). A BSM will automatically switch to the other bus if the active bus has a failure.
Genius Hot Standby	A feature of Genius devices whereby the device prefers output data from the bus controller at SBA 31. When outputs from that bus controller are not available, the device takes output data from the bus controller at SBA 30. If outputs from neither controller are available, the device places its outputs in the designated default state.
Hot Standby	A system where the backup (standby) unit is designated *before* any critical component failure takes place, and any necessary state/control information is passed to this designated backup unit so that it can take control *quickly* in the event of a critical component failure.
Non-Synchronized Active Unit (NSAU)	A unit in a Redundancy System that is in Run mode but not synchronized with a backup unit. The backup unit is either offline (in Stop mode, powered off, or failed), or there are no functional redundancy links between the units.
Primary Unit	The preferred unit to control the process in a Redundancy System. For redundant Genius I/O, the Genius Bus Controllers in the primary unit are configured for serial bus address (SBA) 31.
Redundancy	The use of multiple elements controlling the same process to provide alternate functional channels in case of failure.
Redundancy Link	A complete communications path between the two CPUs, consisting of one RMX in the primary unit, one RMX in the secondary unit, and a high-speed fiber optic cable connecting them to each other.
Redundant IP Address	An IP address that is assigned to the pair of Ethernet interfaces in the primary and secondary units. All data sent to the redundant IP address (including EGD produced to the redundant IP address) is handled by the active unit.
Role Switch	User-initiated switch of control, where the active unit becomes the backup unit and the backup unit becomes the active unit.
Secondary Unit	The unit configured to control the process in a Redundancy System when the primary unit is unavailable or otherwise marked as not controlling the process. For redundant Genius I/O, the Genius Bus Controllers in the secondary unit are configured for SBA 30.
Synchronized	Condition where both units are in Run Mode and the backup unit has received the latest status and synchronization information from the active unit via a redundancy link. When the two units are synchronized, they run their logic solution in parallel. If the active unit goes offline, control of the redundancy outputs is switched bumplessly (without interruption) to the backup unit.
Transfer List	The ranges of references that will be transferred from the active unit to the backup unit. The transfer list is selected in the hardware configuration for the Redundancy CPU.

PROFINET Definitions

Also see GFK-2571, *PACSystems RX3i PROFINET Controller Manual*.

AR	**A**pplication **R**elationship. PROFINET term for a relationship that is established between an IO-Controller/Supervisor and IO-Device. For any data to be exchanged between an IO-Controller/Supervisor and a given IO-Device, an Application Relationship must be established. Within the Application Relationship, various Communication Relationships are then established for the different types of data to be exchanged.
Backup AR	In PROFINET System Redundancy, a standby AR to a redundant device that currently provides no IO data transfer or control, but can become the Primary AR to take control of the device.
Controller	In PROFINET IO, the term *controlle*r refers to a PROFINET IO Controller (IOC).
DAP	**D**evice **A**ccess **P**oint. This access point is used to address an IO-Device as an entity.
Device	In PROFINET IO, the term *device* refers to a PROFINET IO-Device (IOD).
GSDML	**G**eneral **S**tation **D**escription **M**arkup **L**anguage - definition of PROFINET Device Characteristics.
IOC	PROFINET **IO**-**C**ontroller.
IOD	PROFINET **IO**-**D**evice.
IOCR	**I**nput **O**utput **C**ommunication **R**elationship – describes the type (input/output) and amount of I/O data to be transferred, the sequence of the transfers and the transfer cycle between a PROFINET IO-Controller (or IO-Supervisor) and a PROFINET IO-Device.
IOCS	PROFINET **I**nput/**O**utput **C**onsumer **S**tatus is transmitted on the PROFINET network to provide feedback on Input Data for an IO-Controller and Output Data for an IO device.
IOPS	PROFINET **I**nput/**O**utput **P**rovider **S**tatus is transmitted on the PROFINET network to provide feedback on Output Data for an IO-Controller and the Input Data for an IO-Device.
IOxS	PROFINET abbreviation for the IOCS and/or IOPS (see above).
LLDP	**L**ink **L**ayer **D**iscovery **P**rotocol. IEEE standardized protocol used by network devices to advertise their identity and capabilities.
MSOT	**M**ax **S**witch**O**ver **T**ime. Maximum time that an IO-device takes to acknowledge an IO switchover. This time is specified by the device's GSDML file.
MRC	**M**edia **R**edundancy **C**lient. Within Media Redundancy Protocol, an MRC is responsible for helping the MRM detect breaks/no breaks in the ring.
MRM	**M**edia **R**edundancy **M**anager. Within Media Redundancy Protocol, an MRM is responsible for ensuring that the ring does not have a closed loop, while simultaneously ensuring maximal connectivity between nodes on the ring. There must be exactly one MRM in the ring network.
MRP	**M**edia **R**edundancy **P**rotocol. An Ethernet protocol that provides redundant paths for PROFINET-IO cyclic traffic by supporting a ring topology.
Primary AR	IN PROFINET System Redundancy, the AR to a redundant device that currently provides IO data transfer and control.
RDHT	**R**edundancy **D**ata **H**old **T**ime. The maximum time that the IO-Device waits for a Controller to take control of the AR connection during an IO switchover.
Remote Node	For an RX3i PROFINET network, a Remote Node is any PROFINET IO-Device, such as a rack of I/O modules with a Remote Scanner or a third party PROFINET IO-Device.
Update Period	The time between PROFINET cyclic data transfers between an IO-Controller and an IO-Device.

Related Publications

PACSystems CPU Reference Manual, GFK-2222

PACSystems RX7i Installation Manual, GFK-2223

TCP/IP Ethernet Communications for PACSystems, GFK-2224

PACSystems RX7i User's Guide to Integration of VME Modules, GFK-2235

PACSystems Memory Exchange Modules, GFK-2300

PACSystems RX3i System Manual, GFK-2314

PACSystems RX3i PROFINET Controller Manual, GFK-2571

VersaMax PROFINET Scanner Manual, GFK-2721

PACSystems RX3i Ethernet NIU User's Manual, GFK-2439

Series 90-30 Ethernet NIU User's Manual, GFK-2296

Genius I/O System User's Manual, GEK-90486-1

Genius Discrete and Analog Blocks User's Manual, GEK-90486-2

Series 90-70 Genius Bus Controller User's Manual, GFK-2017

Proficy Machine Edition Logic Developer-PLC Getting Started, GFK-1918

VersaMax Genius NIU User's Manual, GFK-1535

PACSystems RX3i Dual Genius Bus Quick Start Guide (provided with the RX3i Dual Bus Templates)

For the most recent versions of PACSystems and related documentation, visit the Support website.

Chapter 2

Hot Standby Redundancy Quick Start with PROFINET I/O

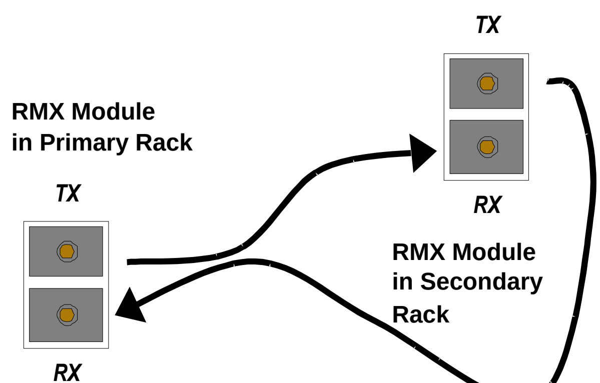
This chapter provides the steps needed to setup and configure a basic RX3i Hot Standby CPU Redundancy system that uses PROFINET I/O. This basic system uses one pair of PROFINET IO-Controllers (PNCs) and at least one VersaMax PROFINET Scanner using a ring network topology.

1. **Install one Redundancy CPU, one Ethernet module, two RMX modules, one PROFINET IO-Controller module, and two Multifunctional 40W Power Supply modules into each RX3i rack.** The Ethernet modules will be used to connect the programmer to the controllers.

   One controller will be designated the Primary, and the other will be designated the Secondary.

2. **Use Fiber Optic cables to connect each RMX module in the Primary Rack to the corresponding RMX module in the Secondary Rack.**

   Using an LC- compatible multimode fiber optic cable, connect the Primary's RMX module's TX connector to the RX connector of the Secondary's RMX module. Also connect the Secondary's RMX module's TX connector to the RX connector of the Primary's RMX module (see diagram at right).



3. **With the CPU battery disconnected, apply power to both controller racks.**

   Each redundancy CPU has Error Checking and Correcting (ECC) memory, which must be initialized by applying power to the CPU with the battery disconnected at least once.

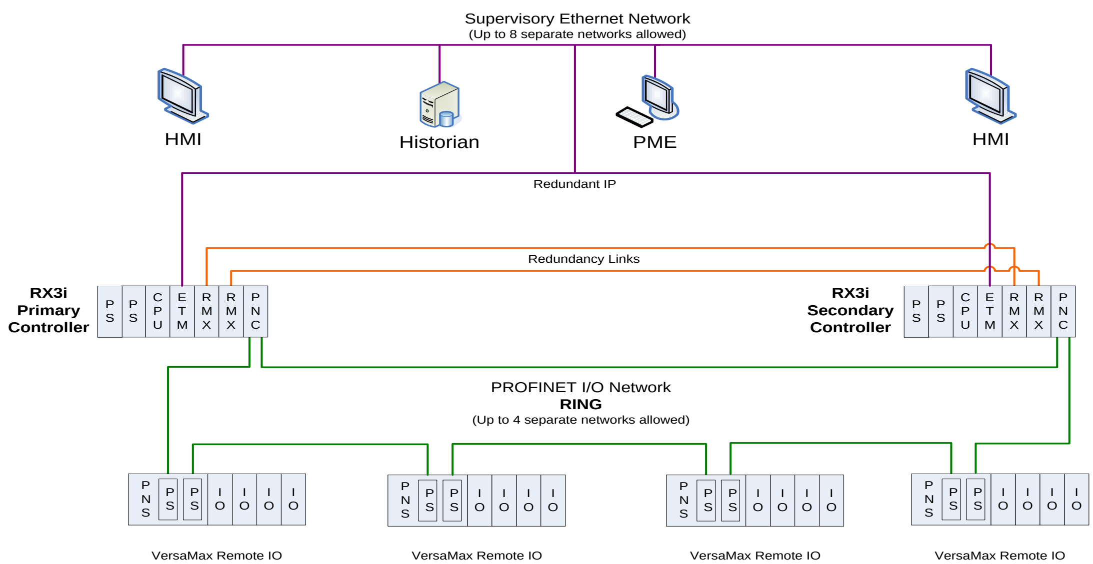
   When power is applied, the RMX module performs an internal loopback test; during this test, the RMX module's OWN DATA and SIGNAL DETECT indicators turn on briefly. Once the RMX module is functioning normally, its OK indicator will be on.

4. **Connect a battery to each redundancy CPU.**

   Because the ECC memory was initialized during step 3, the CPU can now be power cycled with the battery connected.

5. **Connect the PC that will be used to program the controllers to the Ethernet network.** (For details on the Ethernet module refer to GFK-2224, *TCP/IP Ethernet Communications for PACSystems User's Manual*.

6. **Connect the PNCs and the PROFINET device(s) to a daisy chain line network similar to the example diagram below, but do not form a complete ring yet. Leave exactly one of the PROFINET network cables disconnected until the Primary PNC has configuration data that tells it to act as the Media Redundancy Manager (step 11).**



7. **Create the Hardware Configuration (HWC).**

   1. Open Proficy Machine Edition (PME), and create a target for an RX3i controller.

   2. Expand the Hardware Configuration node and expand its Rack 0 node.

   3. Replace the default CPU with a CRU320. When you do this, PME will automatically set the Dual HWC property for the target to True and creates a 'Hardware Configuration [Secondary]' node.

   4. Find the Rack 0 node that is under the 'Hardware Configuration [Primary]' node. If this rack is not the correct size, right-click on it and select Replace Rack….

   5. Expand the Rack 0 node that is under the 'Hardware Configuration [Primary]' node. Move the CRU320 to the correct slot within Rack 0.

   6. Add two RMX modules to this Rack 0.

   7. Add a PNC to this Rack 0. PME automatically creates a new LAN named *LAN01* and attaches the PNC to that LAN. Set the proper subnet mask and range of IP addresses for this LAN. Set the Network Transit Time parameter to **50** (= 5.0 milliseconds, which is recommended for MRP ring operation).

8. Configure the PNC module.

   a. Set this PNC's unique name and IP address.

   b. Set this PNC's Media Redundancy parameter to **Manager**.

9. If you have not already assigned a network name to each of your PROFINET devices, do so now. You can do this by right-clicking on a PNC and selecting Launch Discovery Tool. For more information, refer to "Assigning IO-Device Names" in the *PACSystems RX3i PROFINET IO-Controller Manual*, GFK-2571.

10. Add each of your PROFINET VersaMax PROFINET Scanner (PNS) devices to the HWC by doing the following for each device:

   a. Right-click on the PNC in the 'Hardware Configuration [Primary]' HWC and select Add IO-Device…

   b. Select the desired device from the Device Catalog

   Be sure to select a VersaMaxPNS node that has *V2_3* in its name. (A GSDML file of version 2.3 or higher is required in order to configure the device to be redundantly controlled.)

   c. Because the device supports controller redundancy, PME will automatically set the device's Redundancy Mode parameter to HSB CPU Redundancy.

   d. PME will assign a default name to the device. Be sure to change the device's name to match the name you assigned to it during step 9.

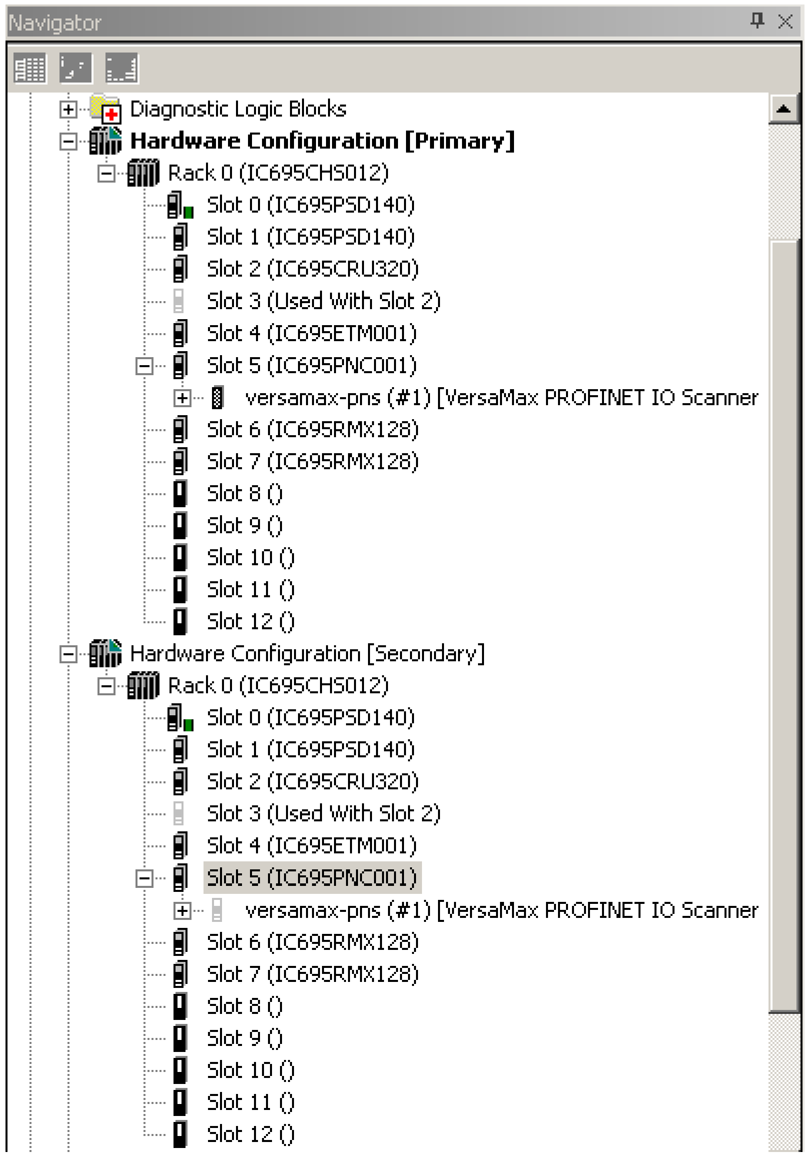
   e. Add all appropriate I/O carriers and I/O modules to the device's configuration and set all of the configuration parameters to appropriate values. For more information about configuring the VersaMax PNS, refer to "Adding a VersaMax PROFINET Scanner to a LAN" in the *PACSystems RX3i PROFINET IO-Controller Manual*, GFK-2571.

   Note that as you assign reference addresses to your redundantly controlled devices, PME will automatically expand the Primary CRU's input transfer list to include all of your redundantly controlled PROFINET inputs. PME will also automatically expand the Primary CRU's output transfer list to include all of your redundantly controlled PROFINET outputs.

11. Add, replace, and/or move additional RX3i rack modules to the 'Hardware Configuration [Primary]' HWC as needed. Examples of these modules include power supplies and Ethernet modules. For each Ethernet module, set its unique IP address.

12. Now that you have finished populating the Primary's Hardware Configuration, right-click on the 'Hardware Configuration [Primary]' node, select Redundancy, and select *Mirror to Secondary Hardware Configuration.*

    This operation will copy the 'Hardware Configuration [Primary]' (including the transfer lists, the PNC, and the redundantly controlled PROFINET devices) to the 'Hardware Configuration [Secondary]' HWC. The result should look similar to the following diagram. (In this diagram, only one VersaMax PNS is shown.)



13. Select the PNC underneath the 'Hardware Configuration [Secondary]' HWC.

    a. Set this PNC's unique name and IP address.

    b. Set this PNC's Media Redundancy parameter to Client.

14. For each Ethernet module in the Secondary Hardware Configuration, set its unique IP address.

8. Add logic to the target.

Note: This is the sequence for downloading configurations into a new redundancy system. Both units are initially stopped with no configuration.

9. Download the Hardware Configuration and Logic to the Primary controller.

1. Right-click on the ‘Hardware Configuration [Primary]’ node and select Set as Selected HWC. (If this menu item is greyed out, then you already have the primary HWC selected.)

2. Click on the target node in PME’s Navigator. In the Property Inspector, set the Physical Port and IP Address so that they correspond to your Primary controller.

3. Select Target -> Go Online…

4. Select Target -> Download <target name> to controller.

5. Select Hardware Configuration and Logic and click OK.

a. Expect the Primary unit to log a *Redundancy link communication failure* Controller fault for each RMX module. For example:

0.6	Redundancy link communication failure
0.7	Redundancy link communication failure

b. Confirm that the Primary unit did not record any Loss of Device faults in its I/O fault table.

6. Select Target -> Go Offline…

10. Download the Hardware Configuration and Logic to the Secondary controller.

1. Right-click on the ‘Hardware Configuration [Secondary]’ node and select Set as Selected HWC.

2. Click on the target node in PME’s Navigator. In the Property Inspector, set the Physical Port and IP Address so that they correspond to your Secondary controller.

3. Select Target -> Go Online…

4. Select Target -> Download <target name> to controller.

5. Select Hardware Configuration and Logic and click OK.

a. For both RMX modules in both units, confirm that the LINK OK LEDs are ON. (This might take a few seconds.)

b. Confirm that the Secondary unit did not record any Loss of Device faults in its I/O fault table.

6. Select Target -> Go Offline…

11. You can now connect the last link of the PROFINET network to complete the ring.

12. Connect PME to the Primary unit, and put the Primary unit into Run mode.

Expect the Primary unit to log a Primary Unit is Active; no Backup Unit available Controller fault. For example:

0.2	Primary Unit is Active; no Backup Unit available

13. Connect PME to the Secondary unit, and put the Secondary unit into Run mode.

Expect the Primary unit to log a Primary Unit is Active and Secondary Unit is Backup Controller fault. For example:

0.2	Primary Unit is Active and Secondary Unit is Backup

This quick start procedure demonstrates the setup and configuration of a basic RX3i Hot Standby CPU Redundancy system that uses PROFINET I/O. This basic setup can be used to learn about other Redundancy features such as Role Switching, Transfer Lists, Non-Synchronized Active Unit (NSAU) and Redundant IP which are described in the latter chapters of this manual.

Chapter 3 Hot Standby Redundancy Quick Start with Ethernet I/O

This chapter provides an overview of the steps needed to configure and operate a basic RX3i or RX7i Hot Standby (HSB) CPU Redundancy system with one Ethernet Remote IO (ENIU) using a ten-ENIU Machine Edition template.

Notes: The Primary and Secondary units in a redundancy system must be of the same type. An RX3i and an RX7i controller cannot function as a redundant pair.

1. **Install one Redundancy CPU, one or two RMX modules and three Ethernet modules each into two rack systems.**

   One Rack system will be designated the Primary rack and the other will be designated the Secondary rack.

2. **With the CPU battery disconnected, apply power to the racks.**

   When power is applied to the RMX module an internal loopback test occurs; the OWN DATA and SIGNAL DETECT indicators turn on briefly during this test. When the RMX module and the CPU are powered up and functioning properly, the RMX module's OK indicator is on.

3. **Connect a battery to each redundancy CPU.**

   The redundancy CPUs support Error checking and correction (ECC) memory, which must be initialized at least one time with the battery disconnected. Once ECC memory is initialized, the CPU can be power cycled with the battery connected.

4. **Download and unzip the appropriate template set for your system.**

   Templates for redundancy systems are available from the *Support* website. On the website, select *Downloads,* then select the *Developer Files* category.

   For a list of available template sets, refer to the *PACSystems RX3i Ethernet NIU User's Manual,* GFK-2439. Each template set consists of a *Controller* template and an *ENIU* template.

5. **Using the Machine Edition Logic Developer software, restore the Controller project from the appropriate ten-ENIU template set.**

6. **Open the restored project. Assign IP addresses to all the Ethernet modules.**

In assigning IP addresses, consider the following functions:

RX3i Configuration

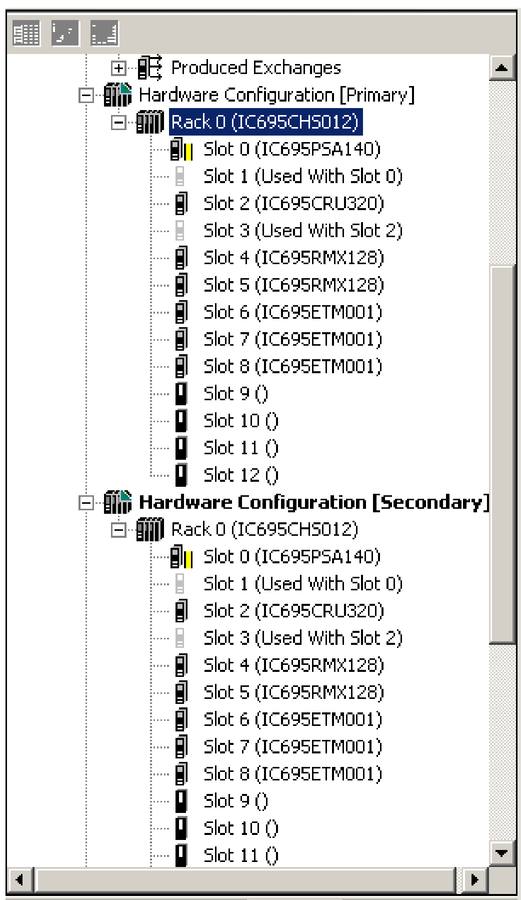
Ethernet Interface	***Function***
ETM001 in Slot 6	Programmer connection to your PC Requires a Redundant IP address, which should be the same IP Address for both the Primary and Secondary rack systems.
ETM001 in Slot 7	Private network, LANA for Ethernet IO exchanges
ETM001 in Slot 8	Private network, LANB for Ethernet IO exchanges

RX7i Configuration

Ethernet Interface	***Function***
Embedded CPU Ethernet Port	Programmer connection to your PC Requires a Redundant IP address, which should be the same IP Address for both the Primary and Secondary rack systems.
ETM001 in Slot 5	Private network, LANA for Ethernet IO exchanges
ETM001 in Slot 6	Private network, LANB for Ethernet IO exchanges

The hardware configuration should appear similar to the following figure, which shows an RX3i configuration.

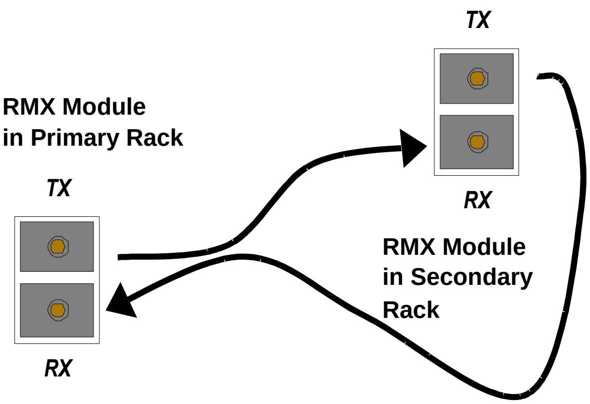
Hardware Configuration provided by the Ten-ENIU Controller Template Project



7. **Use Fiber Optic cable to connect each RMX module in the Primary Rack to the corresponding RMX module in the Secondary Rack (the module in the same Slot number) as described below.**

Using an LC- compatible multimode fiber optic cable, connect the RMX module's TX connector to the RX connector of the other RMX module. Connect the fiber optic cable from other RMX module's TX to the RX connector (see diagram at right).

When the fiber optic transceiver detects a signal on the network, the SIGNAL DETECT indicator will be on.

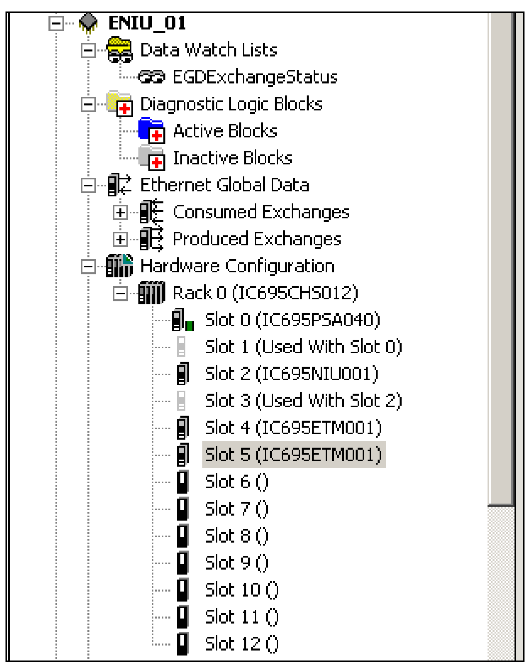


8. **In Proficy Machine Edition, close the Controller project and restore the ENIU project from the ten-ENIU template set:**

Open the project and on target ENIU_01 open the Hardware Configuration. Set the IP addresses of the ETM001 modules, taking into consideration that the ETM001 in Slot 4 will be on a private network called LANA (connected to LANA of the Redundancy CPUs) and the ETM001 in Slot 5 will be on a private network called LANB (connected to LANB of the Redundancy CPUs).

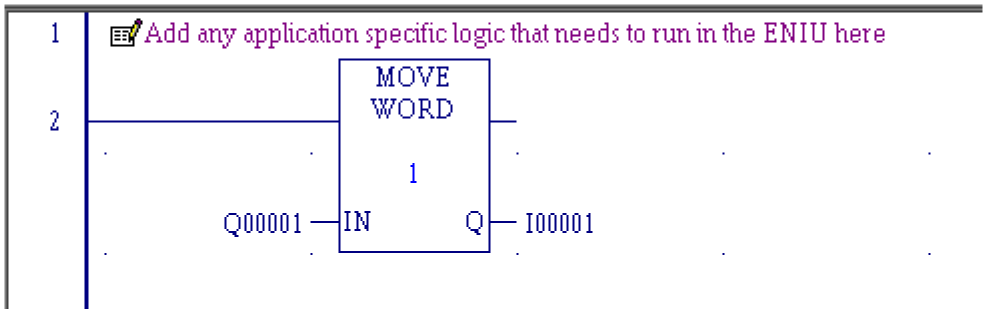
The hardware configuration should appear similar to the following figure, which shows an RX3i configuration.

Hardware Configuration provided by the Ten-ENIU Template Project



9. **Add IO loopback logic to confirm data transfer between ENIU and Redundancy CPUs**

   Under the Logic node in Proficy Machine Edition, open the Program Block Local_User_Logic. Add the logic shown below to loop outputs %Q1-%Q16 back to inputs %I1-%I16.



10. **Install a Power supply, RX3i ENIU (IC695NIU001) and two ETM001 modules into an RX3i backplane as shown the hardware configuration in step 6. Apply power to the system.**

11. **Connect your PC to the ENIU via a Serial cable from the ENIU module's COM1 or COM2 port to one of your PC's COM ports or install an additional ETM001 module to the ENIU rack to provide connectivity via Ethernet. With the template folder open in Proficy Machine Edition, connect to the ENIU either by a COM port or by Ethernet.**

    Store the ENIU_01 application to the ENIU and put the ENIU into run mode.

12. **Connect Ethernet cables between the Redundancy CPUs and the ENIU rack system.**

    RX3i Connections

    Connect one Ethernet cable from ETM001 in Primary Rack Slot 7 to ETM001 in ENIU Rack Slot 4. Connect one Ethernet cable from ETM001 in Primary Rack Slot 8 to ETM001 in ENIU Rack Slot 5.

    Connect one Ethernet cable from ETM001 in Secondary Rack Slot 7 to ETM001 in ENIU Rack Slot 4. Connect one Ethernet cable from ETM001 in Secondary Rack Slot 8 to ETM001 in ENIU Rack Slot 5.

    RX7i Connections:

    Connect one Ethernet cable from ETM001 in Primary Rack Slot 5 to ETM001 in ENIU Rack Slot 4. Connect one Ethernet cable from ETM001 in Primary Rack Slot 6 to ETM001 in ENIU Rack Slot 5.

    Connect one Ethernet cable from ETM001 in Secondary Rack Slot 5 to ETM001 in ENIU Rack Slot 4. Connect one Ethernet cable from ETM001 in Secondary Rack Slot 6 to ETM001 in ENIU Rack Slot 5.

13. Connect Ethernet cables between an Ethernet switch connected to your PC and the ETM001 modules assigned as Programmer connections in both the Primary and Secondary units.

14. Close _10ENIU_CRU_DLDI_ENIUs_1_10 project in Proficy Machine Edition and again open project _10ENIU_CRU_DLDI_Controller.

Right click on the Primary Hardware Configuration node and select Set as Selected HWC. Connect to the Primary CPU, store the application and put the CPU in run mode.

Disconnect from the Primary CPU. Right click on the Secondary Hardware Configuration node and select Set as Selected HWC. Connect to the Secondary CPU, store the application and put the CPU in run mode.

Right click on the Reference View Tables node and select New. Double click the RefViewTable10 node just created. In the address box, enter %Q1. In the next address box below %Q00001, enter %I1. Right click in the Values area just to the left of the Address boxes and select Format View Table. Check the box labeled Apply to Whole Table, Select Word for the Display Type, select Hex for the Display Format and click OK. Enter values into the %Q00001 values area and notice that the same values are displayed at %I00001 because of the loopback logic in the ENIU.

This quick start procedure demonstrates setup of a PACSystems Redundancy Controller pair controlling one ENIU remote IO station. This basic setup can be used to learn about other CPU Redundancy features such as Role Switching, Transfer Lists, Non-Synchronized Active Unit (NSAU) and Redundant IP. For details on the operation of CPU Redundancy systems, refer to the other chapters in this manual.

For details on configuring an RX3i Genius dual bus redundancy system, refer to Appendix A.

Chapter 4 System Configuration

This chapter describes the hardware components for a Hot Standby CPU Redundancy system and describes system configurations for the basic redundancy schemes supported by PACSystems controllers.

For installation instructions, refer to

PACSystems RX7i Installation Manual, GFK-2223

PACSystems RX3i System Manual, GFK-2314

Components of a Hot Standby Redundancy System

- System Racks
- Redundancy CPU
- Redundancy Memory Xchange modules
- Redundant I/O Systems

System Racks

RX3i Systems

In an RX3i redundancy system, an RX3i (IC695CHS0xx) Universal Backplane must be used as the CPU rack, which is also referred to as Rack 0. For specific backplane versions required, refer to the *Important Product Information* document provided with your redundancy CPU.

Any RX3i expansion rack or any Series 90-30 expansion rack that is supported by RX3i can be used in an RX3i redundancy system.

RX7i Systems

In an RX7i redundancy system, any RX7i (IC698CHSxxx) rack can be used as Rack 0.

Any Series 90-70 expansion rack that is supported by RX7i can be used, ***except*** for the VME Integrator racks, IC697CHS782 and IC697CHS783.

Redundancy CPU Modules

To use the features described in this manual, an RX7i Redundancy CPU module must be installed in rack 0, slot 1 of both the primary and secondary units. RX3i Redundancy CPUs can be installed in any slot in rack 0.

Note: A given feature may not be implemented on all PACSystems CPUs. To determine whether a feature is available on a given CPU model and firmware version, please refer to the *Important Product Information* (IPI) document provided with the CPU.

The CPU provides configurable reference memory limits for %AI (Analog Input), %AQ (Analog Output), %R (Register), and %W (bulk memory area) reference memory, as well as symbolic discrete reference memory and symbolic non-discrete reference memory. For additional CPU features and performance specifications, refer to the *PACSystems CPU Reference Manual,* GFK-2222.

Operation of the CPUs can be controlled by the three-position RUN/STOP switch or remotely by an attached programmer and programming software. Program and configuration data can be locked through software passwords. The LEDs on the front of the module indicate CPU and Ethernet interface status.

The CPUs have two configurable ports: COM 1 (RS-232) and COM2 (RS-485). The RX7i CPUs contain an embedded Ethernet interface board that controls two 10 BASE T/100 BASE TX ports and a configurable Station Manager (RS-232) port.

PACSystems CPUs support the following Ethernet interface features:

- Redundant IP address
- Production of selected EGD exchanges in backup mode
- RX7i controller data monitoring over the web. Supports a combined total of up to 16 web server and FTP connections.
- Up to 255 Ethernet Global Data (EGD) exchanges with up to 100 variables per exchange.
- EGD upload and selective consumption of EGD exchanges.
- Upload and download of an Advanced User Parameter (AUP) file, which contains user customizations to internal Ethernet operating parameters.
- Run mode store of EGD (PACSystems releases 5.5 and later), which allows you to add, delete or modify EGD exchanges without stopping the controller. For details on using this feature, refer to *TCP/IP Ethernet Communications for PACSystems,* GFK-2224.

Redundancy CPUs Compared to Other PACSystems CPUs

The following features are ***not*** available:

- I/O and module interrupts: This includes the single edge triggered interrupts from the discrete input modules, the high alarm and low alarm interrupts from the analog input modules, and interrupts from VME modules. A program that declares I/O Interrupt triggers cannot be stored to a Redundancy CPU.
- Interrupt Blocks (I/O, timed, module): Logic that contains interrupt blocks cannot be stored to the CPU.
- Stop I/O Scan mode: If an attempt is made to place the controller in this mode, the controller will reject the selection and return an error.
- #OVR_PRE %S reference, which indicates whether one or more overrides are active, is not supported and should not be used.
- RX3i redundancy controllers do not support the PACMotion module (IC695PMM335).
- RX7i redundancy controllers do not support the 14-point interrupt module (IC697MDL671).
- RX7i redundancy controllers do not support VME integrator racks.

The following features operate differently with the redundancy CPUs than they do with other PACSystems CPUs:

- Error checking and correction (ECC) is enabled.
- RUN/DISABLED mode. This is explained in Chapter 6, “Operation.”
- User-configurable fault actions are not used when the CPUs are synchronized.
- STOP to RUN mode transition. For details, see “Synchronizing Redundant CPUs” in Chapter 6.
- Background Window Timer (in Normal Sweep mode) default is 5ms. It is highly recommended that the Background Window Timer be set to the same value for both CPUs making up a redundancy pair.
- By default, Ethernet Global Data (EGD) is produced only by the active unit. The backup unit can produce individual EGD exchanges that are configured for production in backup mode.

Also, be aware that instance data associated with IEC transitionals (PTCOIL, NTCOIL, PTCON, and NTCON) is not synchronized between the two CPUs. For details, refer to “Data Transfer” in Chapter 6.

Using the Redundancy CPU for Simplex Operation

The Redundancy CPU can be used for both redundant and simplex (non-redundant) applications. The functionality and performance of a Redundancy CPU configured for simplex operation is the same as for a unit that is configured for redundant operation with no backup available. This includes the redundancy informational messages such as those generated when a unit goes to Run mode.

Redundancy Memory Xchange Modules

The RMX modules provide a path for transferring data between the two redundancy CPUs. A complete communications path consists of one RMX in the primary unit, one RMX in the secondary unit, and two high-speed fiber optic cables connecting them to each other. This must be a two-node ring: no other reflective memory nodes are allowed to be part of this fiber optic network.

When using PROFINET as the redundantly controlled I/O, GE Intelligent Platforms requires two redundancy links (a total of four RMX modules) to be configured and installed.

When using Ethernet NIUs or Genius for the redundantly controlled I/O, GE Intelligent Platforms ***strongly recommends*** that two redundancy links (for a total of four RMX modules) be configured and installed. Optionally, Ethernet NIU and Genius systems can be configured with a single redundancy link (for a total of two RMX modules).

RMX modules must be installed in the main rack (rack 0).

The RMX module has a toggle switch that can be used to manually request a role switch. Eight LEDs, described in the following table, provide indication of module status.

Note: For RX7i systems, it is recommended that the RMX modules be installed in slots 3 and 4 of the main rack. This gives VME interrupt request priority to the RMX modules. Although this configuration is recommended, it is not required that the RMX modules be located in slots 3 and 4.

Note: The RX3i RMX128 module supports hot insertion and removal. However, the redundancy communication link associated with a hot swapped RMX module will not be restored automatically. The LINK OK indicator on both RMX modules in the link will be OFF. To restore the link, refer to “Online Repair” in Chapter 7.

RMX LEDs

LED Label	***Description***
OK	ON indicates the module is functioning properly.
LINK OK	When used as a redundancy link, ON indicates the link is functioning properly.
LOCAL READY	ON indicates the local unit is ready.
LOCAL ACTIVE	ON indicates the local unit is active.
REMOTE READY	ON indicates the remote unit is ready.
REMOTE ACTIVE	ON indicates the remote unit is active.
OWN DATA	ON indicates the module has received its own data packet from the network at least once.
SIGNAL DETECT SIG DETECT	ON indicates the receiver is detecting a fiber optic signal.

Redundant I/O Systems

PROFINET

Applications that require a highly available control system that survives a single point of failure in the controllers and a single point of failure in the I/O network can leverage PROFINET I/O. This solution allows you to interface the RX3i Redundancy CPU to remote VersaMax I/O across an Ethernet network. RX3i PROFINET Redundancy is an evolution of the PACSystems Hot Standby ENIU solution to an industry-standard I/O protocol.

For sample Hot Standby CPU Redundancy systems that use PROFINET I/O, see page 4-7.

Ethernet Network Interface Unit (ENIU)

CPU-based ENIU modules can be used to interface the RX7i or RX3i Redundancy CPU to remote I/O stations through Ethernet LANs. These devices, which include IC695NIU001 and IC693NIU004, make it possible to use PACSystems RX3i and Series 90-30 I/O remotely on an Ethernet network.

An identical set of EGD exchange definitions is downloaded to both the primary and secondary controllers. An ENIU can consume EGD exchanges from two controllers simultaneously. However, when used with redundant controllers, the ENIU automatically switches to the standby controller if the active controller becomes unavailable.

For sample redundancy systems using EGD, see page 4-6. For details on EGD operation in a redundancy system, see “Ethernet Global Data in an HSB Redundancy System” in chapter 6. For details on the operation of ENIUs, see the *PACSystems RX3i Ethernet NIU User’s Manual,* GFK-2439

Genius Bus Controller and Genius Devices

The Genius Bus Controller interfaces the Redundancy CPU to a Genius I/O bus. The bus controller scans Genius devices asynchronously and exchanges I/O data with the CPU.

An HSB CPU Redundancy system can have multiple Genius I/O bus networks. Any Genius device can be placed on the bus (Genius blocks, Field Control, Remote I/O Scanner, VersaMax I/O, etc.). The Genius outputs are determined by the active unit. The Genius Bus Controller in the primary unit has a Serial Bus Address of 31; the Genius Bus Controller in the secondary unit has a Serial Bus Address of 30. For sample redundancy systems using Genius I/O, see page 4-14.

Note: For RX3i systems with Dual Genius Buses, only VersaMax I/O Genius Network Interface Units (GNIU) are supported. For non Dual Genius Buses, any Genius device can be placed on the bus (Genius blocks, Field Control, Remote I/O Scanner, VersaMax I/O, etc.)

Local I/O

Local I/O can be included in either unit; however, it is ***not*** part of the redundant I/O system. A failure in the Local I/O system will affect the unit as described in the *PACSystems CPU Reference Manual,* GFK-2222.

CPU Redundancy Using PROFINET I/O

This section discusses sample system architectures using PROFINET I/O with Hot-Standby CPU Redundancy. These sample system architectures support both ***general communications*** (such as a programmer connection) and ***remote I/O data transfers***. Remote I/O data transfers use PROFINET across an Ethernet connection to the remote devices.

If you need I/O network redundancy, you must use an MRP ring topology. If you do not need I/O network redundancy, you can use a star network topology. Additional details on these network architectures are presented below.

A CPU Redundancy system can also contain simplex (non-redundantly controlled) IO devices that are configured and controlled at only one CPU unit.

Configuration Considerations

Two Redundancy Links Are Required

When you use redundantly controlled PROFINET I/O, you are required to configure two redundancy links. Any failed redundancy link should be repaired as soon as possible.

Input Data Validation

To determine the health of PROFINET Inputs, the logic application must use the I/O Point Faults associated with those inputs. To use point faults, they must be enabled in Hardware Configuration (HWC) on the Memory parameters tab of the CPU.

The logic application may use the "All Devices Connected" PNC module status bit to determine connectivity to PROFINET I/O-Devices. However, the logic application must not use the "All Devices Connected" status bit to determine the health of Input data from a PROFINET I/O-Device because this bit is not synchronized to Input data delivery.

For additional information on input data validation, refer to the *PACSystems CPU Reference Manual,* GFK-2222.

Network Size

- A Redundancy CPU can control a maximum of 128 PROFINET IO-Devices.
- The Media Redundancy Protocol (MRP) allows a maximum of 64 nodes to be connected together in a ring topology. One of the nodes must operate as the Media Redundancy Manager. All of the other nodes that participate in the ring must operate as Media Redundancy Clients.
- An individual PNC can control a maximum of 64 IO-devices.

Configuration Overview

For both controllers to be able to connect to a redundantly controlled PROFINET IO-Device and control that device's I/O, both controllers must have identical copies of the hardware configuration for that device. Proficy Machine Edition does not permit a redundantly controlled IO-Device to be configured in a standalone (non-Dual HWC) target.

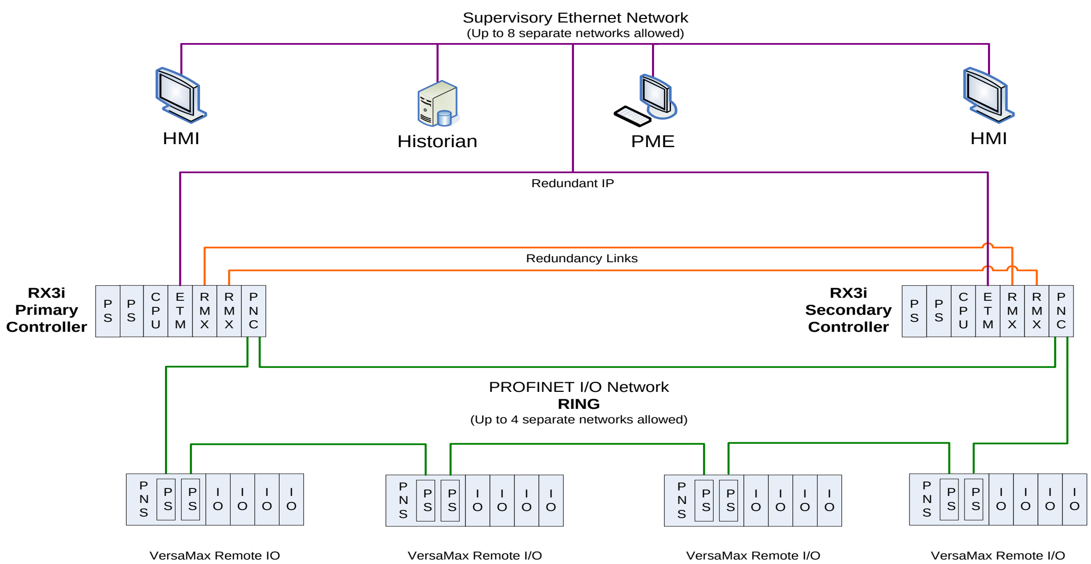
For more information, refer to Chapter 5, "Configuration Requirements."

PROFINET Network Architectures

MRP Ring Topology (Strongly Recommended)

To ensure greater reliability and eliminate your I/O network as a single point of failure, the PROFINET devices should be connected together in a ring topology as shown below. This ring topology uses the PROFINET Media Redundancy Protocol (MRP), as described in "Redundant Media" in the *PACSystems RX3i PROFINET Controller Manual,* GFK-2571.

Even though a Hot-Standby CPU Redundancy system uses PROFINET IO-Controllers in both the Primary and Secondary units, only one IO-Controller in the entire IO network can operate as the Media Redundancy Manager (MRM). All other PROFINET IO-Controllers in the same IO network must be configured as Media Redundancy Clients (MRCs).



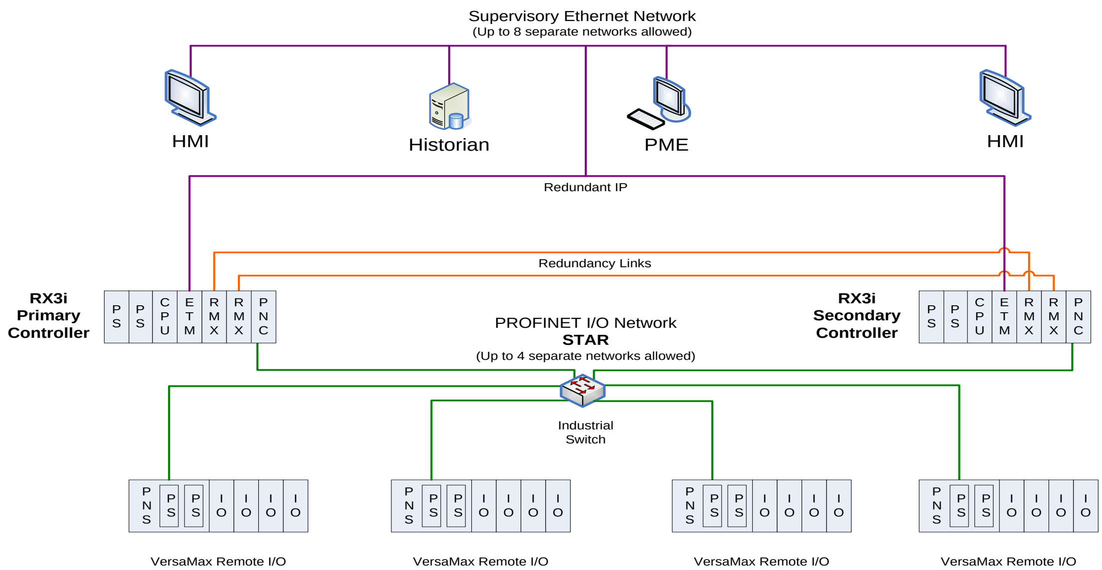
Using an MRP Ring Topology

Note: The HMIs and the Historian shown in this figure are optional.

Star Topology

If eliminating your network as a single point of failure is not required, the PROFINET devices can be connected together in a star topology as shown below.

Note: To eliminate single point failures within your network infrastructure, the MRP ring topology is recommended.



Using a Star Topology

Note: The HMIs and the Historian shown in this figure are optional.

CPU Redundancy Using Ethernet NIU Remote I/O

This section discusses sample system architectures using Ethernet remote I/O with CPU hot-standby redundancy systems.

These sample system architectures support both ***general communications*** (such as a programmer connection) and ***remote I/O data transfers***. Remote I/O data transfers use EGD to and from the ENIUs.

For general communication in a hot-standby redundancy system, the Redundant IP feature must be enabled for the Ethernet interface. In general communication, only the active CPU produces EGD exchanges. When a redundancy role switch occurs, the backup CPU becomes active and begins producing EGD. The formerly active CPU switches to backup and stops producing EGD.

For remote I/O operation, the active and backup CPUs simultaneously process remote I/O EGD exchanges for each ENIU. For architectures using redundant remote I/O LANs, the CPUs process separate remote I/O EGD exchanges on each LAN. All EGD exchanges that can simultaneously occur on a network must have unique Exchange IDs. Hence remote I/O exchanges that are produced by both the primary and secondary units must have different Exchange ID values. Remote I/O EGD production continues across CPU role switches. The application logic in the ENIU selects which EGD remote I/O output exchanges to consume for controlling outputs.

If the active controller transitions to Run IO Disabled mode, it continues to receive inputs from the ENIU. However the ENIU no longer receives outputs from the controller. The ENIU's status words can be monitored to detect communication activity. For details on the status words, refer to the *PACSystems RX3i Ethernet NIU User's Manual,* GFK-2439.

Note: These architectures are based on the template sets provided for use with Proficy Machine Edition and Proficy Process Systems programmers. The templates are set up with coordinated references and coordinated parameters for 10, 20, or 24 ENIUs. For systems with other numbers of ENIUs, select the template with the next larger number of ENIUs and delete the extra ENIUs.

For details about the ENIU configuration and operation and use of the ENIU templates, refer to the *PACSystems RX3i Ethernet NIU User's Manual,* GFK-2439.

Dual Controller, Single LAN Systems

The following template sets are available to configure these architectures.

Architecture	Templates for Proficy Machine Edition	Templates for Proficy Process Systems
Dual RX7i CRE Controllers, Single LAN	10 ENIUs, 20 ENIUs	10 ENIUs, 20 ENIUs
Dual RX3i CRU Controllers, Single LAN	10 ENIUs, 20 ENIUs	10 ENIUs, 20 ENIUs

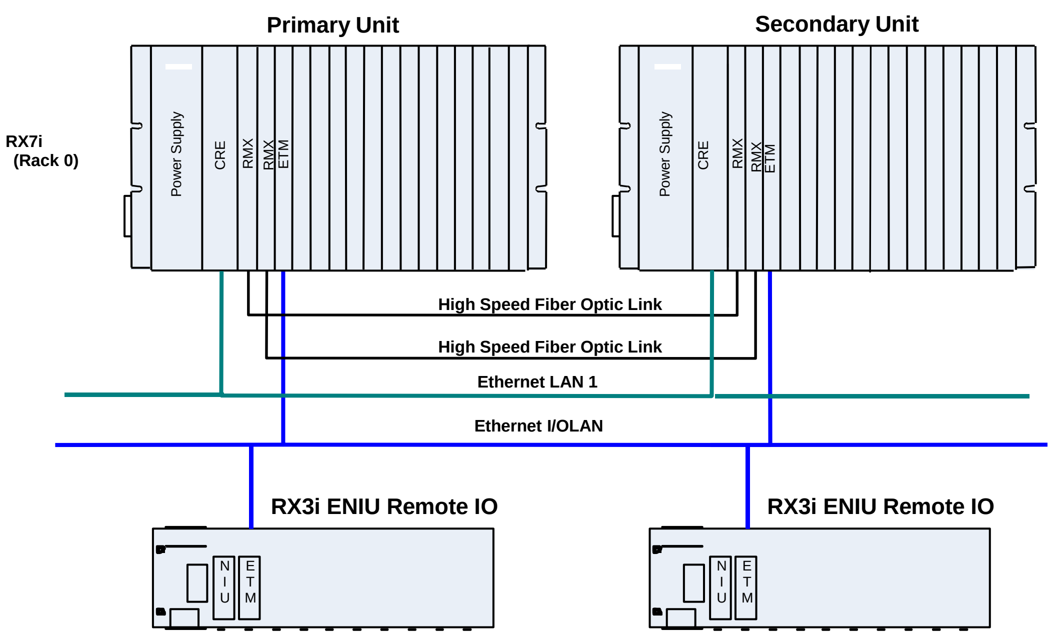
RX7i Dual Controller, Single LAN System

In this architecture, general communications and remote I/O data transfer exist on separate Ethernet LANs and thus do not contend for network bandwidth. This keeps remote I/O performance from being degraded.

The Redundant IP feature is enabled for the Ethernet interface in both controllers to permit general communications. Any EGD exchanges used for general CPU communications are not produced in backup mode.

The produced EGD exchanges that are used for remote I/O data transfer are configured as "Produce in backup mode" so that they will be produced in both active and backup mode.

For easier configuration, each EGD exchange marked as "Produce in backup" is configured with the Exchange ID value used by the Primary unit. The Programmer automatically generates a unique Exchange ID value for the Secondary unit by adding the configured "Secondary Produced Exchange Offset" value to the configured Exchange ID value. For details on the exchange offset, see "Ethernet Global Data Production" in chapter 5.



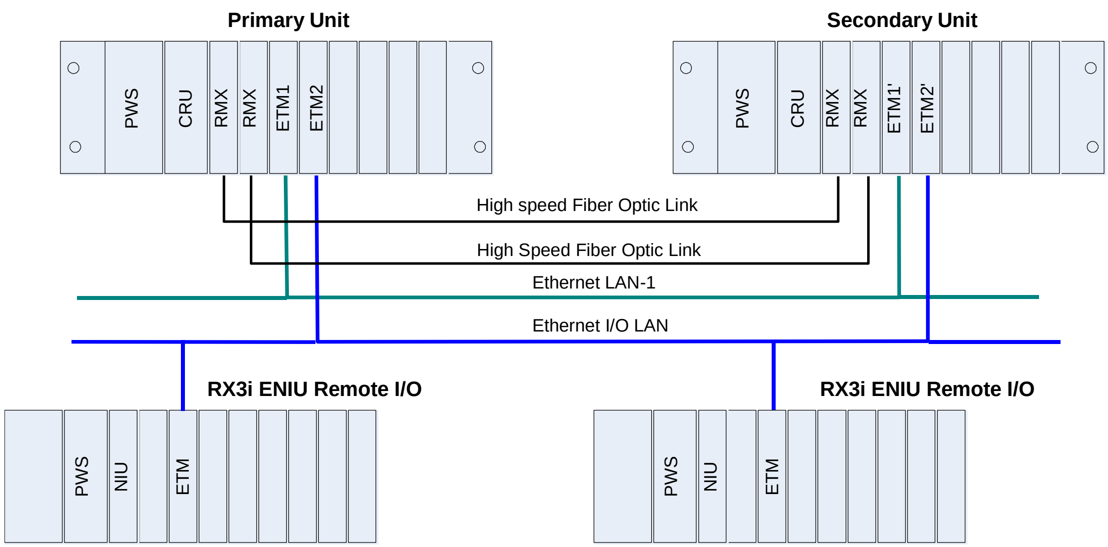
RX3i Dual Controller, Single LAN System

In this architecture, general communications and remote I/O data transfer exist on separate Ethernet LANs and thus do not contend for network bandwidth. This keeps remote I/O performance from being degraded.

The Redundant IP feature is enabled for the Ethernet interface in both controllers to permit general communications. Any EGD exchanges used for general CPU communications are not produced in backup mode.

The produced EGD exchanges that are used for remote I/O data transfer are configured as “Produce in backup mode” so that they will be produced in both active and backup mode.

For easier configuration, each EGD exchange marked as “Produce in backup” is configured with the Exchange ID value used by the Primary unit. The Programmer automatically generates a unique Exchange ID value for the Secondary unit by adding the configured “Secondary Produced Exchange Offset” value to the configured Exchange ID value. For details on the exchange offset, see “Ethernet Global Data Production” in chapter 5.



Dual Controller, Dual LAN Systems

The following template sets are available to configure these architectures.

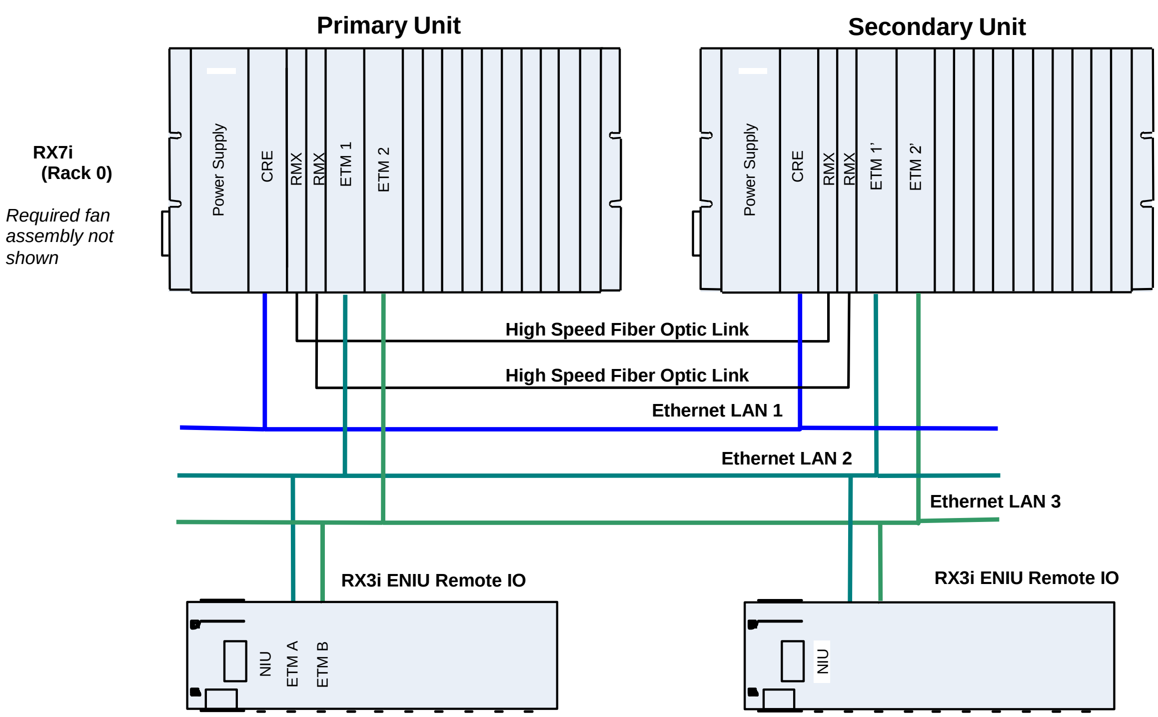
Architecture	***Templates for Proficy Machine Edition***	***Templates for Proficy Process Systems***
Dual RX3i CRU Controllers, Dual LAN	10 ENIUs, 20 ENIUs	10 ENIUs, 20 ENIUs
Dual RX7i CRE Controllers, Dual LAN	10 ENIUs, 24 ENIUs	10 ENIUs, 20 ENIUs

RX7i Dual Controller, Dual LAN System

In this system architecture, the remote I/O stations each have two Ethernet modules to provide the stations with redundant LAN connections to the controllers. LAN 3 acts as a backup to LAN 2.

The Redundant IP feature is enabled for the Ethernet interfaces on LAN 1 because it handles general communications. EGD exchanges used for general CPU communications are not produced in backup mode.

Each controller uses a separate Ethernet interface for communication on each remote I/O LAN (one for LAN 2 and another for LAN 3). The remote I/O EGD exchanges are configured on the Ethernet interfaces for the appropriate LAN.

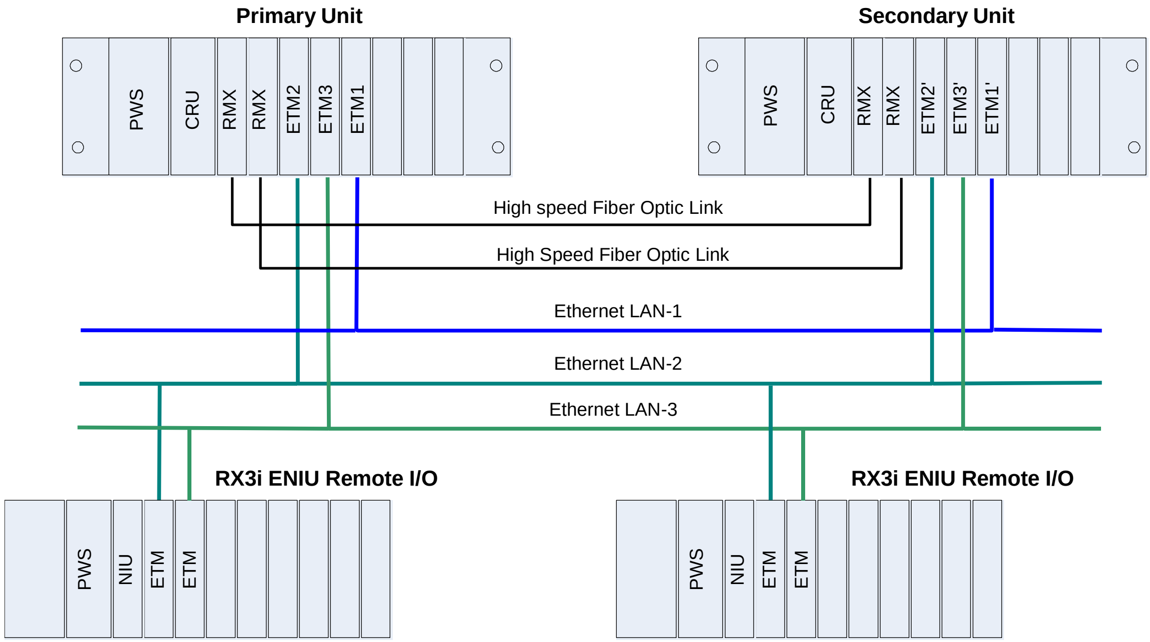


RX3i Dual Controller, Dual LAN System

In this system architecture, the remote I/O stations each have two Ethernet modules to provide the stations with redundant LAN connections to the controllers. LAN 3 acts as a backup to LAN 2.

The Redundant IP feature is enabled for the Ethernet interfaces on LAN 1 because it handles general communications. EGD exchanges used for general CPU communications are not produced in backup mode.

Each controller uses a separate Ethernet interface for communication on each remote I/O LAN (one for LAN 2 and another for LAN 3). The remote I/O EGD exchanges are configured on the Ethernet interfaces for the appropriate LAN.



Genius Hot Standby Operation

In a Genius Hot Standby CPU redundancy system, the Genius outputs are controlled by only one unit (the active unit). The inputs are shared between both units. One unit is the Primary unit and the other is the Secondary unit. The Primary unit contains all externally redundant Genius Bus Controllers at SBA 31; the Secondary unit contains all externally redundant Genius Bus Controllers at SBA 30.

The Genius output devices are normally configured for Genius Hot Standby redundant operation. With this configuration, the devices choose between outputs from the Genius Bus Controller at SBA 31 and the Genius Bus Controller at SBA 30. If outputs from both Genius Bus Controllers are available, the devices will use outputs from SBA 31. If there are no outputs from SBA 31 for three consecutive Genius I/O bus scans, the devices will use the outputs from SBA 30. If outputs are not available from either SBA 31 or 30, the outputs go to their configured default (OFF or hold last state).

Genius Output Control

In a Genius Hot Standby CPU Redundancy system, the active unit determines the values of the Genius outputs.

Both the primary and secondary units send outputs regardless of which one is active. The user is responsible for ensuring that all redundant Genius outputs[1] are included in the output data transfer. Because the same output values will then be sent to the GBCs in both units, the devices will receive the same output values from SBA 31 and SBA 30. There is no data interruption on switchover because both units are always sending Genius outputs.

Basic CPU Redundancy Using Genius I/O

Hot Standby CPU Redundancy supports two types of bus schemes for the Genius networks:

- Single bus networks
- Dual bus networks

Note: For RX3i systems, Dual Genius Bus support is provided by a set of logic blocks. Templates for RX3i Dual Genius Bus support can be downloaded from the Support web site. For details on using these templates, refer to Appendix A, "RX3i Dual Genius Bus Overview" and the *PACSystems RX3i Dual Genius Bus Quick Start Guide,* which is provided with the RX3i Dual Bus Templates.

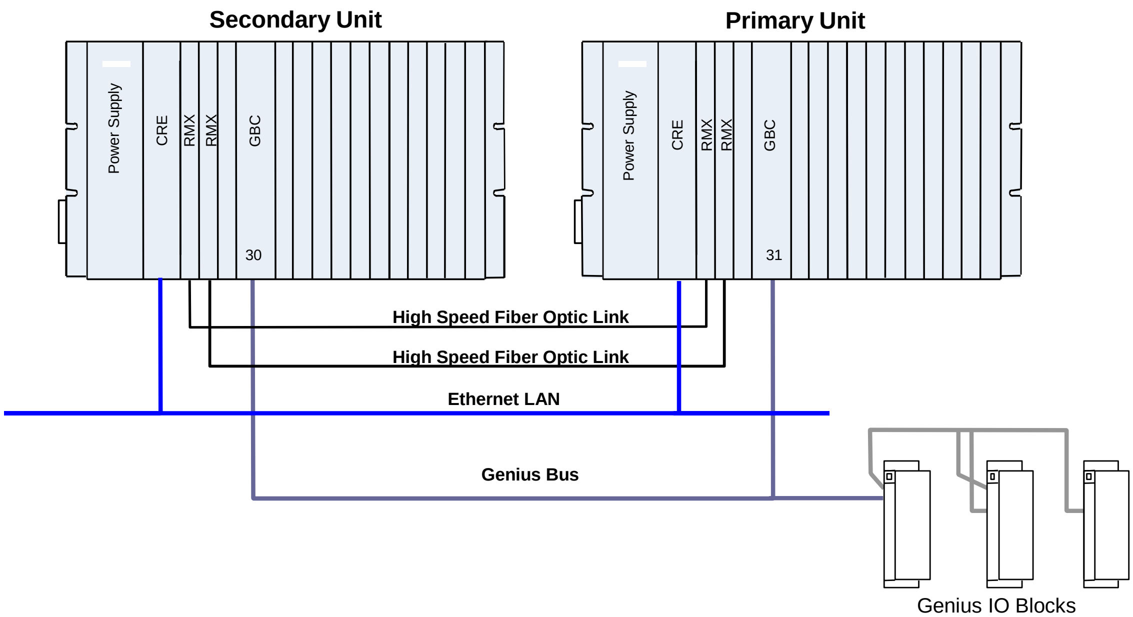
PACSystems CPU Redundancy implements a floating master algorithm. If an application requires a preferred master algorithm, see "Implementing Preferred Master" in chapter 5.

[1] In an RX3i CPU Redundancy system, when a GBC is configured as Redundant Controller – External, all its outputs are redundant.

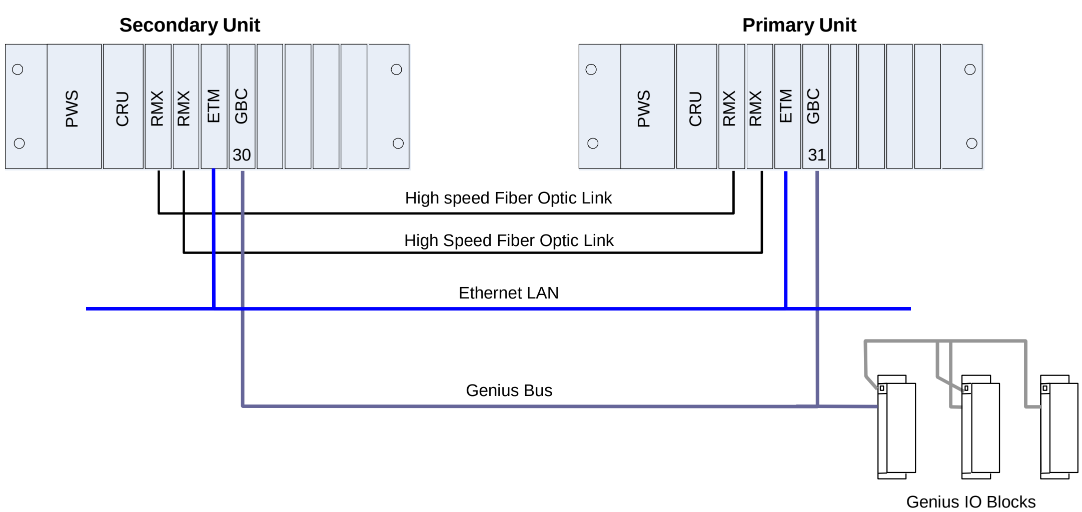
Single Bus Networks

This type of network uses a single bus with one Genius Bus Controller in each controller.

Sample RX7i Single Genius Bus Redundancy System



Sample RX3i Single Genius Bus Redundancy System



The single bus setup is suitable if the application does not require redundant I/O buses.

When using single-bus Genius networks in a Hot Standby CPU Redundancy system, one Genius Bus Controller for the bus must be located in the primary unit and one in the secondary unit. There can be multiple Genius buses in the system. The bus controllers in the primary unit are assigned Serial Bus Address 31. The bus controllers in the secondary unit are assigned Serial Bus Address 30.

Genius output devices will use outputs from Serial Bus Address 31 in preference to outputs from Serial Bus Address 30. Outputs are determined by the active unit, regardless of which bus controller provides the outputs since all redundant Genius outputs are transferred from the active unit to the backup unit.

Any type of Genius device can be connected to the network. Each Genius network can have up to 30 additional Genius devices connected to it. You may want to reserve one Serial Bus Address for the Hand-Held Monitor.

As a safety feature, a watchdog timer protects each Genius I/O link. The bus controller periodically resets this timer. If the timer expires, the bus controller stops sending outputs. If this happens in a Single Bus Genius network of a CPU Redundancy system, the paired GBC in the other unit drives the outputs of the Genius devices. The cause of the failure must be remedied to re-establish communications.

Hardware Configuration for RX7i Single Bus Network

For RX7i targets, the hardware configuration for single bus networks can be created by selecting *Redundant Controllers, Two PLCs* in the Redundancy Wizard.

The GBCs must be configured with the following settings.

Redundancy Mode: Redundant Controller

Paired GBC: External

SBA: 31 (primary unit) or 30 (secondary unit)

The redundant devices must be configured for Hot Standby mode. For example, use the following settings for a Genius block:

(Programming software) Redundancy = YES
(Hand-Held Monitor) CPU Redundancy = HOT STBY MODE
(Hand-Held Monitor) BSM Present = NO

Hardware Configuration for RX3i Single Bus Network

For RX3i targets, the hardware configuration for single bus networks is created by adding a GBC and adding Genius devices to that GBC.

The GBCs must be configured with the following settings.

Redundancy Mode: Redundant Controller - External

SBA: 31 (primary unit) or 30 (secondary unit)

The Genius devices must be configured for Hot Standby mode. For example, use the following settings for a Genius block:

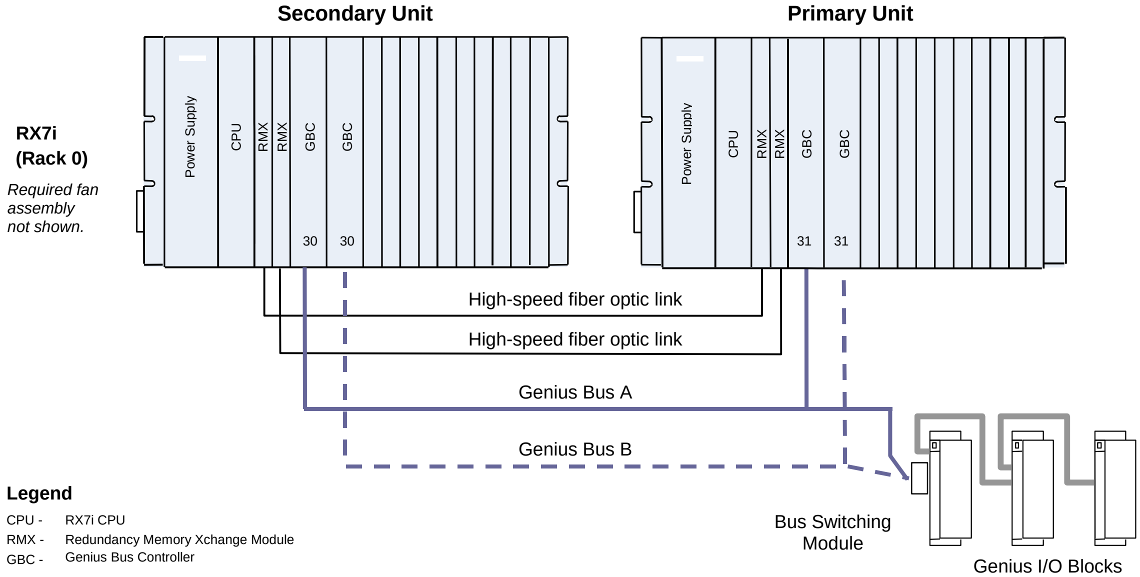
(Hand-Held Monitor) CPU Redundancy = HOT STBY MODE
(Hand-Held Monitor) BSM Present = NO

Dual Bus Networks

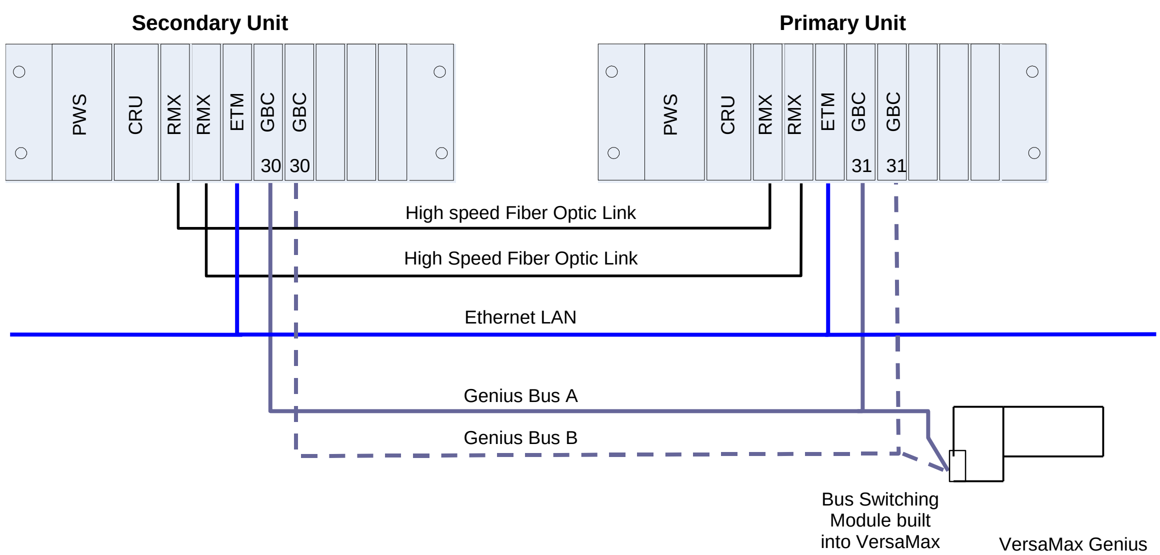
This option provides redundancy of both the controller and the I/O bus. This type of system uses dual buses with bus controllers in each controller. The Dual Bus network is suitable if the application requires redundancy of the controller and the I/O bus.

A Bus Switching Module (BSM) is required to connect the initial block in the Genius block daisy chain to the dual bus.

Sample RX7i Dual Genius Bus Redundancy System



Sample RX3i Dual Genius Bus Redundancy System



When using dual bus Genius networks in a Hot Standby CPU Redundancy system, two bus controllers for the bus pair must be located in the primary unit and two more in the secondary unit. There can be multiple dual bus pairs. The bus controllers in the primary unit are assigned Serial Bus Address 31. The bus controllers in the secondary unit are assigned Serial Bus Address 30.

Genius output devices will use outputs from Serial Bus Address 31 in preference to outputs from Serial Bus Address 30. Outputs are determined by the active unit, regardless of which bus controller provides the outputs since all redundant Genius outputs are transferred from the active unit to the backup unit.

Any type of Genius device can be connected to the network. Each Genius network can have up to 30 additional Genius devices connected to it. You may want to reserve one Serial Bus Address for the Hand-Held Monitor.

As a safety feature, a watchdog timer protects each Genius I/O link. The bus controller periodically resets this timer. If the timer expires, the bus controller stops sending outputs. If this happens in a Dual Bus Genius network of a CPU Redundancy system, the paired GBC in the other unit drives the outputs of the Genius devices. If the GBC in the other unit is not available, the BSMs switch to the other bus. The cause of the failure must be remedied to re-establish communications.

Hardware Configuration for RX7i Dual Bus Network

The hardware configuration for this type of network can be created by selecting *Dual Bus, Redundant Controllers* in the Redundancy Wizard.

The GBCs must be configured with the following settings:

Redundant Mode = Dual Bus_Redundant Controller

Paired GBC = External and Internal

SBA = 31 (primary unit) or 30 (secondary unit)

The redundant devices must be configured for Hot Standby and dual bus mode. For example, use the following settings for a Genius block:

(Programming Software) Redundancy = YES

(Hand-Held Monitor) CPU Redundancy = HOT STBY MODE

(Hand-Held Monitor) BSM Present = YES

(Hand-Held Monitor) BSM Controller = YES (if BSM is mounted) or NO

Hardware Configuration for RX3i Dual Bus Network

The hardware configuration for this type of network can be created by adding two GBCs, one for each bus, and adding the Genius devices to both GBCs. See the *PACSystems RX3i Dual Genius Bus Quick Start Guide* for more information.

The GBCs must be configured with the following settings:

Redundancy Mode: Redundant Controller - External

SBA: 31 (primary unit) or 30 (secondary unit)

The GBCs must be configured with the following settings:

The Genius devices must be configured for Hot Standby and dual bus mode. For example, use the following settings for a VersaMax GNIU.

(Programmer) CPU Redundancy = HOT Standby

(Programmer) BSM Present = YES

(Programmer) BSM Controller = YES

Note: Templates for RX3i Dual Bus Genius come with the VersaMax GNIUs already configured for the correct Genius network settings.

Location of GBCs and Blocks

For fastest switching, all Genius Bus Controllers in the Hot Standby CPU Redundancy system should be in the main rack. This will cause the Genius Bus Controller to lose power at the same time that the CPU loses power and allow the backup unit to gain full control of the I/O as soon as possible. Each GBC has an output timer that it resets during every output scan. If the GBC determines that the CPU in its controller has failed, it will stop sending outputs to its Genius devices. This allows the other GBC to take control of the I/O.

For single and dual bus Genius networks, the Genius Bus Controllers should be placed at the same end of the bus, as shown on page 4-17. In particular, **the secondary unit should be placed at one end of the bus and the primary unit must be placed between the secondary unit and the Genius devices. No I/O blocks or other devices should be located on the bus between the bus controllers.**

In the case of dual bus networks, placing the bus controllers and devices in this manner minimizes the risk of a bus break between the two units. A bus break between the units could result in only some devices switching buses, and make the other devices inaccessible to one of the units. It also allows the primary unit to continue to control the I/O in bus failure conditions that might otherwise result in loss of inputs and unsynchronized control of outputs.

Since the recommended configuration for single and dual bus networks still has the possibility of a bus breaking between the two CPUs, you may want to program the application to monitor the status of the buses from the unit configured at the end of the buses and request a role switch or bus switch (dual bus network only) if loss of bus is detected.

Duplex Genius Output Mode

Although it is not common, you can configure your Genius I/O system for duplex mode, meaning that they will receive outputs from ***both*** bus controllers 30 and 31 and compare them. Only devices that have discrete outputs can be configured for Duplex mode.

If the controllers at SBAs 30 and 31 agree on an output state, the output goes to that state. If the controllers at SBAs 30 and 31 send different states for an output, the device defaults that output to its pre-selected Duplex Default State. For example:

Commanded State from Device Number 31	***Commanded State from Device Number 30***	***Duplex Default State in the Block or I/O Scanner***	***Actual Output State***
On	On	Don’t Care	On
Off	On	Off	Off
Off	Off	Don’t Care	Off
On	Off	On	On

If either controller 30 or 31 stops sending outputs to the device, outputs will be directly controlled by the remaining controller.

Chapter 5 Configuration Requirements

Overview

This chapter defines the special configuration requirements of a Hot Standby CPU Redundancy system.

When the redundantly controlled I/O is **PROFINET**, you must use a Dual HWC target to configure your system.

When the redundantly controlled I/O is **Ethernet NIUs or Genius**, if the program logic will be the same for both units, it is recommended that you use a Dual HWC target.

If you are using Ethernet NIUs or Genius and you do not want to use the same logic in both units, you should create two separate targets and set the target property Dual HWC to FALSE in each target.

When you select a Redundancy CPU, the programming software automatically presents the Dual HWC target. The remainder of this chapter assumes a Dual HWC target.

CAUTION

If both units are configured as primary or as secondary, they will not recognize each other. If this happens in an RX7i system that uses Genius I/O, the GBCs report SBA conflict faults and blink their LEDs. If this happens in an RX3i system that uses Genius I/O, the GBCs only blink their LEDs and no fault is reported.

Correct the configuration of both units before placing either unit in Run mode.

Note: The Redundancy CPU can be used for redundant and non-redundant applications. For non-redundant applications, set the Dual HWC for the target to False and do not configure any redundancy links.

PROFINET I/O Configuration

This section details how to configure an HSB CPU Redundancy system that uses redundantly controlled PROFINET I/O.

Requirements

When using redundantly controlled PROFINET I/O in an HSB CPU Redundancy system, the following requirements apply:

- The HSB CPU Redundancy system must be configured as a Dual HWC target. When you select a Redundancy CPU, the programming software automatically presents the Dual HWC Target. The programming software will not permit redundantly controlled PROFINET IO-Devices to be configured in a standalone (non-redundant) target.
- The HSB CPU Redundancy target must be configured with two redundancy links (two RMX modules in each unit). The programming software will not permit redundantly controlled PROFINET IO-Devices to be downloaded with fewer than two redundancy links. Any failed redundancy link should be repaired as soon as possible.
- To be redundantly controlled, a device has to support PROFINET System Redundancy. In addition, you must use a GSDML file for the device that is at least version 2.3 and indicates that the device supports PROFINET System Redundancy.
- To ensure that they are configured consistently at both units, any additions, modifications, or deletions of redundantly controlled PROFINET IO-Devices must be configured in the Primary hardware configuration (HWC) and then mirrored to the Secondary HWC.
- All inputs assigned to redundantly controlled PROFINET IO-Devices must be included in the CPU’s input transfer list. (This includes all inputs assigned to the PROFINET Scanner module.) All outputs assigned to redundantly controlled PROFINET IO-Devices must be included in the CPU’s output transfer list.
- All inputs and outputs assigned to redundantly-controlled PROFINET IO-Devices must be assigned to an I/O scan set that is scanned at every sweep (such as the default Scan Set 1).

Restrictions

When using redundantly controlled PROFINET I/O in an HSB CPU Redundancy system, the following restrictions apply:

- Do not use any other type of redundantly controlled I/O such as Genius devices or Ethernet NIUs.
- Do not use the DO_IO function block with redundantly controlled PROFINET inputs or outputs.
- Do not use the SCAN_SET_IO function block with redundantly controlled PROFINET inputs or outputs.
- Do not use the SUS_IO function block.
- Do not use the Skip Next I/O Scan (SVC_REQ 45) service request function block.
- Do not use the Disable Data Transfer Copy in Backup Unit (SVC_REQ 43) service request function block.
- Do not use I/O point fault contacts with redundantly controlled PROFINET outputs.

Generating the Hardware Configuration

To generate the hardware configuration for redundantly controlled PROFINET I/O:

1. Add and configure the PROFINET IO-Controllers (PNCs) in the Primary HWC
2. Configure the LANs
3. Add the PROFINET IO-Devices to the Primary HWC
4. Mirror the Primary HWC to the Secondary HWC
5. Set any parameters unique to the Secondary HWC

Configuring the PROFINET IO-Controllers

First select an empty slot in the Primary HWC of the Navigator window, right-click it, select Add Module, and select the PROFINET IO-Controller. Then attach the PNC to a new or existing LAN.

For more information regarding the configuration of the PROFINET IO-Controller, refer to GFK-2571 *RX3i PROFINET Controller Manual*, Chapter 3: Configuration – Configuring an RX3i PROFINET IO-Controller.

Note: When redundantly-controlled IO-Devices are configured at a PNC module, the programming software always sets the Mirror to Secondary property for that PNC to True.

Configuring the PROFINET LANs

For information regarding how to configure a PROFINET LAN, refer to GFK-2571 *RX3i PROFINET Controller Manual*, Chapter 3: Configuration – Configuring PROFINET LANs.

Transfer List Auto-Expansion

All inputs assigned to redundantly controlled PROFINET IO-Devices must be included in the CPU’s input transfer list and all outputs assigned to redundantly controlled PROFINET IO-Devices must be included in the CPU’s output transfer list.

For convenience, the programming software automatically expands the length of the input or output transfer list to include the reference addresses of any newly added or modified redundantly controlled PROFINET IO devices or modules. Whenever you add a redundantly controlled PROFINET IO-Device or module, you should check the CPU’s transfer list to ensure the adjusted starting addresses and lengths do not include reference memory that was not intended to be transferred. If the reference addresses assigned to redundantly controlled PROFINET I/O are already included in the current transfer list, the transfer list will not be modified by the programming software.

To avoid unintended inclusion of reference addresses in the transfer list, it is recommended that you allocate the memory ranges planned for redundantly controlled PROFINET I/O as a contiguous block near the end of the %I, %Q, %AI, or %AQ tables, allowing room for the future addition of redundantly controlled PROFINET I/O devices or modules. If the addition of future devices or modules using %I, %Q, %AI, or %AQ reference addresses is likely and must be done without stopping the process (see page 5-11), adding some or all of the remaining memory to the transfer list can simplify the process, but is not necessary. For information regarding the CPU scan time impact per byte of memory added to the transfer list, refer to “Estimating Data Transfer Time” in Chapter 6: “Operation.”

Configuring Redundantly Controlled PROFINET Devices

To add a redundantly controlled PROFINET IO device to the HWC, first select the PNC in the Primary HWC of the Navigator window, right-click on it, and select Add IO-Device.

In the PROFINET Device Catalog, select the entry that corresponds to the device. You must use a GSDML file for the device that is at least version 2.3 and indicates that the device supports PROFINET System Redundancy.

For each device added, the programming software provides a Redundancy tab and sets the Redundancy Mode parameter on that tab to HSB CPU Redundancy.

For additional information regarding the configuration of the VersaMax PROFINET Scanner, refer to “Adding a VersaMax PROFINET Scanner to a LAN” in the *RX3i PROFINET Controller Manual*, GFK-2571.

Configuring Simplex PROFINET Devices

A Hot Standby CPU Redundancy system can contain both redundantly controlled and simplex (non-redundantly controlled) PROFINET IO-Devices. A simplex IO-Device is always controlled by **one** of the two units (either Primary or Secondary) and will always be controlled by that unit regardless of whether that unit is active or backup.

To configure a device that supports PROFINET System Redundancy as a simplex device for the Primary unit, add that device to the Primary HWC and set the Redundancy Mode parameter on its Redundancy tab to None.

To configure a device that supports PROFINET System Redundancy as a simplex device for the Secondary unit, add that device to the Secondary unit’s HWC. The programmer automatically sets the Redundancy Mode parameter on its Redundancy tab to None.

During mirror operations, simplex devices in the Primary’s HWC are not copied to the Secondary’s HWC, and simplex devices in the Secondary’s HWC are not affected.

Configuring PROFINET Media Redundancy

PROFINET media redundancy is described in GFK-2571 *RX3i PROFINET Controller Manual*, Chapter 6: Redundant Media. All nodes participating in the media redundancy ring must be configured for media redundancy operation.

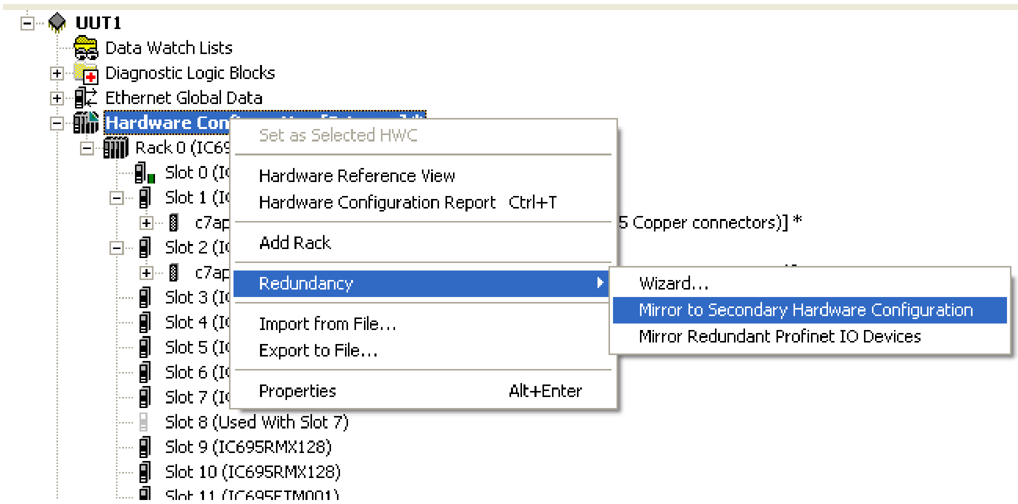
When using PROFINET media redundancy in an HSB CPU Redundancy system, configure the PROFINET Controller (PNC) module in the Primary unit as the media redundancy manager. All of the other nodes that participate in the ring (e.g. the corresponding PNC module in the Secondary unit, other PNC modules, IO-devices, other PNC modules, switches) must be configured as media redundancy clients. If the system uses multiple independent LANs, configure exactly one PNC module on each LAN as the media redundancy manager.

When a PNC is added to the HWC, it is not setup for media redundancy. A PNC module can be configured as either a media redundancy manager or client on the Media Redundancy tab according to GFK-2571 *RX3i PROFINET Controller Manual*, Chapter 3: Configuration.

Note: To avoid network problems, be sure to follow the instructions in GFK-2571 *RX3i PROFINET Controller Manual*, Chapter 6: Redundant Media, when initially setting up a media redundancy network, when enabling or disabling media redundancy in an IO network, or when replacing a PNC module configured as the media redundancy manager.

Synchronizing PROFINET IO Configuration to Secondary Hardware Configuration

When you have finished adding, modifying, or deleting redundantly-controlled PROFINET IO devices in the Primary configuration, you must synchronize those changes to the Secondary configuration. To do this right-click the Hardware Configuration [Primary], choose Redundancy, and then choose Mirror to Secondary Hardware Configuration. This command copies the Primary's configuration (those modules that have their Mirror to Secondary property set to True) to the Secondary's configuration. The redundantly controlled PROFINET IO devices are included in this copy.



You will receive a prompt that this mirroring operation cannot be undone; select Yes to continue.

If this mirror operation has added a new PNC to the Secondary's HWC, you must set the following parameters for that PNC:

- The PROFINET Controller's Device Name
- The PROFINET Controller's IP Address

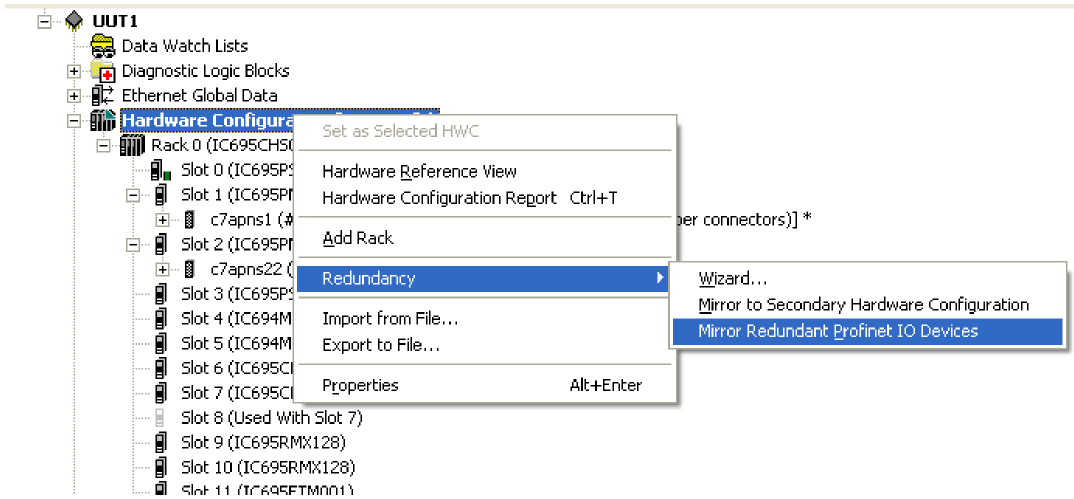
If this mirror operation has added a new Ethernet module to the Secondary's HWC, you need to set that Ethernet Interface's IP Address (see "Ethernet Interface Parameters" on page 5-30.)

After mirroring, check the following in the Primary and Secondary configurations:

- PNC device name and IP address are correct in the Secondary configuration. These parameters must be different from the Primary configuration.
- All redundantly-controlled PROFINET inputs are included in the Primary and Secondary CPUs' Input transfer lists.
- All redundantly controlled PROFINET outputs are included in the Primary and Secondary's CPUs' Output transfer lists.
- The Secondary CPU's transfer lists match the Primary CPU's transfer lists.
- The Ethernet module IP addresses are correct in the Secondary configuration.

Mirroring Redundantly Controlled PROFINET Devices to Secondary

When the only changes to an existing Primary hardware configuration are addition, modification, or deletion of redundantly-controlled PROFINET IO devices, you can choose to mirror only those devices to the Secondary configuration. To do this right-click the Hardware Configuration [Primary], choose Redundancy, and then choose Mirror Redundant Profinet IO-Devices. This command copies only the redundantly-controlled PROFINET IO devices from the Primary HWC to the Secondary HWC.



Downloading PROFINET IO Configuration to the HSB CPU Redundancy System

This section describes recommended sequences for downloading configurations containing PROFINET IO from the Proficy Machine Edition programming software into an HSB CPU redundancy system. Before downloading, generate the Primary and Secondary configurations as described in “Generating the Hardware Configuration” on page 5-4.

The recommended download sequence varies according to situation:

- Initial Download to Redundancy System
- Download a Modified Configuration to a Redundancy System – Stopping the Process
- Add/Modify a PROFINET Device Using Reference Memory Without Stopping the Process
- Add/Modify a PROFINET Device Using I/O Variables Without Stopping the Process

Initial Download to Redundancy System

This is the sequence for downloading configurations into a new redundancy system. Both units are initially stopped with no configuration. For this procedure refer to Chapter 2, “Hot Standby Redundancy Quick Start with PROFINET I/O.

Download a Modified Configuration to a Redundancy System – Stopping the Process

This is the sequence for downloading modified configurations to a redundant target that is already configured and running. Either unit can be the Active unit. This download sequence stops both units.

1. **Stop and Clear the Secondary unit.**
   a. Select the Secondary unit. Stop the Secondary unit. If the Secondary unit was the Active unit, the Primary unit becomes the Active unit.
   b. Clear the Secondary unit’s HWC. (If logic and HWC are coupled, select Program option in the Clear Memory dialog; this will clear both logic and HWC.
   c. Clear the Secondary unit’s Controller and I/O Fault Tables.
2. **Stop and Download the Primary unit**
   a. Select the Primary unit. Stop the Primary unit.
   b. Expect the Primary unit to log a Loss of Device and an Add’n of Device fault for each redundantly controlled IO-Device. For example:

0.1.D2	Add'n of Device
0.1.D2	Loss of Device

   c. Clear the Primary unit’s Controller and I/O Fault Tables.

d. Download the revised HWC to the Primary unit. (If logic and HWC are coupled, select both Hardware Configuration and Logic in the Download to Controller dialog.)

   Expect the Primary unit to log a *Redundancy link communication failure* Controller fault for each RMX module. For example:

0.9	Redundancy link communication failure
0.10	Redundancy link communication failure

e. Confirm that the Primary unit did not record any unexpected Loss of Device faults in its I/O Fault table.

3. Download the Secondary unit

a. Select the Secondary unit.

b. Download the revised HWC to the Secondary unit. (If logic and HWC are coupled, select Hardware Configuration and Logic in the Download to Controller dialog.)

c. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this could take a few seconds)

d. Confirm that the Secondary unit did not record any unexpected Loss of Device faults in its I/O fault table.

4. Start the Primary and Secondary units

a. Select the Primary unit and put it into Run mode.

b. Select the Secondary unit and put it into Run mode.

5. [Optional] The logic application in the Primary and Secondary units can examine the All Devices Connected module status bit at each PNC module.

Adding or Modifying a PROFINET IO Device Without Stopping The Process

It is possible to add a new redundantly controlled PROFINET IO device, or add I/O module(s) to an existing redundantly controlled PROFINET IO device in an HSB CPU redundancy system that is already running without stopping the application process. The procedures differ, depending upon whether the PROFINET IO device uses reference memory or I/O variables. Both procedures are presented below.

Add/Modify a PROFINET Device Using Reference Memory Without Stopping the Process

If the new IO Device or new I/O module(s) will use reference memory, use this procedure. If the new reference memory locations are not already in the transfer lists, you must first modify the transfer lists and execute a dual run-mode-store of the revised transfer lists ***before*** you add the new IO device and/or I/O module(s) to the configuration.

Warning

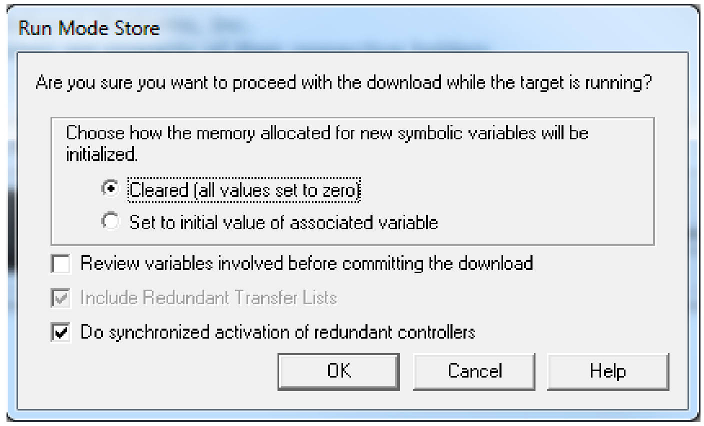
This procedure allows you to modify a device's Hardware Configuration without stopping the process that is being controlled. *However, that device's inputs and outputs will default and remain defaulted for a short period of time during this procedure.*

1. When adding a new IO device, determine the IO network on which you will add this device. If you have not already assigned the network name for this device, assign it now. You can do this from the programming software by right-clicking the PNC module and selecting Launch Discovery Tool. For more information, refer to GFK-2571, *PACSystems RX3i PROFINET Controller Manual*, Chapter 3, Assigning IO-Device Names.

Update Transfer Lists

2. Display the Primary CRU's Transfer List tab. Record the starting addresses and lengths for %I and %AI of the Input Transfer Point. Record the starting addresses and lengths for the %Q and %AQ of the Output Transfer Point.
3. Determine the list of modules to be added to the device. (For a new device, also include the head-end in the list.) Use this module list during steps 4 and 15 below.
4. For each module in the list, determine the reference memory ranges to be added for this module. Then determine the overall reference memory ranges used by this new or modified device.
5. If the overall reference memory ranges for this device are already present in the CRU's transfer lists, the transfer lists do not need to be revised. Proceed to step 14 to edit and download the Hardware Configuration.
6. If the overall reference memory ranges for this device fall outside of the CRU's transfer lists, edit the Primary CRU's transfer list to include the reference memory ranges used by this device. Also update the Transfer List starting addresses and lengths that you recorded in step 2.
7. Confirm that both the Primary and Secondary units are in Run mode and that the LINK OK LEDs are ON for both RMX modules in both units.
8. Connect the programming software to the Primary unit.

9. Initiate a download to the controller. Be sure to leave the box next to Do synchronized activation of redundant controllers checked. Press OK.



10. Disconnect the programming software.
11. Connect the programming software to the Secondary unit.
12. Initiate a download to the controller. Be sure to leave the box next to Do synchronized activation of redundant controllers checked. Press OK.
13. Disconnect the programming software.

Add new Device and/or Modules to Hardware Configuration

14. For a new device, add the new device to the Primary unit's Hardware Configuration.
15. Add modules to the device in the Primary unit's Hardware Configuration. For each module in a new device (including the head-end), or for each new module in an existing device, do the following:
    a. Make sure the module's Variable Mode property to False (the default value).
    b. Set the module's Reference Address parameters. (These were recorded in the module list that was created in step 3 above.)
16. Display the Primary CRU's Transfer List tab and readjust the CRU Transfer Lists to the reference memory ranges that you previously recorded. Set the starting addresses and lengths for %I and %AI of the Input Transfer Point to the recorded values. Set the starting addresses and lengths for the %Q and %AQ of the Output Transfer Point to the recorded values.

Note: During validation, the programming software automatically mirrors redundantly controlled PROFINET devices from the Primary hardware configuration to the Secondary hardware configuration. You do not need to manually mirror the new or modified PROFINET device.

Download Hardware Configuration to both units

17. Connect the programming software to the backup unit.

18. Stop the backup unit.

19. Initiate a download to the controller. Select Hardware Configuration in the Download to Controller dialog. When the download completes:

    If changing the configuration of an existing device:

    a. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this may take a few seconds).
    b. Wait approximately 10 seconds to give the stopped unit time to connect to all of its unmodified PROFINET devices.
    c. Expect this unit to log a Loss of Device fault in its I/O Fault table for the device undergoing Hardware Configuration changes. This occurs because this unit's copy of the device's Hardware Configuration does not match the other unit's copy.

0.5.D2	Loss of Device

    d. Because at least one configured device is not connected, the ACTIVE LED on the corresponding PNC should become solid amber.
    e. Confirm that the stopped unit did not record any unexpected Loss of Device faults in its I/O fault table.

Note: If a role switch or a control takeover occurs before a device connects to this unit, that device's inputs and outputs will default.

If adding a new device only:

    f. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this may take a few seconds).
    g. Wait approximately 10 seconds to give the stopped unit time to connect to all of its unmodified PROFINET devices.
    h. If all of the devices configured for a PNC are present, that PNC's ACTIVE LED should become solid green. If one or more devices are not present, confirm that the stopped unit did not record any unexpected Loss of Device faults in its I/O Fault table.

Note: If a role switch or a control takeover occurs before a device connects to this unit, that device's inputs and outputs will default.

20. Put the stopped unit into Run mode.

21. ***If adding a new device only:***
    Optional: If you would like to switch control to this unit before it happens automatically in step 2426, you can request a role switch now.

22. Disconnect the programming software.

23. Connect the programming software to the other unit.

24. Stop that unit.

If changing the configuration of an existing device:

a. The modified device's inputs and outputs will default and remain defaulted until step 25.

b. The stopped unit will log a Loss of Device fault for that device in its I/O Fault table.

0.5.D2	Loss of Device

c. The stopped unit may log an Add'n of Device fault for that device in its I/O Fault table.

0.5.D2	Add'n of Device

25. Initiate a download to the controller. Select Hardware Configuration in the Download to Controller dialog. When the download completes:
    a. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this may take a few seconds).
    b. Wait approximately 10 seconds to give the stopped unit time to connect to all of its PROFINET devices.

       If changing the configuration of an existing device: Within this 10 second interval, expect I/O to resume on the device that was modified, and expect the ***running unit*** to log an Add'n of Device fault for that device in its I/O fault table.

0.5.D2	Add'n of Device

    c. If all of the devices configured for a PNC are present, that PNC's ACTIVE LED should become solid green. If one or more devices are not present, confirm that the stopped unit did not record any unexpected Loss of Device faults in its I/O fault table. Note: If a role switch or a control takeover occurs before a device connects to this unit, that device's inputs and outputs will default.
26. Put the stopped unit into Run mode. This unit now becomes the backup unit.

If desired, request a role switch to make this unit the Active unit.

27. Disconnect the programming software.

Add/Modify a PROFINET Device Using I/O Variables Without Stopping the Process

This is the sequence for adding a new PROFINET IO device, or adding IO modules(s) to an existing PROFINET IO device, when the PROFINET IO device uses I/O variables.

If the new IO Device or new I/O module(s) will use I/O Variables, use this procedure. This procedure requires you to create the I/O variables and execute a dual run-mode-store of the revised transfer lists ***before*** you add the new IO device and/or I/O module(s) to the configuration.

Warning

This procedure allows one to modify a device's Hardware Configuration without stopping the process that is being controlled. *However, that device's inputs and outputs will default and remain defaulted for a short period of time during this procedure.*

1. When adding a new IO device, determine the IO network on which you will add this device. If you have not already assigned the network name for this device, assign it now. You can do this from the programming software by right-clicking on the PNC module and selecting Launch Discovery Tool. For more information, refer to GFK-2571, *PACSystems RX3i PROFINET Controller Manual*, Chapter 3, Assigning IO-Device Names.

Create I/O Variables

2. Display the Primary CRU's Transfer List tab. Record the starting addresses and lengths for %I and %AI of the Input Transfer Point. Record the starting addresses and lengths for the %Q and %AQ of the Output Transfer Point.
3. Determine the list of modules to be added to the device. (For a new device, also include the head-end in the list.) Use this list during steps 4 through 7 below.

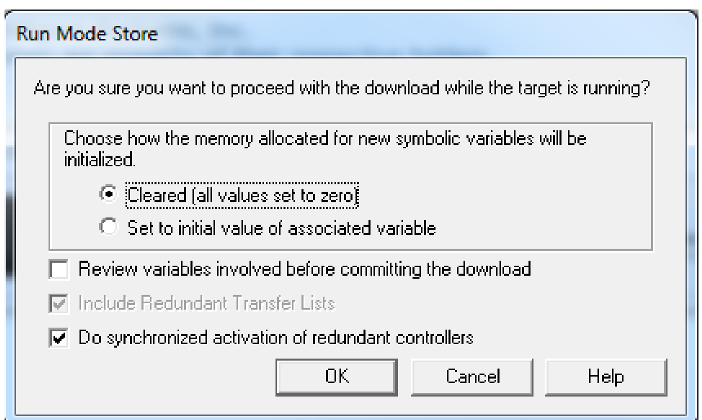
Note: Do not add the device or module(s) to the Hardware Configuration until step 15.

4. For each module in your list that will have discrete inputs:
    a. Create a new variable of Data Type BOOL.
    b. Set the Array Dimension 1 property to the number of input points provided by the module.
    c. Set the Ref Address property to an unused %I location.
    d. Set the Input Transfer List property to True.
5. For each module in your list that will have discrete outputs:
    a. Create a new variable of Data Type BOOL.
    b. Set the Array Dimension 1 property to the number of output points provided by the module.
    c. Set the Ref Address property to an unused %Q location.
    d. Set the Output Transfer List property to True.

6. For each module in your list that will have analog inputs:
    a. Create a new variable of Data Type WORD.
    b. Set the Array Dimension 1 property to the number of channels provided by the module.
    c. Set the Ref Address property to an unused %AI location.
    d. Set the Input Transfer List property to True.
7. For each module in your list that will have analog outputs:
    a. Create a new symbolic variable of Data Type WORD.
    b. Set the Array Dimension 1 property to the number of channels provided by the module.
    c. Set the Ref Address property to an unused %AQ location.
    d. Set the Output Transfer List property to True.

Download the Revised Transfer Lists to both units (Dual Run-mode Store)

8. Confirm that both the Primary and Secondary units are in Run mode and that the LINK OK LEDs are ON for both RMX modules in both units.
9. Connect the programming software to the Primary unit.
10. Initiate a download to the controller. Be sure to leave the box next to *Do synchronized activation of redundant* controllers checked. Press OK.



11. Disconnect the programming software.
12. Connect the programming software to the Secondary unit.
13. Initiate a download to the controller. Be sure to leave the box next to *Do synchronized activation of redundant controllers* checked. Press OK.
14. Disconnect the programming software.

Add new Device and/or Modules to Hardware Configuration

15. For a new device, add the new device to the Primary unit's Hardware Configuration.
16. Add modules to the device in the Primary unit's Hardware Configuration. For each module in a new device (including the head-end), or for each new module in an existing device, do the following:
    a. Set the module's Variable Mode property to True.
    b. Select module's Terminals tab.
    c. For each group of inputs and outputs shown on this tab, right-click on the first point and select Map Variable. Select the variable that you created for this group during steps 4 through 7.
17. Visit the Primary CRU's Transfer List tab and readjust the CRU Transfer Lists to original reference memory ranges that you recorded in step 2. Set the starting addresses and lengths for %I and %AI of the Input Transfer Point to the recorded values. Set the starting addresses and lengths for the %Q and %AQ of the Output Transfer Point to the recorded values.

Note: During validation, the programming software automatically mirrors redundantly controlled PROFINET devices from the Primary hardware configuration to the Secondary hardware configuration. The user does not need to manually mirror the new or modified PROFINET device.

Download Hardware Configuration to both units

18. Connect the programming software to the backup unit.
19. Stop the backup unit.
20. Initiate a download to the controller. Be sure to select both Hardware Configuration and Logic in the Download to Controller dialog. When the download completes:

    If changing the configuration of an existing device:

    a. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this may take a few seconds).
    b. Wait approximately 10 seconds to give the stopped unit time to connect to all of its unmodified PROFINET devices.
    c. Expect this unit to log a Loss of Device fault in its I/O fault table for the device undergoing Hardware Configuration changes. This occurs because this unit's copy of the device's Hardware Configuration does not match the other unit's copy.

0.5.D2	Loss of Device

    d. Because at least one configured device is not connected, the ACTIVE LED on the corresponding PNC should become solid amber.
    e. Confirm that the stopped unit did not record any unexpected Loss of Device faults in its I/O fault table. Note: If a role switch or a control takeover occurs before a device connects to this unit, that device's inputs and outputs will default.

If adding a new device only:

f. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this may take a few seconds).
g. Wait approximately 10 seconds to give the stopped unit time to connect to all of its unmodified PROFINET devices.
h. If all of the devices configured for a PNC are present, that PNC's ACTIVE LED should become solid green. If one or more devices are not present, confirm that the stopped unit did not record any unexpected Loss of Device faults in its I/O fault table. Note: If a role switch or a control takeover occurs before a device connects to this unit, that device's inputs and outputs will default.

21. Put the stopped unit into Run mode.
22. ***If adding a new device only:***

    Optional: If you would like to switch control to this unit before it happens automatically in step 25, you can request a role switch now.
23. Disconnect the programming software.
24. Connect the programming software to the other unit.
25. Stop that unit.

    If changing the configuration of an existing device:

a. The modified device's inputs and outputs will default and remain defaulted until step 26.
b. The stopped unit will log a Loss of Device fault for that device in its I/O fault table.

0.5.D2	Loss of Device

c. The stopped unit may log an Add'n of Device fault for that device in its I/O fault table.

0.5.D2	Add'n of Device

26. Initiate a download to the controller. Be sure to select both Hardware Configuration and Logic in the Download to Controller dialog. When the download completes:
    a. Confirm that the LINK OK LEDs are ON for both RMX modules in both units (this may take a few seconds).
    b. Wait approximately 10 seconds to give the stopped unit time to connect to all of its PROFINET devices.
       If changing the configuration of an existing device: Within this 10 second interval, expect I/O to resume on the device that was modified, and expect the **running unit** to log an Add'n of Device fault for that device in its I/O fault table.

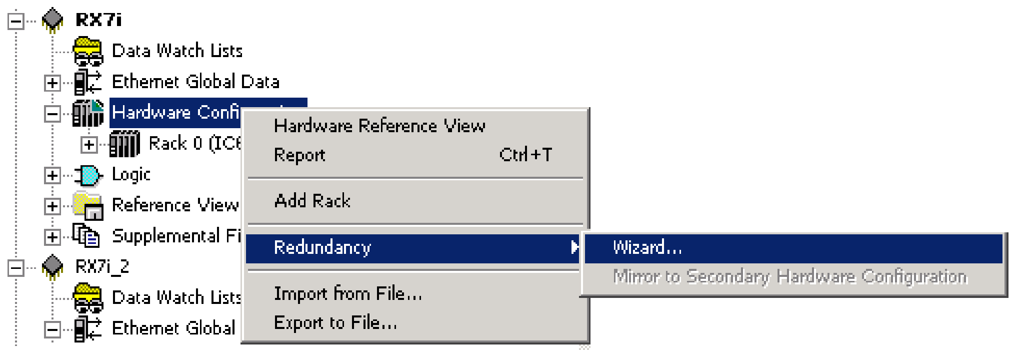
0.5.D2	Add'n of Device

    c. If all of the devices configured for a PNC are present, that PNC's ACTIVE LED should become solid green. If one or more devices are not present, confirm that the stopped unit did not record any unexpected Loss of Device faults in its I/O fault table. Note: If a role switch or a control takeover occurs before a device connects to this unit, that device's inputs and outputs will default.
27. Put the stopped unit into Run mode. This unit now becomes the backup unit.

    If desired, request a role switch to make this unit the Active unit.
28. Disconnect the programming software.

Using the Redundancy Wizards

Machine Edition software provides redundancy wizards to create a hardware configuration with the correct parameter settings for the redundancy scheme that you choose. See "Hardware Configuration Parameters" for details on parameters specific to redundancy systems. To launch the wizard, go to the Navigation window, right click Hardware Configuration, point to Redundancy, and then choose Wizard.



To configure a Hot Standby CPU Redundancy system using the wizards:

1. Run the Set up Primary Hardware Configuration for CPU Redundancy wizard. This wizard configures a redundancy CPU in slot 1 of the main rack and allows you to select the location of the RMX modules used for redundancy links.
2. *For RX7i systems,* run the Add GBCs for Genius Redundancy wizard to configure Genius Bus Controllers in the primary unit.

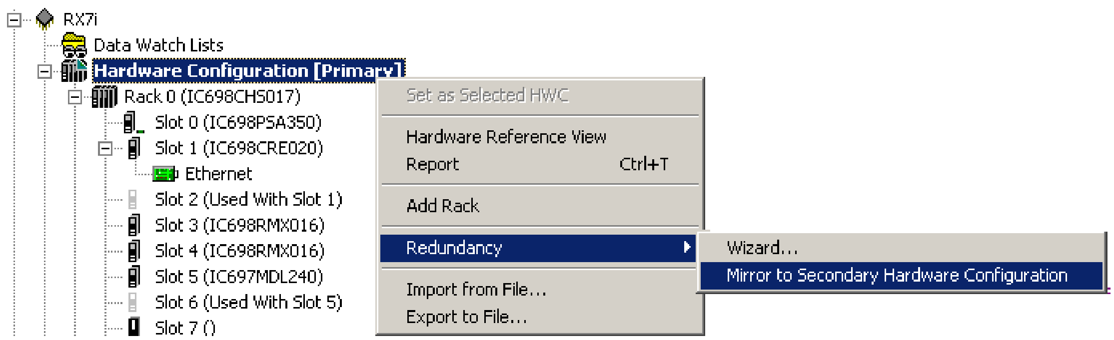
   For RX3i systems, configure the Genius Bus Controllers in Hardware Configuration.
3. Complete configuration of all parameters for the primary unit.
4. When you have finished configuring the primary unit, run the Generate Secondary Hardware Configuration from the Current Configuration wizard. This wizard copies the primary hardware configuration to the secondary configuration and adjusts appropriate parameters for the secondary configuration.
5. Edit the configuration parameters for each item in the secondary unit's hardware configuration that is unique for the secondary unit (for example, the secondary unit's direct IP address and the CPU's SNP ID).

Synchronizing the Hardware Configurations

To synchronize the two configurations (after making changes to the primary configuration or uploading a different primary configuration), right click Hardware Configuration, choose Redundancy, and Mirror to Secondary Hardware Configuration. This command copies the primary hardware configuration to the secondary configuration and adjusts appropriate parameters for the secondary configuration.

Note: You can control whether the contents of specific slots in the primary configuration are copied to the secondary configuration. If the Mirror to Secondary property for a slot is set to True (default), the configured module in that slot in the primary configuration overwrites the corresponding slot in the secondary configuration. I/O variables associated with a module in the primary configuration are copied to the corresponding module in the secondary configuration.

To prevent a slot from being mirrored, set this property to False.



Hardware Configuration Parameters

CPU Parameters

This section discusses only the parameters that apply to redundancy systems. For information on all the CPU parameters, see the *PACSystems CPU Reference Manual,* GFK-2222.

Settings

Parameter	*Default*	*Choices*	*Description*
Stop-Mode I/O Scanning	Disabled	N/A	Always Disabled for a Redundancy CPU.
Watchdog Timer (ms)	200	10 through 1000, in increments of 10ms Requires a value that is greater than the program sweep time.	The watchdog timer, which is designed to detect *failure to complete sweep* conditions, is useful in detecting abnormal operation of the application program, which could prevent the CPU sweep from completing within a specified time period. The CPU restarts the watchdog timer at the beginning of each sweep. The watchdog timer accumulates time during the sweep. **Note:** In a CPU redundancy system, the watchdog timer should be set to allow for the maximum expected scan time plus two fail wait times. (The Fail Wait parameter is set on the Redundancy tab.) Furthermore, the watchdog timer setting must allow enough time for the CPU to complete one input data transfer and two output data transfers.

Scan Parameters

Communications Window Considerations

The redundancy CPU supports the use of high-speed communications modules such as the Ethernet Interface. Requests from devices attached to these communications modules are handled in the Controller and Backplane Communications windows. Because these requests can be sent in large volumes, there is the potential for either of these windows to be processing requests for a significant amount of time.

One way to reduce the risk of one CPU failing to rendezvous at a synchronization point with the other CPU is to configure the Controller and Backplane Communications windows for Limited Window mode. This sets a maximum time for these windows to run.

Other options are to configure the CPU sweep mode as Constant Window or Constant Sweep. The CPU will then cycle through the communications and background windows for approximately the same amount of time in both units.

Parameter	Default	Choices	Description
Sweep Mode	Normal	Normal Constant Window Constant Sweep.	For details on sweep modes, refer to *the PACSystems CPU Reference Manual,* GFK-2222.
Controller Communications Window Mode	Limited	**Limited:** Time sliced. The maximum execution time for the Controller Communications Window per scan is specified in the Controller Communications Window Timer parameter. **Complete:** The window runs to completion. There is no time limit.	(Available only when Sweep Mode is set to *Normal*.) Execution settings for the Controller Communications Window.
Controller Communications Window Timer	Controller Communications Window Mode is: **Limited:** 10 **Complete:** There is no time limit.	Controller Communications Window Mode is: **Limited:** 0 through 255 ms. **Complete:** Read only. There is no time limit.	The maximum execution time for the Controller Communications Window per scan.
Backplane Communications Window Mode	Limited	**Limited:** Time sliced. The maximum execution time for the Backplane Communications Window per scan is specified in the Backplane Communications Window Timer parameter. **Complete:** The window runs to completion. There is no time limit.	(Available only when Sweep Mode is set to *Normal*.) Execution settings for the Backplane Communications Window.
Backplane Communications Window Timer (ms)	10ms for Limited mode	**Limited:** Valid range: 0 through 255 ms. **Complete:** Read only. There is no time limit.	(Available only when Sweep Mode is set to *Normal.)* The maximum execution time for the Backplane Communications Window per scan. This value can be greater than the value for the watchdog timer. It is highly recommended that this parameter be set to the same value for both CPUs in a redundancy pair.
Background Window Timer	5ms	0 through 255ms	Setting the background window time to zero disables the background RAM tests.
Sweep Timer (ms)	100ms	5 through 2550ms, in increments of 5. If the value typed is not a multiple of 5ms, it is rounded to the next highest valid value.	(Available only when Sweep Mode is set to *Constant Sweep.*) The maximum overall controller scan time. This value cannot be greater than the value for the watchdog timer. Some or all of the windows at the end of the sweep might not be executed. The windows terminate when the overall sweep time has reached the value specified for the Sweep Timer parameter.

Parameter	Default	Choices	Description
Window Timer (ms)	10	3 through 255, in increments of 1.	(Available only when Sweep Mode is set to *Constant Window.*) The maximum combined execution time per scan for the Controller Communications Window, Backplane Communications Window, and Background Communications Window. This value cannot be greater than the value for the watchdog timer.
Number of Last Scans	0	0–5 (Should be set to 0.)	The number of scans to execute after the PACSystems CPU receives an indication that a transition from Run to Stop mode should occur. **Note:** In a redundancy system, this parameter should be set to 0 (default). Using a non-zero value would allow a unit to stay in RUN mode for a few sweeps after detecting a fatal fault.

Memory Parameters

Point Fault References

For applications that use redundantly controlled PROFINET IO, the use of input point faults is strongly recommended. By default, point faults are disabled; they must be enabled in the CPU configuration. Select the CPU module; in the Memory tab set the Point Fault References parameters to Enabled. For further details, refer to the *PACSystems CPU Reference Manual,* GFK-2222.

Fault Parameters

Parameter	Default	Choices	Description
Recoverable Local Memory Error	Diagnostic	Diagnostic Fatal	***Redundancy CPUs only.*** Determines whether a single-bit ECC error causes the CPU to stop or allows it to continue running.

Redundancy Parameters

Parameter	Default	Choices	Description
Redundancy Mode	Primary	Primary Secondary (Read-only when the Dual HWC target property is set to True.)	Specifies whether the current Hardware Configuration is Primary or Secondary. **Note:** When the Dual HWC target property is set to True, one Hardware Configuration is automatically set to Primary, and the other to Secondary.
Control Strategy	HSB	HSB	Selects the HSB control strategy.
Fail Wait Time	60	40 through 400 ms, in increments of 10 ms.	The maximum amount of time this CPU waits for the other CPU to reach a synchronization point. For recommendations on setting Fail Wait time, see chapter 6.
Redundancy Links	Determined by number of redundancy links configured for this unit.	Read-only **0:** The CPU behaves as a redundancy CPU without a backup. **1:** The CPU behaves as a redundancy CPU with one redundancy link. **2:** The CPU behaves as a redundancy CPU with two redundancy links. – ***Strongly Recommended***	The number of redundancy links configured for this unit. Each redundancy link is a pair of RMX modules (one in each unit) that have the Redundancy Link parameter set to Enabled.
--- Redundancy Link 1 ---			
Rack Number	0	(Read only) 0	The rack location of the first RMX module. (Shown only if the Redundancy Links parameter is 1 or 2.)
Slot Number	Determined by slot location of RMX module.	(Read-only)	The slot location of the first RMX module. (Shown only if the Redundancy Links parameter is 1 or 2.)
--- Redundancy Link 2 ---			
Rack Number	0	(Read-only) 0	The rack location of the second redundancy link. (Shown only if the Redundancy Links parameter is 2.)
Slot Number	Determined by slot location of RMX module.	(Read-only)	The slot location of the second redundancy link. (Shown only if the Redundancy Links parameter is 2.)

Transfer List

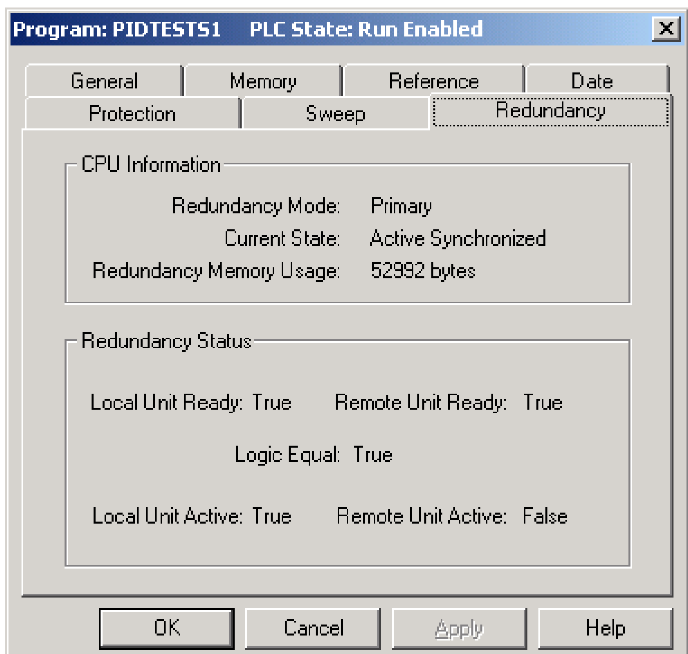
Use this tab to select the ranges of references that will be transferred from the active unit to the backup unit. If the program logic requires identical input values for the two units, those references must be included in the input transfer list.

A maximum of 2Mbytes of data can be included in the transfer list. The amount of data transferred is also limited by the amount of user memory consumption. Overrides and Legacy-style Transitions are transferred for any specified discrete transfer data, as well as point fault information for transferred discrete and analog data if Point Faults are enabled. Transferred data, along with user program, configuration, and reference memory size, etc. all count against the user memory size and contributes to the CPU scan time.

Because the redundancy transfer list is part of hardware configuration, the transfer lists in both units must be the same for synchronization to occur.

Note: Individual variables can also be configured as transferred variables in either or both the input and output transfer lists. For details, see page 5-33.

To view the amount of memory used for transfer data (redundancy memory usage), go online and store the configuration. Then right click the Target, choose Online Commands, and select Show Status. In the status dialog box, select the Redundancy tab.



Parameter	Default	Choices	Description
Input/Output Transfer Point			
%I Reference	%I00001	This address must be byte-aligned, that is, it must have a value of *8n + 1.* Example: %I00025 where *25= (8 × 3) + 1*.	The starting address for the range of %I references that are synchronized between the redundant CPUs.
%I Length	0	0 through (32,768 - Iref + 1), in increments of 8, where Iref = the value set in the %I Reference parameter.	The number of %I references that are synchronized between the redundant CPUs.
%Q Reference	%Q00001	This address must be byte-aligned, that is, it must have a value of *8n + 1.* Example: %Q00049, where *49 = (8 × 6) + 1.*	The starting address for the range of %Q references that are synchronized between the redundant CPUs.
%Q Length	0	0 through (32,768 - Qref + 1), in increments of 8, where Qref = the value set in the %Q Reference parameter.	The number of %Q references that are synchronized between the redundant CPUs.
%M Reference	%M00001	This address must be byte-aligned, that is, it must have a value of *8n + 1.* Example: %M00121, where *121 = (8 × 15) + 1.*	The starting address for the range of %M references that are synchronized between the redundant CPUs.
%M Length	0	0 through (32,768 - Mref + 1), in increments of 8, where Mref = the value set in the %M Reference parameter.	The number of %M references that are synchronized between the redundant CPUs.
%G Reference	%G00001	This address must be byte-aligned, that is, it must have a value of *8n + 1*. Example: %G00081, where *81 = (8 × 10) + 1.*	The starting address for the range of %G references that are synchronized between the redundant CPUs.
%G Length	0	0 through *(7,680 - Gref + 1),* in increments of 8, where *Gref* = the value set in the %G Reference parameter.	The number of %G references that are synchronized between the redundant CPUs.
%AI Reference	%AI00001	The limit configured for %AI references is based on values provided in the Memory tab. The value of the beginning references plus the value of the length must be less than, or equal to, the configured limit.	The starting address for the range of %AI references that are synchronized between the redundant CPUs.
%AI Length	0	0 through (AIul - AIref + 1), where Aiul = the upper limit of %AI memory configured on the Memory tab, and Airef = the value set in the %AI Reference parameter.	The number of %AI references that are synchronized between the redundant CPUs.
%AQ Reference	%AQ00001	The limit configured for %AQ references is based on values provided in the Memory tab. The value of the beginning reference address plus the value of the length must be less than, or equal to, the configured limit.	The starting address for the range of %AQ references that are synchronized between the redundant CPUs.
%AQ Length	0	0 through (AQul - AQref + 1), where Aqul = the upper limit of %AQ memory configured on the Memory tab, and Aqref = the value set in the %AQ Reference parameter.	The number of %AQ reference addresses that are synchronized between the redundant CPUs. The limit configured for %AQ references is based on values provided in the Memory tab. The value of the beginning reference plus the value of the length must be less than, or equal to, the configured limit.

Parameter	Default	Choices	Description
%R Reference	%R00001	The limit configured for %R references is based on values provided in the Memory tab. The value of the beginning references plus the value of the length must be less than, or equal to, the configured limit.	The starting address for the range of %R references that are synchronized between the redundant CPUs.
%R Length	0	0 through (Rul - Rref + 1), where Rul = the upper limit of %R memory configured on the Memory tab, and Rref = the value set in the %R Reference parameter.	The number of %R reference addresses that are synchronized between the redundant CPUs. The limit configured for %R references is based on values provided in the Memory tab. The value of the beginning address plus the value of the length must be less than, or equal to, the configured limit.
%W Reference	%W00001	The limit configured for %W references is based on values provided in the Memory tab. The value of the beginning reference address plus the value of the length must be less than, or equal to, the configured limit.	The starting address for the range of %W references that are synchronized between the redundant CPUs.
%W Length	0	0 through (Wul - Wref + 1), where Wul = the upper limit of %W memory configured on the Memory tab, and Wref = the value set in the %W Reference parameter.	The number of %W references that are synchronized between the redundant CPUs. The limit configured for %W references is based on values provided in the Memory tab. The value of the beginning reference address plus the value of the length must be less than, or equal to, the configured limit.

Genius HSB

If the program logic requires identical input values for the two units, those references (including Genius inputs) must be included in the input transfer list.

You must include all redundant Genius outputs, i.e. those %Q and %AQ references tied to redundant Genius devices, in the output transfer list.[1] Failure to do so will result in the primary unit always determining the output values, even when it is the backup unit. By default, Machine Edition generates an error and prevents storing of the configuration if a redundant output is not included in the transfer list. For special situations, you can adjust the Target property, Genius Output, to generate a warning instead.

[1] In an RX3i CPU Redundancy system, when a GBC is configured as Redundant Controller - External, all its outputs are redundant.

Redundancy Memory Xchange Module Parameters

Parameter	Default	Choices	Description
Redundancy Link	Enabled	Enabled Disabled	If the RMX module is being used as a redundancy link, this parameter must be set to Enabled. An RMX module being used as a redundancy link cannot be used as a general-purpose reflective memory module. All the reflective memory parameters are unavailable, and the Interrupt parameter is set to Disabled.

Ethernet Interface Parameters

Each unit contains at least one Ethernet interface that is assigned a direct IP address used to directly access the specific unit. A third, redundant, IP address can be assigned to the pair of Ethernet interfaces in both the primary and secondary units. The redundant IP address is active on the Ethernet interface in only one of the units at a time, the active unit. All data sent to the redundant IP address (including EGD produced to the redundant IP address) is handled by the active unit. When active, the Ethernet interface always initiates communications using the redundant IP address. When the unit is not active, all communications are initiated through the direct IP address. For more information about the Redundant IP address, refer to "Redundant IP Addresses" in chapter 6.

You can have up to four Ethernet interfaces in each rack, including the embedded Ethernet interface in an RX7i CPU. Each Ethernet interface can be set up as part of a pair for the purposes of redundant IP. (You can also include Ethernet interfaces in the unit that are not part of a redundant IP pair.)

When an Ethernet Interface is configured to produce Ethernet Global Data (EGD), you must configure a redundant IP address in addition to the direct IP address. For more information about using EGD in a redundancy system, see chapter 6.

Parameter	***Default***	***Choices***	***Description***
IP Address	0.0.0.0	x.x.x.x where x ranges from 1 to 255	This IP address, also known as the *direct IP address,* always applies only to this unit. The IP Address should be assigned by the person responsible for your network. TCP/IP network administrators are familiar with these sorts of parameters and can assign values that work with your existing network. If the IP address is improperly set, your device might not be able to communicate on the network and could disrupt network communications.
Redundant IP	Disable	Disable Enable	Enabling this feature allows the Ethernet Interface to share an IP address with the corresponding Ethernet Interface in the other unit. When this parameter is enabled, a Redundant IP Address must be entered.
Redundant IP Address	0.0.0.0	x.x.x.x where x ranges from 1 to 255	(Available only when the Redundant IP parameter is set to Enable.) The IP address shared by two Ethernet Interfaces that are connected to the same network and reside in separate units (one in the primary unit and the other in the secondary unit). Although the redundant IP address is shared by both Ethernet Interfaces, only the Interface in the active unit responds to this IP address. This IP address is assigned in addition to the device's primary IP address. For a pair of Ethernet Interfaces, the redundant IP address must be the same value on the primary and secondary units. **Note:** The redundant IP address must not be the same as the direct IP address of either Ethernet Interface. The redundant IP address must be on the same sub-network as the direct IP address and Gateway IP address, if used. For more information about Ethernet redundancy, see *TCP/IP Ethernet Communications for PACSystems*, GFK-2224.

Rack Module Configuration Parameters

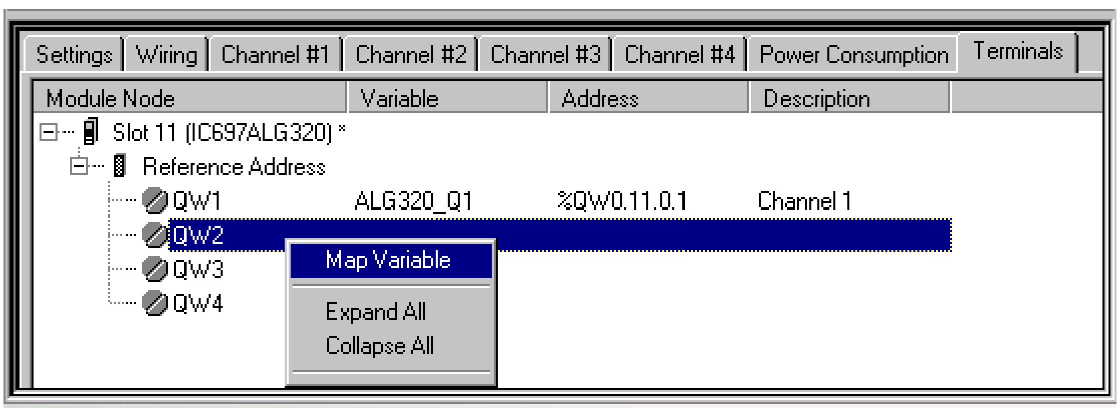
I/O Interrupts

Interrupts cannot be ENABLED when the configured CPU is a Redundancy CPU. When a redundant CPU is configured, any interrupts enabled in the configuration are DISABLED.

I/O Variables

An I/O variable is a symbolic variable that is mapped to a terminal in the hardware configuration for individual modules. A terminal can be one of the following: a physical discrete or analog I/O point on a PACSystems module or on a Genius device, a discrete or analog status returned from a PACSystems module, or Global Data. The use of I/O variables allows you to configure hardware modules without having to specify the reference addresses to use when scanning their inputs and outputs. Instead, you can directly associate variable names with a module's inputs and outputs.

I/O variables can be used any place that other symbolic variables are supported, such as in logic as parameters to built-in function blocks, user defined function blocks, parameterized function blocks, C blocks, bit-in-word references, and transitional contacts and coils. For additional information on the use of I/O variables, see the *PACSystems CPU Reference Manual,* GFK-2222.



Mapping Hardware I/O Variables Example

Using I/O Variables in a Redundancy System

In a redundancy system, the mapping of I/O variables must be the same in both units. It is possible to have different modules configured in each unit, as long as the modules that differ do not have I/O variables assigned to them.

When an I/O variable is added, moved or deleted in one hardware configuration, Machine Edition performs the same action on the other hardware configuration. If you move a module with I/O variables to a different rack location, the variables in the corresponding module in the other hardware configuration are disassociated, causing an I/O Variable Mismatch error. If an I/O variable is assigned to a module in one unit without a corresponding I/O variable on a module of the same type in the other unit, an I/O Variable Mismatch error will be generated upon validation.

I/O variables can be configured as transferred variables in either or both the input and output transfer lists. For details, see "Adding Individual Variables to the Transfer Lists" on page 5-33.

Genius Bus Configuration

Bus Controller Configuration Parameters

- When configuring the PRIMARY controller, all GBCs configured for external redundancy[1] must have Serial Bus Address 31.
- When configuring the SECONDARY controller, all GBCs configured for external redundancy[1] must have Serial Bus Address 30.

Note: It is possible to configure Genius networks in which there is not a redundant bus controller in the other unit. For such networks, it is not necessary for the serial bus addresses to be 31 in the primary unit and 30 in the secondary unit.

- For single Genius bus networks in RX7i targets, the GBCs' Redundancy Mode parameter must be configured for Redundant Controller with the redundant pair set to External.
- For single Genius bus networks in RX3i targets, the GBCs' Redundancy Mode parameter must be configured for Redundant Controller — External.
- For Dual Bus Genius networks in RX7i targets, the GBCs must be configured for Dual Bus/Redundant Controller.
- For Dual Bus Genius networks in RX3i targets, the GBCs must be configured for Redundant Controller — External.

Note: Dual Bus Genius networks in RX3i targets need to be configured manually, and %I and %AI references on Genius bus B must have offsets. The %I offset is 10000 and the %AI offset is 5000.

Note: GBCs for networks that are connected to just one unit can have any setting.

Genius Device Configuration Parameters

All Genius devices that are connected to both units must be configured as redundant. [1]

Note: Devices that are connected to just one unit can use any available setting.

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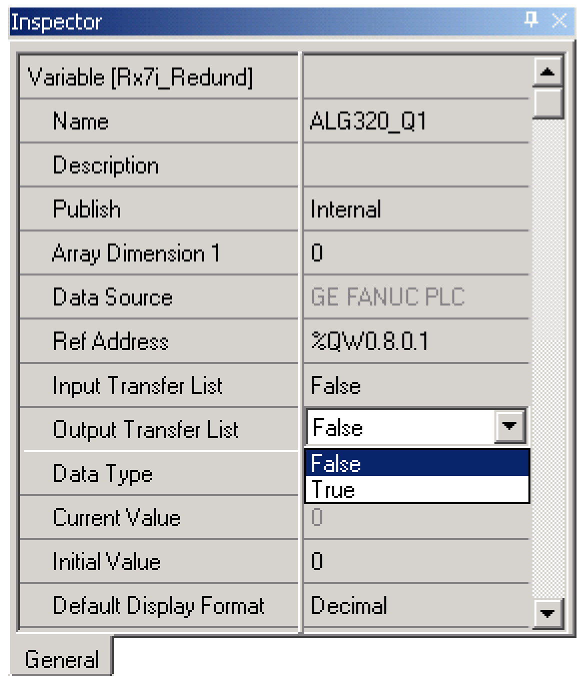
[11] In an RX3i CPU Redundancy System, when a GBC is configured as Redundant Controller – External, all its outputs are redundant.

Adding Individual Variables to the Transfer Lists

Individual variables can be configured as transferred variables in the input transfer list and/or the output transfer list. Mapped, managed (symbolic and I/O), and function block instance variables can be transferred. This is the only way that managed and function block instance variables can be transferred.

The following types of variables cannot be transferred:

- Mapped BOOL variables with bit-in-word addresses
- Elements of BOOL arrays that are mapped to word memories (%R, %W, %AI, %AQ)
- Aliases to variables



The Input Transfer List and Output Transfer List properties for a variable are set to False by default. To add or remove a variable to or from the variable transfer list, edit the Properties for that variable.

In most cases, a variable should be part of the input or output transfer, but not both. In some unusual cases, where there is a need to update a variable at both transfer points in the sweep, the variable can be configured for both lists.

Mapped Variables

An advantage of configuring mapped variables this way instead of including them in the CPU's Transfer List is that the transfer properties are tied to the variable, not the memory location. If you need to relocate a variable, you do not risk accidentally moving it out of the transfer area.

Mapped variables must be assigned to one of the memory ranges allowed for redundancy transfer: %I, %AI, %Q, %AQ, %R, %M, %W, or %G.

Note: If a mapped variable within a range specified in the CPU hardware configuration Transfer List (page 5-26) is also configured as a transferred variable, it will be transferred twice.

Arrays

Arrays can be configured as Mixed transferred variables, allowing individual elements to be included in the input transfer list and/or the output transfer list. If the top level of the array variable is set to True or False for either list, all elements in the array are set to the top-level value for that list.

Instance Data Structure Variables

All elements of instance data structure variables, such as those associated with a function block, are transferred according to the setting of the head of the data structure.

Using the Variable Transfer List Report

The report provides the total number of variable bytes, the total whole bytes, and the total partial bytes included in the input and the output transfer lists.

To access this report, right click the Target and select Report. In the Available Reports list, select Variable Transfer List Report and click OK.

Variable Transfer List Report

Target: Example **Total Variables:** 7

Input List: (Remove all variables from list) Jump to output list

Name	Type	Address	Publish	Description
ALG320_Q1	INT	%QW0.8.0.1	*	
ALG320_Q2	INT	%QW0.8.0.2	*	
ALG320_Q3	INT	%QW0.8.0.4	*	
ALG320_Q4	INT	%QW0.8.0.3	*	
XYZ1	BOOL			
XYZ2	BYTE			
XYZ3	WORD		*	

Total Variables in Input List: 7	
Total Variable Bytes Transferred: (rounded up) 15	
Whole Bytes Transferred: 12	Entries Containing Only Whole Bytes: 6
Partial Bytes Transferred: 3	Entries Containing Partial Bytes: 3

Storing (Downloading) Hardware Configuration

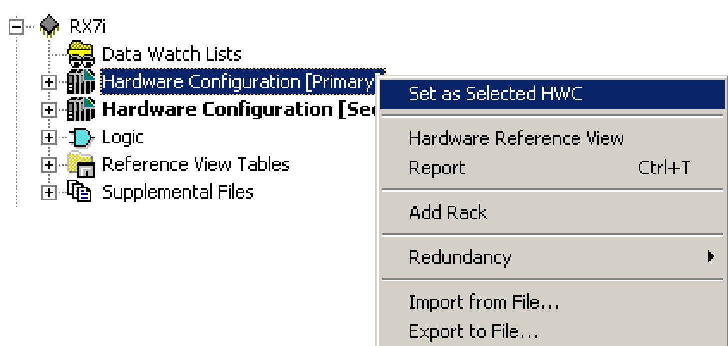
A PACSystems control system is configured by creating a configuration file in the programming software, then transferring (downloading) the file from the programmer to the CPU via the Ethernet Interface or serial port. The CPU stores the configuration file in its non-volatile RAM memory.

In the programming software all online operations, including downloading a folder, are performed on the controller that is the selected hardware configuration. You must download the hardware configuration to each controller in the redundancy system in a separate operation.

CAUTION

If both units are configured as primary or as secondary, they will not recognize each other. If this happens in an RX7i system, the GBCs report SBA conflict faults and blink their LEDs. If this happens in an RX3i system, the GBCs only blink their LEDs and no fault is reported.

Correct the configuration of both units before placing either unit in Run mode.



1. Make sure the primary HWC is selected.

   To select a hardware configuration, right click on Hardware Configuration and choose Set as Selected HWC.
2. If not already done, set the physical port parameters for the primary unit in the Target properties.
3. Connect to the CPU. Make sure the CPU is in Stop mode.
4. Download.
5. Go offline.
6. Select the secondary HWC.
7. If not already done, set the physical port parameters for the secondary unit in the Target properties.
8. Connect to the CPU. Make sure the CPU is in Stop mode.
9. Download.

Run Mode Stores

PACSystems releases 5.5 and later support run mode store (RMS) of the redundancy transfer list. This capability allows you to add, delete or modify transfer list entries without stopping the controllers.

If two redundant units are synchronized, the RMS must be performed as a dual operation. However, when a redundant unit is not synchronized to another unit, the redundancy transfer list can be stored in a single RMS. This facilitates the commissioning phase of a redundancy system, where the redundant partner might not be in place yet.

Caution

Do not attempt to synchronize a unit while an RMS is in progress to a non-synchronized active unit. If the unit attempting to synchronize in this case is taken to run mode, both units will be non-synchronized active units. For systems that contain redundantly controlled PROFINET I/O, when both units become non-synchronized active units, the unit that was the synchronized active unit will then go to Stop mode.

An RMS of the transfer list requires two copies of the redundancy configuration to be resident on the controller for a short time. During that period both copies of the transfer list are charged against the user memory limit. If there is not enough user space available for both copies (along with any new logic or EGD data that is part of the RMS), the store will fail.

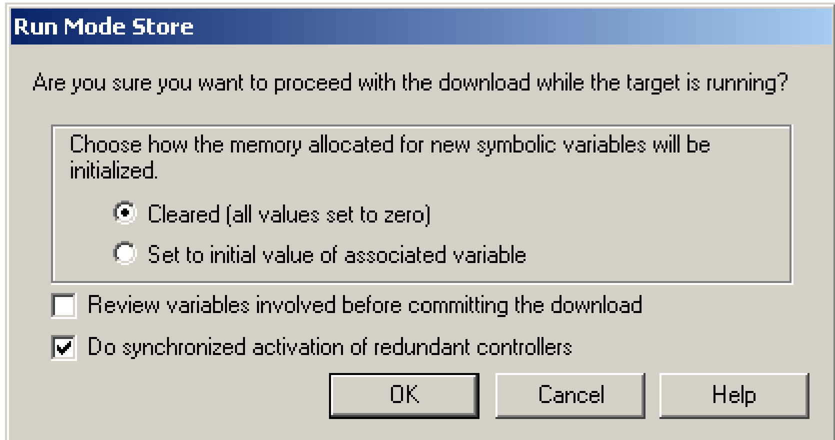
Dual RMS with Simultaneous Activation In Redundant Systems

Warning

A synchronous RMS of invalid user logic or configuration, such as would cause a watchdog or processor exception, could cause both units to fail. To mitigate the risk of such application errors, the procedure, "Initial RMS Followed by Dual RMS" on page 5-37 is recommended.

To modify EGD, application logic and/or the redundancy transfer list using RMS and have the controllers simultaneously activate the changes, you must perform independent downloads to both controllers. The two controllers then negotiate when to activate the new items. The initial store can be done to either the primary or the secondary unit. Note that a dual RMS does not have to include transfer lists. It could include only EGD and/or logic.

When you command an RMS to one of the units, you will be given the option of selecting synchronized activation of the redundant controllers.



If you select *Do synchronized activation of redundant controllers*, the first unit defers application of the newly stored application data until the following actions have occurred:

1. You disconnect from the first unit, connect to the other unit, and command an RMS to that unit.
2. The programmer performs the RMS to the second unit.
3. Both units validate that the new application data is compatible in the two units.

Because the controller sweeps are synchronized, both units will activate the new logic and transfer lists on the same sweep.

If a power loss occurs on one of the units after activation of the new components begins, but before it completes, the unit maintaining power will complete the activation and continue as a non-synchronized active unit. When the other unit is powered back on (assuming a good battery) it will either have the newly stored application or the original application. If the units match, they can synchronize without a download. If the unit that lost power does not contain the new application data, a *Primary and secondary units are incompatible fault* (fault 9 in group 138) will be generated.

Initial RMS Followed by Dual RMS

The following procedure is recommended to avoid the risk of both units failing due to logic errors in a dual RMS:

1. Perform an RMS of the new application data only to the backup controller prior to modifying the transfer list. (*Do synchronized activation of redundant controllers* is not selected.)
2. Perform a role switch to make the modified controller active.
3. Add any variables that require synchronization to the transfer list. (See “Adding Individual Variables to the Transfer Lists” on page 5-33.
4. Initiate a dual RMS.
5. If necessary, perform a role switch so that the primary unit is the active unit.

The unit whose logic had already been stored in run mode will receive only the new transfer list. The other unit will receive the new transfer list and new logic/EGD.

RMS Operational Errors

Certain operational errors can occur only when performing a dual RMS to two synchronized controllers and performing simultaneous activation of new application data. The table below outlines possible modes of failure and the system operation when the failure occurs.

Error Mode	*System Operation*
User requests a normal store (single RMS, not dual RMS) when the transfer list has changed.	The programmer will not attempt the run mode store and will display an error message.
User requests a dual RMS on a controller that is not synchronized to a redundant partner.	The dual store will not be completed. The programmer will display the following controller error message: *The requested action could not be completed because the target is not synchronized with another controller. (0x05, 0x3E)*
User requests a dual RMS on a controller whose redundant partner does not support dual RMS.	The dual store will not be completed. The programmer will display the following controller error message: *The firmware for the remote redundant controller does not support the operation. (0x05, 0x3C)*
Dual RMS aborted (user commanded, loss of communications, failed download) to a controller whose redundant partner does *not* have a pending dual RMS.	The controller will abort the RMS and delete any new application data that had been stored.
Dual RMS aborted (user commanded, loss of communications, failed download) to a controller whose redundant partner has a pending dual RMS.	Both controllers will abort the RMS and delete any new application data that had been stored.
Loss of synchronization in a dual RMS where only one controller has a pending dual RMS.	The controller will abort the RMS and delete any new application data that had been stored.
Loss of synchronization in a dual RMS where both controllers have a pending dual RMS.	Both controllers will abort the RMS and delete any new application data that had been stored.
The two controllers determine that the newly stored transfer lists are not compatible.	Both controllers will abort the RMS and delete any new application data that had been stored.
One or both of the units determine that there is a problem with one of the components downloaded during the run mode store.	Both controllers will abort the RMS and delete any new application data that had been stored.
A loss of synchronization occurs after the activation of the new components begins, but before it completes.	Both units complete the activation of newly stored application data and run as non-synchronized active units.[1]
A fatal error (stop halt) occurs after the activation of the new components begins, but before it completes.	Both units complete the activation of newly stored application data. If only one unit has a fatal error, the other unit will run as a non-synchronized active unit.
A power loss occurs on one of the units after activation of the new components begins, but before it completes.	The unit maintaining power will complete the activation and continue as a non-synchronized active unit. If the other unit is powered back on (assuming a good battery) it will either have the newly stored application or the original. The firmware will attempt to ensure that this unit has the new application so that it can synchronize to the other unit without a download, but it will not be guaranteed. If the units match, they can synchronize without a download. If the unit that lost power does not contain the new application data, a *Primary and secondary units are incompatible fault*

[1] For systems that contain redundantly controlled PROFINET I/O, when both units become non-synchronized active units, the unit that was the synchronized active unit will go to Stop mode.

Error Mode	System Operation
	(fault 9 in group 138) will be generated.
User attempts to go to programmer mode on a controller that already has a pending dual RMS.	You will be prompted to either abort the dual RMS or stay in monitor mode.
User requests a role switch via logic or the physical switch on the RMX module.	User commanded role switches do not impact the ability to do a dual RMS. The role switch could be deferred for a maximum of one sweep if it coincides with the simultaneous activation.
Dual RMS could fail in Normal sweep mode with the Backplane Communication Window Mode set to Complete. Synchronization is lost and both units transition to NSAU operation.[1]	When RMS of a large file is performed with the CPU in this sweep mode, the CPU tries to complete the RMS in a single scan, causing the sweep time to exceed the Fail Wait time. To avoid this failure, set the Backplane Communication Window Mode to Limited or select the Constant Window or Constant Sweep mode.

Behavior of EGD in a Dual RMS

Added exchanges will begin consumption/production shortly after the activation of logic that is part of the RMS. Deleted exchanges will cease consumption/production shortly before the activation of logic that is part of the RMS. Modified exchanges will be offline for a short time during the activation of new logic that is part of the RMS. For general information about the behavior of this feature in a simplex system, refer to “Run Mode Store of EGD” in *TCP/IP Ethernet Communications for PACSystems,* GFK-2224.

Unlike activation of the transfer list and logic, activation of EGD changes is not guaranteed to be simultaneous between the two units in a dual RMS. Even in cases where hardware configuration and logic are identical on the two units, it cannot be guaranteed that production/consumption of deleted or modified exchanges will stop on the same controller sweep. Likewise, it cannot be guaranteed that production/consumption of added or modified exchanges will resume on the same controller sweep. This is consistent with normal operation of EGD in a redundancy system.

Hardware Configuration and Logic Coupling

If I/O Variables are used, an RMS must include both logic and hardware configuration.

If I/O Variables are not used, you can choose whether to RMS logic, hardware configuration, or both. If you choose hardware configuration or both, all portions of hardware configuration that can be stored in run mode will be included. If there are portions of hardware configuration that are not equal and cannot be stored in run mode, a warning will be generated.

[1] For systems that contain redundantly controlled PROFINET I/O, when both units become non-synchronized active units, the unit that was the synchronized active unit will go to Stop mode.

Chapter 6

Operation

This chapter discusses aspects of PACSystems CPU operation that function differently in a redundancy system. For general details of CPU operation, refer to the *PACSystems CPU Reference Manual,* GFK-2222.

- Powerup of a Redundancy CPU
- Synchronizing Redundant CPUs
- %S References for CPU Redundancy
- Scan Synchronization
- Fail Wait Time
- Data Transfer
- Switching Control to the Backup Unit
- STOP to RUN Mode Transition
- RUN with Outputs Disabled Mode
- RUN to STOP Mode Transition
- Error Checking and Correction
- Timer and PID Functions
- Timed Contacts
- Multiple I/O Scan Sets
- Genius Bus Controller Switching
- Redundant IP Addresses
- Ethernet Global Data in an HSB Redundancy System

Powerup of a Redundancy CPU

When a redundant CPU is powered up, it performs a complete hardware diagnostic check and a complete check of the application program and configuration parameters. This causes the powerup time of a redundancy CPU to be longer than a non-redundancy CPU. If the primary and secondary units power up together, the primary becomes the active unit and the secondary unit becomes the backup unit.

When the secondary unit powers up, if it does not detect the primary unit, the secondary unit waits up to 30 seconds for the primary unit to power up. If the primary unit has not completed its powerup sequence within 30 seconds, the secondary unit assumes the primary unit is not present. In this case, if the secondary unit is configured to transition to Run on powerup, it becomes an active unit without a backup unit.

If the primary unit completes its powerup sequence before the secondary unit, the primary unit waits a few seconds for the secondary unit to complete its powerup sequence. If the primary unit is set up to transition to Run on powerup and does not detect the secondary unit within this time, it becomes an active unit without a backup.

Note: If the system should be fully redundant upon powerup, the secondary unit must complete power-up first but no more than 30 seconds before the primary unit. To be sure that this happens, apply power to the secondary unit first.

If either unit is powered up after the other unit is already in Run mode, communications between the two units are established. If the unit being powered up goes to Run mode, a resynchronization occurs.

Synchronizing the Time of Day Clocks

At the point when the two units establish communications through the redundancy link(s), the primary unit’s time of day clock is copied to the secondary unit.

Validity of PROFINET I/O at Powerup

When a PACSystems controller returns to service after a power outage, it can take several seconds for that controller's PNCs to come online and for each PNC to bring its configured IO devices online. The CPU does not prevent itself from going into RUN mode while it is in the process of bringing the PROFINET IO online. Because a PACSystems CPU can go to RUN mode before its IO devices are ready, you should be aware of the following.

Inputs and Input Point Faults

When a **redundantly-controlled** PROFINET IO device is not online with the **active** unit, the active CPU sets that device's inputs to the default values and sets the corresponding input point faults to the faulted state. At powerup, these inputs and input point faults will remain in this state until that IO device comes online and starts transferring inputs to the PNC in the active unit,

When a **simplex** PROFINET IO device is not online, the CPU for which that device is configured will set that device's inputs to the default values and set the corresponding input point faults to the faulted state. At powerup, these inputs and input point faults will remain in this state until that IO device comes online and starts transferring inputs to corresponding PNC.

Therefore, if the control application needs to know whether a set of PROFINET inputs is valid or not, it must refer to the input point faults.

Output Point Faults

Whenever a **simplex** PROFINET IO device is not online, the CPU for which that device is configured for will set the output point faults for that device to the faulted state.

However, the Hot Standby CPUs do not support use of the output points faults associated with **redundantly-controlled** PROFINET IO devices. Thus, the application should ***not*** use the point faults that correspond to redundantly-controlled PROFINET outputs.

Additional information on operation at a STOP-RUN transition can be found in the "STOP to RUN Mode Transition" section of this manual.

Synchronizing Redundant CPUs

When synchronization is initiated, the CPUs exchange information about their configurations. If a transitioning CPU detects that the configurations are not in agreement, that CPU will not transition to RUN mode; if both CPUs are transitioning at the same time, neither CPU transitions to RUN mode.

The following items must be in agreement in order to synchronize:

1. Both CPUs must be configured for the same redundancy control strategy.
2. Both CPUs must have identical transfer lists.
3. If %I, %Q, %AI, or %AQ references are included in the transfer list, the Point Fault References configuration parameter must be identical on both units.

During synchronization, the active unit sends a synchronization request to the backup unit and waits for a response from the backup unit. If the active unit does not receive a response from the backup unit within its configured Fail Wait time, it operates as a non-synchronized active unit (NSAU).

During synchronization, the backup unit waits for a synchronization request from the active unit. If the backup unit does not receive the request within its configured Fail Wait time, it transitions to NSAU operation. If the backup unit receives a synchronization request within the Fail Wait time, it waits to receive the synchronization data. If it receives the data within 60ms, synchronization completes. If it does not receive the data, the backup unit operates as a NSAU.

Dual Synchronization

Dual Synchronization occurs when both CPUs transition to Run at the same time. The primary unit becomes the active unit and the secondary unit becomes the backup unit. Non-retentive data is cleared, and the #FST_SCN reference and #FST_EXE bits are set to 1.

Resynchronization

Resynchronization occurs when one unit is already in Run mode and the other unit is put into Run mode. The unit already in RUN mode remains the active unit and the transitioning unit becomes the backup unit. The behavior is the same whether the unit going to RUN is the primary unit or the secondary unit.

At this point, the active unit sends the output transfer data and the input transfer data to the backup unit. In addition to the configured redundancy transfer data, the #FST_SCN %S reference as well as internal timer information and #FST_EXE for each common logic block are transferred from the active unit to the backup unit. Only the internal timers and #FST_EXE data for program blocks with the same name are transferred. Therefore, the #FST_SCN and #FST_EXE bits for common blocks are not set on the first scan of the transitioning unit.

Operation when a Redundancy Link is Removed

When one of the links in a system with dual redundancy links is lost, for example when the fiber optic cable is removed from one RMX module, and the CPUs remain synchronized with one link, the redundancy status LEDs (Local Ready, Local Active, Remote Ready, Remote Active) on the RMX modules associated with the failed link will continue to be updated.

%S References for CPU Redundancy

%S33 through %S39 and %SB18 reflect the status of the redundancy units. The table below describes these %S references, and shows their expected states, assuming the primary unit is active and the secondary unit is backup.

%S Bit	Definition	Name	Description	Expected State	
				Primary Unit	Secondary Unit
%S33	Primary Unit	#PRI_UNT	Set to 1 if the local unit is configured as the primary unit: otherwise it is cleared. For any given local unit, if PRI_UNT is set, SEC_UNT cannot be set.	ON	OFF
%S34	Secondary Unit	#SEC_UNT	Set to 1 if the local unit is configured as the secondary unit: otherwise it is cleared. For any given local unit, if SEC_UNT is set, PRI_UNT cannot be set.	OFF	ON
%S35	Local Unit Ready	#LOC_RDY	Set to 1 if local unit is in Run mode with outputs enabled. Other wise set to 0.	ON	ON
%S36	Local Unit Active	#LOC_ACT	Set to 1if local unit is currently the active unit; otherwise it is cleared. For any given local unit, if LOC_ACT is set, REM_ACT cannot be set.	ON	OFF
%S37	Remote Unit Ready	#REM_RDY	Set to 1 if remote unit is in Run mode with outputs enabled. Otherwise set to 0.	ON	ON
%S38	Remote Unit Active	#REM_ACT	Set to 1 if remote unit is currently the active unit; otherwise it is cleared. For any given local unit, if REM_ACT is set, LOC_ACT cannot be set.	OFF	ON
%S39	Logic Equal	#LOGICEQ	Set to 1 if the application logic for both units in the redundant system is the same. Otherwise set to 0.	ON	ON
%SB18	Redundancy Informational Message Logged	#RDN_MSG	Set if a redundancy informational message was logged. It can be cleared in reference tables, logic, or by clearing the fault tables.		

%S references can be read from the application program, but cannot be altered or overridden. These references are always OFF when no configuration has been stored. Anytime a configuration is stored, the states of these %S references are updated in both STOP and RUN modes.

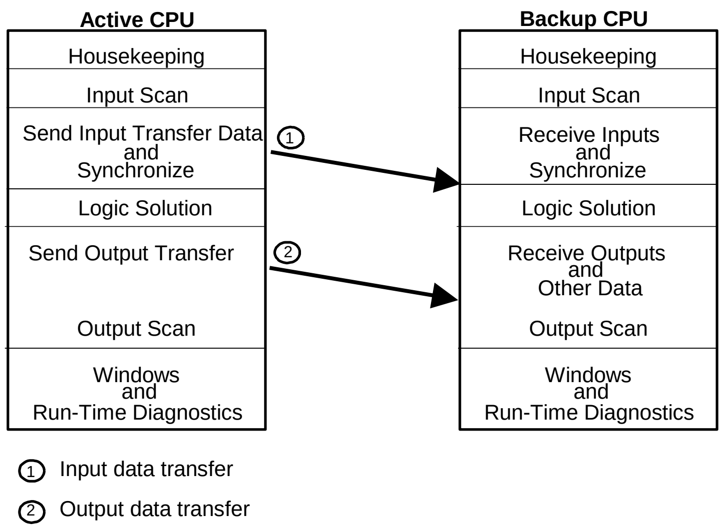
The four redundancy status LEDs on the RMX Module correspond to the %S35, %S36, %S37, and %S38 references. The programming software summarizes the state of the redundancy system on the Redundancy tab of the Show Status dialog box, accessed from Online commands. Additionally, external indicators can be used to monitor the state of any status reference.

If the two CPUs are in Run mode but lose synchronization (due to Fail Wait time set too short or failure of both redundancy links), both units generally log faults and proceed as NSAUs. In this case both units attempt to control the process independently; both units set their #LOC_ACT status to 1, and clear the #REM_RDY, #REM_ACT, and #LOGICEQ status flags. However, for systems that contain redundantly controlled PROFINET I/O, when both units become non-synchronized active units, the unit that was the synchronized active unit will go to STOP mode instead.

Note: The #OVR_PRE reference, %S00011, ***is not*** supported by the Redundancy CPU and should not be used.

Scan Synchronization

The figure below shows the sweep components for the active and the backup CPUs.



There are two synchronization points in the sweep. The input transfer point occurs immediately after the inputs are scanned. At this point in the sweep, the newly read inputs are sent from the active unit to the backup unit. At the output transfer point, the rest of the data (outputs, internal references, registers) is sent from the active unit to the backup unit. These data transfers are automatic; they require no application program logic, but **do** require proper configuration.

Data can be transferred on either redundancy link. If one link fails, the transfer switches to the other link without causing a loss of synchronization.

Synchronization of PROFINET I/O

In a Hot Standby CPU Redundancy system, a redundantly controlled PROFINET IO device exchanges its inputs and outputs with only one of the two controllers that it is connected to. This transfer occurs with the active unit. The backup unit does not receive inputs directly from, or send outputs directly to, the IO Device because the backup unit has a backup connection with that IO-Device.

Because of this, the programmer requires that all redundantly controlled inputs be included in the Input Transfer list and all redundantly controlled outputs be included in the Output Transfer list.

The active CPU collects the values of the redundantly controlled inputs during its Input Scan. Whenever the two Hot Standby CPUs are synchronized, the active unit sends a copy of those inputs to the backup unit during the input data transfer. Then both CPUs execute the logic solution with the same input values. When the logic solution is complete, the active unit sends a copy of the redundantly controlled PROFINET outputs to the backup unit during the output data transfer. Then both CPUs provide those outputs to their PNCs during the output scan.

Fail Wait Time

The active and backup CPUs synchronize their execution twice each sweep: once before logic execution and once afterwards. Certain failures of one CPU, such as an infinite loop in the logic, are detected by the other CPU as a failure to reach the next synchronization point on time. The maximum time to wait for the other CPU is known as the *Fail Wait* time. The duration of this time must be specified during configuration of both the Primary and Secondary Units and can range from 40 ms to 400 ms (in increments of 10 ms), with the default being 60 ms.

The configured Fail Wait time for the system must be based on the maximum expected or allowable difference in the two CPUs reaching a synchronization point. For example, if one CPU might spend 20ms in the communications phase of the sweep and the other unit might spend 95ms in communications in the same sweep, the Fail Wait time must be set to at least 80ms (80 > 95 -20) to prevent loss of synchronization. In addition, Fail Wait Time must be greater than the sum of the Controller Communications Window, Backplane Communications Window and Background Window timer settings.

Differences in the logic execution time and other phases must also be considered when selecting a Fail Wait time. Some applications limit the possible difference during the communications window by using Constant Sweep mode or Constant Window mode, or by setting the system communications window to Limited and selecting a small window time.

If the Communications Window mode is set to Complete (run to completion), the controllers could lose synchronization, particularly during RMS using a rack-based Ethernet module.

Data Transfer

The data is transferred in blocks. Each block is checked for data integrity. The backup CPU holds the transferred data in a temporary area until all the data has been received and verified. Then the backup CPU copies the data into the actual controller memories. If the full transfer fails to complete properly, the backup unit becomes an NSAU and discards the data in the temporary area.

Synchronization and Data Transfer Process

Input Data and Synchronization Data Transfer to the Backup Unit

Immediately after the input scan, the active unit sends the selected input data to the backup unit. This includes the selected ranges within %I, %Q, %AI, %AQ, %R, %M, %G and %W memories, as well as transferred variables. For discrete data, the status, override, and legacy-style transition information is transferred. If point faults are configured, point fault data is also sent.

Sweep Time Synchronization

During the first transfer, the active unit automatically sends a synchronizing message to the backup unit. This message contains the Start of Sweep Time. The CPUs stay synchronized because the active unit waits for the backup CPU to respond to the synchronizing message before starting its logic execution.

The Start of Sweep Time message transfer repeatedly coordinates the elapsed time clocks (upon which timers are based) in the redundant CPUs. The system time is continuous as long as one of the two systems is running. When a switchover occurs, the same time continues to be kept in the new active unit.

Transition Contacts and Coils

PACSystems supports two types of Transition contacts and coils:

- Legacy Transition contacts and coils: POSCON, NEGCON, POSCOIL, and NEGCOIL
- IEC Transition contacts and coils: PTCON, NTCON, PTCOIL, and NTCOIL

For additional information on both types of Transition contacts and coils, refer to the *PACSystems CPU Reference Manual,* GFK-2222. (See “Transition Contacts” and “Transition Coils”.)

For any redundant transfer data item placed in a transfer list that is located in a discrete reference table or in the symbolic discrete reference region, the associated Override and legacy-style Transition data is transferred as part of that list. However, the IEC-style transition data is ***not*** synchronized. For this reason, IEC transitionals should not be used in redundancy if the application requires that this data be synchronized. IEC transitionals must be used with symbolic data; no legacy-style transition data exists for symbolic data.

Output Data Transfer to the Backup Unit

After the input data transfer, both units operate independently until the end of the program logic solution. Before the output scan starts, a second automatic data transfer occurs. At this time, the active unit transfers the output transfer data to the backup unit. This includes the selected ranges within %I, %Q, %AI, %AQ, %R, %M, %G and %W memories, as well as transferred variables. For discrete data, the status, override, and legacy transition information is transferred. If point faults are configured, point fault data is also sent.

After the output data transfer, the active and the backup units independently perform their output scans and run their communications and background windows. They continue to operate independently until they synchronize again after the next input scan.

Estimating Data Transfer Time

When a system is synchronized, there are additions to the sweep time (compared to a similar non-redundancy CPU model) for transferring data from one unit to the other. The data transfer time includes the time for the active unit to read the data from the appropriate reference memory type as specified in the configured redundancy transfer list, move it from the CPU memory across the backplane, with appropriate data integrity information, into the RMX on-board memory. The data is then transferred from the RMX module in the active unit to the backup unit's RMX module via a high-speed fiber optic link. On the backup unit, the data is moved from the RMX on-board memory over the backplane into the CPU memory. A data integrity check is performed, and assuming the integrity checks pass, the transfer data is written to the appropriate reference memory in the backup unit.

These additions to the sweep time can be estimated using the data and equations given in this section.

1. **Calculate the total number of bytes configured as memory ranges in the CPU configuration's Transfer List.**

Reference Type	***Reference Size***	***If Point Faults are* Disabled*:***	***If Point Faults are* Enabled*:***
%I	Bit	(%I length x 3) ÷ 8	(%I length x 4) ÷ 8
%AI	Word	(%AI length x 2)	(%AI length x 3)
%Q	Bit	(%Q length x 3) ÷ 8	(%Q length x 4) ÷ 8
%M	Bit	(%M length x 3) ÷ 8	
%G	Bit	(%G length x 3) ÷ 8	
%AQ	Word	(%AQ length x 2)	(%AQ length x 3)
%R	Word	(%R length x 2)	
%W	Word	(%W length x 2)	

2. **Use the following formulas to estimate the data transfer time for memory ranges.**

RX3i Formulas

Data transfers less than 56K bytes:	Estimated transfer time for memory ranges (ms)	=	0.00005705959 x Total Transfer Data Size + 0.212556909
Data transfers greater than 56K bytes:	Estimated transfer time for memory ranges (ms)	=	0.00004790867 x Total Transfer Data Size + 0.341614952

RX7i Formulas

Data transfers less than 28K bytes:	Estimated transfer time for memory ranges (ms)	=	(0.00018355 x Total Bytes Transferred) + 0.184
Data transfers greater than 28K bytes:	Estimated transfer time for memory ranges (ms)	=	(0.00013738 x Total Bytes Transferred) + 1.954

Analysis of the linear curve resulting from the measurement of various data points yielded a break point around 28K, resulting in the two linear equations stated above. Using the proper equation for the amount of transfer data will yield a minimum amount of error when doing the calculation. The actual data transfer time can vary slightly from the estimated time; most systems will see slightly better performance than the estimated value. In addition, the estimated data transfer time is based on a redundant system with two redundancy links in a steady state non-error condition without CPU serial communications activity, Genius bus faults or other high backplane interrupt activity.

3. **Calculate the total number of bytes and number of symbolic variables in the transfer list.**

This information is obtained from the variable transfer list report. For details, see "Using the Variable Transfer List Report" in chapter 5.

Size of transfer list	=	Total Variable Bytes Transferred (in Input List) + Total Variable Bytes Transferred (in Output List)
Number of entries	=	Entries Containing Only Whole Bytes (in Input List) + Entries Containing Partial Bytes (in Input List) + Entries Containing Only Whole Bytes (in Output List) + Entries Containing Partial Bytes (in Output List)

4. **Use one of the following formulas to estimate the total transfer time for symbolic variables.**

CRU320	Transfer time for variables[1]	=	0.00003923 x (size of transfer list) + 0.000177916 x (number of entries) – 0.61871745
CRE020	Transfer time for variables	=	0.000130992 x (size of transfer list) + 0.000376524 x (number of entries) + 2.1
CRE030	Transfer time for variables	=	0.000111019 x (size of transfer list) + 0.000249549 x (number of entries) + 1.9
CRE040	Transfer time for variable	=	0.0000940902 x (size of transfer list) + 0.0000783293 x (number of entries) + 1.4

[1] For a negative result, use a value of 0.

Add the following quantities:

RX3i Formula

	Synchronization base sweep addition – additional amount of time required to synchronize the CPUs with 0 Data Transfer (ms)	3.238 ms
+	Total transfer time for memory ranges (step 2)	_____ ms
+	Total transfer time for transferred symbolic variables (step 4)	_____ ms
=	Total estimated transfer time:	_____ ms

RX7i Formula

	Synchronization base sweep addition – additional amount of time required to synchronize the CPUs with 0 Data Transfer (ms)	3.234 ms
+	Total transfer time for memory ranges (step 2)	_____ ms
+	Total transfer time for transferred symbolic variables (step 4)	_____ ms
=	Total estimated transfer time:	_____ ms

Tips for Reducing Transfer Time

Transferred BOOL variables and non-byte aligned BOOL arrays will increase transfer time. For these, you can create an array of BOOLs and transfer the entire array for efficiency. You can alias individual array elements to make logic more readable.

Data structures that contain non-contiguous members of different data types can be created. You can also create arrays of these structures. This feature allows you to put individual members of a data structure or the entire structure on one or both of the transfer lists. Placing arrays of structures in the transfer list has the potential to significantly increase the number of entries in the transfer list, which will impact user space charged and transfer time.

Programming a Data Transfer from Backup Unit to Active Unit (SVC_REQs 27 and 28)

The program logic can be used to transfer eight bytes (four registers) of data from the backup unit to the active unit before the next logic solution.

To initiate this transfer, the backup unit executes SVC_REQ 27 (Write to Reverse Transfer Area). This command copies eight bytes of data from the reference in the backup unit specified by the PARM parameter. Note that SVC_REQ 27 only works when its CPU is the backup unit. When its CPU is the active unit, SVC_REQ 27 has no effect.

The active unit stores the transferred data in a temporary buffer. The program in the active unit must execute SVC_REQ 28 (Read from Reverse Transfer Area), which copies the eight bytes of data from the temporary buffer to the reference specified by the PARM parameter. SVC_REQ 28 only works in the active unit. It has no effect when its CPU is the backup unit.

There is always a one-sweep delay between sending data from the backup unit using SVC_REQ 27 and reading the data at the active unit using SVC_REQ 28.

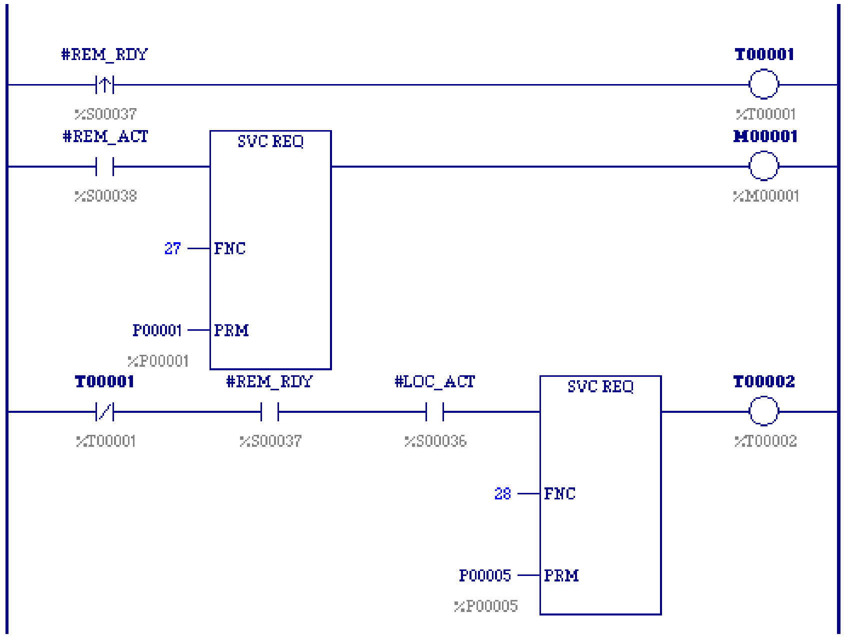
This data copied from the buffer is not valid in the following cases:

- During the first scan after either unit has transitioned to RUN;
- While the backup unit is in STOP mode;
- If the backup unit does not issue SVC_REQ 27.

The data should not be used if #REM_RDY is off or if #REM_RDY is transitioning to on.

Reverse Data Transfer Example

The following rungs would be placed in the program logic of both units. In this example, the backup unit would send %P0001 through %P0004 to the active unit. The active unit would read the data into %P0005 through %P0008. %P0001 through %P0004 on the active unit and %P0005 through %P0008 on the backup unit would not change. %T0002 would be set to indicate that the operation was successful and that the data could be used.



Disabling Data Transfer Copy in Backup Unit (SVC_REQ 43)

To instruct the backup unit to bypass the copy of the transfer data from the active unit, use SVC_REQ 43. This operation can be used to determine if the active and backup units are arriving at the same results.

This function is valid only when issued in the backup CPU. It is ignored if issued when the units are not synchronized, or if it is issued in the active unit.

SVC_REQ 43 disables the copy of data for one sweep, beginning with the output data transfer and ending with the input data transfer of the next sweep. The copy can be disabled for multiple sweeps by invoking SVC_REQ 43 once each sweep for the appropriate number of sweeps.

The resynchronization data transfer always occurs, even if SVC_REQ 43 is invoked in the first sweep after synchronization (this data transfer includes all inputs, outputs, and internal data that must be exchanged) since the resynchronization data transfer occurs before the start of logic execution.

This service request can be set up to disable the copies for all transfers or just the output transfers. If just the output copy is disabled, the two units can still use the same set of inputs on each unit. This makes it possible to test the ability of the two units to derive the same results from the same inputs.

In all cases, the data is still transferred over the redundancy link every sweep and the synchronization points are still met. The effect of SVC_REQ 43 is to disable the copy of the data from the transfer to the actual reference memories on the backup unit.

Warning

When SVC_REQ 43 is in effect, the backup unit still takes control of the system in event of a failure or role switch. Switches to the backup unit can cause a momentary interruption of data on the outputs because the two units might not be generating the exact same results.

While SVC_REQ 43 is in effect, you should consider disabling outputs on the backup unit. Disabling outputs on the backup unit eliminates the risk of an unsynchronized switch of control (which can cause a momentary interruption of data in the outputs) if the active unit fails or loses power while the input/output copies are disabled. If the active unit fails or loses power while outputs are disabled on the backup unit, the system's outputs will go to their default settings. A secondary effect of disabling outputs on the backup unit is that the non-synchronized fault action table is used by the active unit to determine which faults are fatal.

Note: If the CPU is already in RUN/ENABLED mode, a command to disable its outputs will not take effect until one sweep after the command is received. Therefore, disable the outputs at least one sweep before you enable SVC_REQ 43.

SVC_REQ 43 cannot be used to disable output data transfer on the primary unit when outputs are enabled on the primary unit. If that is attempted, the SVC_REQ 43 is rejected.

The first time SVC_REQ 43 is used, a fault is logged as a warning that the controllers are not completely synchronized.

The reverse data transfer, if any, is unaffected by SVC_REQ 43.

Enabling logic should be used with SVC_REQ 43. A contact with a non-transferred reference should be part of this enabling logic. That will allow the service request to be turned on/off directly without being overwritten by the value from the active unit.

If the service request is invoked multiple times in a single sweep, the last call is the one that determines the action taken.

Successful execution occurs unless:

- The values in the command block are out of range.
- The service request is invoked when the two units in a redundant system are not synchronized.
- The service request is issued on the active unit.
- The service request is issued on the primary unit while the primary unit's outputs are enabled.

If the service request is unsuccessful, it will not pass power flow to the right.

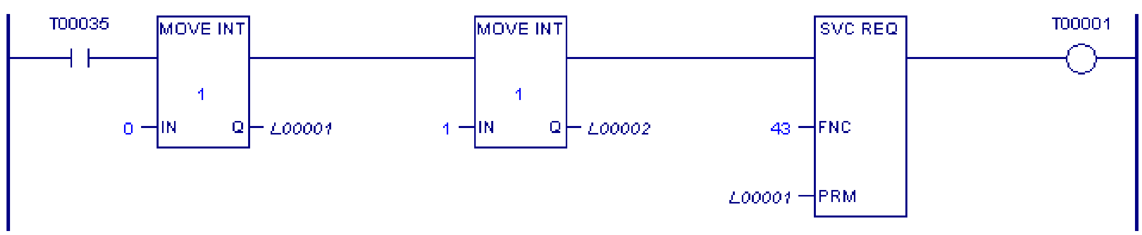
Command Block for SVC_REQ #43

The command block for SVC_REQ #43 has two words:

Address	0
Address +1	1 = Disable input and output copies 2 = Disable output copy only

Example

In the following example, when %T00035 is on, the input and output copies are disabled.



Validating the Backup Unit (SVC_REQ 43)

SVC_REQ 43 can be used to determine if the backup unit is collecting inputs properly (that is, validate the input scan). It can also be used to determine whether the backup unit is calculating outputs and internal variables properly (that is, validate the logic solution).

Validating the Backup Unit's Input Scan

To determine whether the backup controller is collecting inputs properly, follow these steps:

1. Activate SVC_REQ 43 on the backup CPU, passing the values 0 and 1 to disable the input and output data transfer copies.
2. Monitor the backup unit's input references and input variables. The values presented correspond to the inputs that the backup is currently collecting.
3. Visually compare the backup unit's input references and input variables with those presented by the active unit. Pay special attention to the references and variables that are included in the input transfer.
4. When you are satisfied that the backup unit is collecting inputs properly, disable the rung that calls SVC_REQ 43.

Validating the Backup Unit's Logic Solution

To determine whether the backup unit is calculating outputs and internal variables properly, follow these steps:

1. Activate SVC_REQ 43 on the backup CPU, passing the values 0 and 2 to disable the output data transfer copy.
2. Monitor the backup unit's output references, output variables, and internal variables. The values presented correspond to the values that the backup is currently calculating.
3. Visually compare the backup unit's output references, output variables, and internal variables with those presented by the active unit. Pay special attention to the references and variables that are included in the output transfer.
4. When you are satisfied that the backup unit is calculating outputs and internal variables properly, disable the rung that calls SVC_REQ 43.

Switching Control to the Backup Unit

Control switches from the active unit to the backup unit if:

1. The active unit detects a fatal fault.
2. The active unit is placed in Stop mode.
3. The active unit fails or is powered off.
4. The toggle switch on an RMX module is activated.[2]
5. A switch is commanded from the application program.[2]

PROFINET IO Switchovers

For PROFINET IO, whenever control switches from the active unit to the backup unit, the new active unit tells each redundantly controlled IO device to make its connection active and start transferring inputs and outputs over that connection. When this happens, the other unit's connection to the IO device becomes a backup connection. During this process, the redundantly controlled inputs and outputs might hold last state for a short period of time.

The time that redundantly controlled PROFINET inputs and outputs hold their last state during an IO switchover typically will not exceed

$$(4 \times \text{IO cycle time}) + (2 \times \text{CPU sweep time}) + \text{MSOT},$$

where *MSOT* is the MaxSwitchOverTime of the IO device that contains these inputs and outputs. (The MaxSwitchOverTime value is specified in the IO device's GSD file. For example, the MaxSwitchOverTime of the VersaMax PNS is 15 milliseconds.)

Switching Times and Impact to Sweep Time

The amount of time needed to switch control from the active unit to the backup unit depends on the reason for the switch.

There are two ways that the backup unit detects that the active unit has failed or lost power.

A. Failure of all remaining redundancy links. This type of failure has negligible impact on the controller sweep time.

B. Failure of the active unit to rendezvous at a synchronization point within the Fail Wait time. An example of this type of failure is the CPU not responding because the user logic is in an endless loop. If the redundancy links are still operational, the increase to the sweep time will equal the Fail Wait Time.

For these two cases the switchover occurs immediately.

For all other cases, the switchover occurs just before the next input data transfer. The maximum delay is 1 sweep. There may be an input and an output scan between detection of the fatal fault and the switch.

[2] These two types of requests are not honored if they occur within 10 seconds of the previous request.

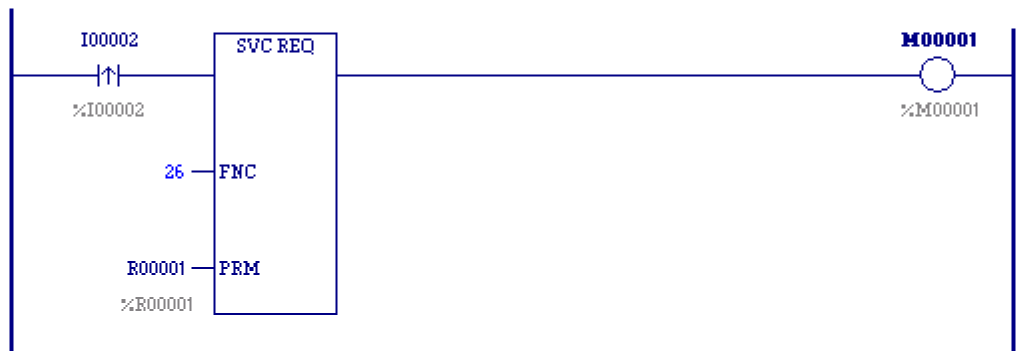
Commanding a Role Switch from the Application Program (SVC_REQ 26)

The application program can use SVC_REQ 26 to command a role switch between the redundant CPUs (active to backup *and* backup to active). As long as the units remain synchronized, the switch occurs just before the input data transfer of the next sweep.

When SVC_REQ 26 receives power flow to its enable input, the controller is requested to perform a role switch. Power flow from SVC_REQ 26 indicates that a role switch will be attempted on the next sweep. Power flow *does not* indicate that a role switch has occurred or that a role switch will definitely occur on the next sweep. The role switch request is not valid if it occurs within 10 seconds of a previous request. The 10-second limitation guarantees that only a single switch occurs if both units make a request at approximately the same time. SVC_REQ 26 ignores the PARM parameter; however the programming software requires that an entry be made for PARM. You can enter any appropriate reference here; it will not be used.

Example

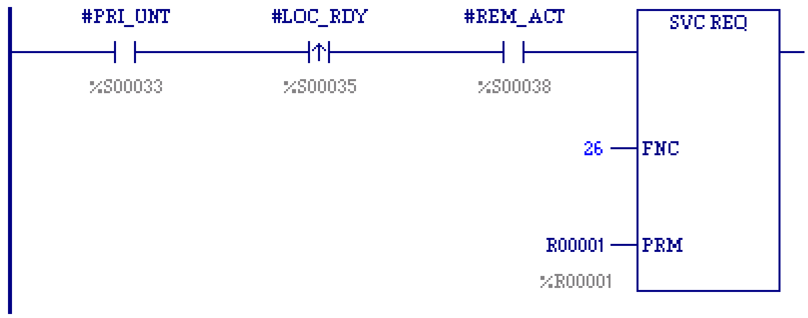
In this example, a pushbutton switch on a control console is wired to input %I0002. In the program logic, the reference for %I0002 is used as the input to the SVC_REQ 26 function block. When the button is pressed, logic power flows to SVC_REQ 26, causing a role switch to be requested. The PRM reference is not used and can have any value.



Implementing Preferred Master Using SVC_REQ 26

The PACSystems Hot Standby CPUs implement a floating master algorithm. This means that when one unit is put into Run mode while the other unit is already in Run mode, the transitioning unit always becomes the backup unit.

If an application requires a preferred master algorithm where the primary unit always becomes the active unit when placed in Run mode, the logic can use the Role Switch service request, SVC_REQ 26, as shown in the sample LD rung below. This logic must be included in the primary unit and may also be included in the secondary unit.



STOP to RUN Mode Transition

A resynchronization will occur at all *STOP* to *RUN* mode transitions. The time to perform this resynchronization may be larger than STOP to RUN transitions on non-redundancy CPUs. The STOP to RUN mode transition has two separate paths.

1. If the unit performing the transition is doing so alone or both units are transitioning to Run at the same time, a normal STOP to RUN mode transition is performed (clear non-retentive memory and initialize #FST_SCN and #FST_EXE).
2. If the other unit is active when this unit performs a STOP to RUN mode transition, non-retentive references will be cleared followed by a resynchronization with the active unit.

Behavior with PROFINET I/O when no healthy Redundancy Links are available

When no healthy redundancy links are available, a CPU will allow itself to be put into RUN mode only if it has a connection to at least one redundant PROFINET IO-Device[3] ***and*** none of the devices to which it is connected report that the other PNC is controlling its I/O.

If any device indicates that the other PNC is controlling its I/O, the local CPU logs a *No Redundancy Links and Secondary Unit has control; Run mode not allowed* or *No Redundancy Links and Primary Unit has control; Run mode not allowed* fault and the local CPU selects or remains in STOP mode.

If the local CPU is not connected to any redundant devices, the CPU logs a *No Redundancy Links and No redundant PROFINET Devices Connected; Run mode not allowed* fault and the local CPU selects or remains in STOP mode.

Validity of PROFINET I/O Immediately after a Configuration Download

When you download a hardware configuration to a PACSystems controller, it can take several seconds for that controller's PNCs to come online and for each PNC to bring its configured IO devices online. The CPU does not prevent you from putting it into RUN mode while it is in the process of bringing the PROFINET IO online. Because one can command a PACSystems CPU into RUN mode before all of its IO devices are ready, you should be aware of the following.

Inputs and Input Point Faults

When a **redundantly-controlled** PROFINET IO device is not online with the **active** unit, the active CPU sets that device's inputs to the default values and sets the corresponding input point faults to the faulted state. On a STOP to RUN transition, these inputs and input point faults will remain in this state until that IO device comes online and starts transferring inputs to the PNC in the active unit,

When a **simplex** PROFINET IO device is not online, the CPU for which that device is configured will set that device's inputs to the default values and set the corresponding input

[3] A special case exists when a standalone Primary CPU is setup to go to RUN mode at powerup. The Primary CPU waits only 3 seconds before attempting to go to RUN, which is not enough time to establish connections to its PROFINET devices. This means that a standalone Primary CPU always powers up into STOP mode. After the PROFINET connections have been established, the standalone Primary CPU can be manually switched to RUN mode.
A standalone Secondary CPU, however, waits 30 seconds before attempting to go to RUN, which is sufficient time to establish its PROFINET device connections. This means that a standalone Secondary CPU can power-up into RUN mode.

point faults to the faulted state. On a STOP to RUN transition, these inputs and input point faults will remain in this state until that IO device comes online and starts transferring inputs to corresponding PNC.

Therefore, if the control application needs to know whether a set of PROFINET inputs is valid, it must refer to the input point faults.

Output Point Faults

When *a* ***simplex*** PROFINET IO device is not online, the CPU for which that device is configured for will set the output point faults for that device to the faulted state.

However, the Hot Standby CPUs do not support use of the output points faults associated with ***redundantly-controlled*** PROFINET IO-Devices. Thus, the application should not use the point faults that correspond to redundantly-controlled PROFINET outputs.

RUN with Outputs Disabled Mode

RUN with Outputs Disabled mode causes all physical outputs to go to their default state in that controller. Inputs are still scanned and logic is solved. A CPU in RUN with Outputs Disabled mode *may be* the active unit.

The following guidelines apply to using RUN/DISABLED mode with PACSystems Hot Standby CPUs.

1. If a unit is in RUN/DISABLED mode, its #LOC_RDY %S reference and the other unit's REM_RDY %S reference are not set and the corresponding LEDs on the RMX modules are OFF. This indicates that the unit (with #LOC_RDY reference off) is not available to drive outputs.
2. If a unit is in RUN/ENABLED mode and the other unit is in RUN/DISABLED mode, the unit in RUN/ENABLED mode does not use its synchronized fault action table. Instead, it uses the user-configurable fault actions since there is no backup available to drive outputs.
3. Redundantly controlled PROFINET devices only enable their outputs if the **active** unit has its outputs enabled. This means that whenever the **active** unit is in RUN/DISABLED mode, the redundantly controlled PROFINET outputs are commanded to their default states.
4. Redundantly controlled Genius devices and ENIUs will enable their outputs if either unit (active or backup) has its outputs enabled. As long as these outputs are included in the output transfer list, their values will be copied from the active unit to the backup unit during the Output Data transfer. This means that the output devices will be commanded to the output values that were calculated by the active unit. (There is one exception to this. It is described by item #5.)

   Note: When a Genius output is connected to both Redundancy CPUs, that output should always be included in the output transfer list.
5. If the *Outputs from Active Unit Only* configuration parameter is enabled in an ENIU, placing the active controller in RUN/DISABLED mode will result in that ENIU's outputs being held in their last state.

Note: If the backup unit is in RUN/DISABLED mode, the backup unit continues NOT to drive outputs upon failure of the active unit and *therefore is not a complete backup.*

RUN to STOP Mode Transition

The behavior of a Hot Standby CPU Redundancy system when one of the two units stops is dependent upon whether the two units were previously synchronized. If the units were synchronized, the behavior also depends upon whether the stopped unit was previously the active unit.

- When the backup unit from a pair of synchronized controllers goes to STOP mode, the active unit will continue to control the Redundant I/O.
- When the active unit from a pair of synchronized controllers goes to STOP mode, the backup unit will become active and take control of the Redundant I/O. Additional information on the switchover process can be found in the "Switching Control to the Backup Unit" section of this manual.

Since most RUN to STOP transitions in a Hot Standby system occur as the result of a fault condition, refer to the "Faults" chapter of this manual for additional information.

Behavior with PROFINET I/O when no healthy Redundancy Links are available

When a CPU that does not have any healthy redundancy links (for example, a standalone CPU) goes from RUN to STOP, each of its PNCs will log a Loss of Device fault for each redundant device that is present and configured. It will take approximately 5 seconds for those PNCs to re-connect to at least one of those devices (and log an Add'n of Device fault for it). During this period of time, the CPU will not allow itself to be put back into RUN mode. If a second CPU (without healthy redundancy links) is also present, it will exhibit the same behavior.

Once a CPU that does not have any healthy redundancy links goes from RUN to STOP, that CPU will not see any faults from the redundant controlled IO-Devices. Faults from the devices will be ignored until either a) the CPU returns to RUN mode OR b) the redundancy links are recovered. If a second CPU (without healthy redundancy links) is present, it will exhibit the same behavior.

Error Checking and Correction

Error checking and correction (ECC) allows the CPU firmware to detect errors in memory and correct some of them on the fly. This added layer of checking differs from parity checking in that it can correct a single-bit error. If the ECC error is a single-bit corrected error, the CPU generates a diagnostic fault and sets %SA0006 so that you can know of a possible impending problem and take corrective action. If the ECC error is a multi-bit error, which cannot be corrected, the CPU logs a fatal fault and goes to Stop-Halt mode.

The Error Checking and Correction function of the memory controller is enabled on the redundancy CPU regardless of the Background Window Timer setting. This provides parity-like checking on the contents of every RAM location: the ECC bits are set on every non-cached memory write and checked on every non-cached memory read. If you are comfortable with the level of integrity checking that the ECC function provides, you may chose to disable the additional background RAM tests entirely by setting the Background Window Timer value to 0.

Timer and PID Functions

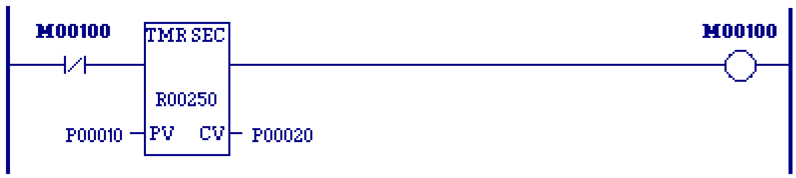
Timer and PID function blocks remain in lock step between two synchronized units provided:

A. Enabling logic for each function is identical on both units. This includes power flow, how often the block is called, and so forth.

B. The block in which the function occurs has the same name in both units. Note that _MAIN is always common.

C. Reference registers (3 for timers, 40 for PID), enabling references, and reset references for each timer and PID function block are included in the data transfer lists.

   For example, if the following ladder logic appears in the _MAIN block on both units, %M100, %R250, %R251, and %R252 must all be included in the output data transfer list to keep this timer synchronized between the two units:



Timed Contacts

When both systems are synchronized, timed contacts (%S3, %S4, %S5, %S6) have exactly the same value in both units. For example, whenever T_SEC is on in one unit, it also is on in the other unit as long as both units are synchronized.

Multiple I/O Scan Sets

The Redundancy CPU supports the configuration of multiple scan sets. However, it is strongly recommended that the redundant I/O be configured in the default scan set (Scan Set 1), which is scanned every sweep. The I/O scan set feature allows the scanning of I/O points to be more closely scheduled with its use in user logic programs.

If an I/O Scan set is not scanned every sweep, it is not guaranteed to be scanned in the same sweep in the Primary and Secondary CPUs. For example, if the Primary and Secondary CPUs each have a scan set that is scanned every other sweep (that is, PERIOD=2), the Primary CPU might scan its scan set in one sweep and the Secondary CPU scan its scan set in the next.

Use of non-default scan sets can cause variance in the time the units get to the rendezvous points. This should be considered when determining the Fail Wait time.

Redundantly controlled PROFINET inputs and outputs must be assigned to IO scan sets that are scanned every sweep (such as Scan Set 1). This requirement is enforced during CRU configuration.

Genius Bus Controller Switching

For PACSystems Hot Standby CPUs, Genius outputs are always enabled for both units (unless explicitly disabled) so that bumpless switching is possible regardless of which unit is currently the active unit. Because of the way Genius Hot Standby operates, all redundant Genius outputs must be included in the output transfer lists.

Genius Bus Controllers stop sending outputs to Genius devices when no output data has been received from the CPU for a period equal to two times the configured watchdog timeout.

If the CPU in the primary unit becomes inoperative in an uncontrolled fashion (for example, because of a power failure), the Genius Bus Controllers detect this within twice the watchdog setting, and stop sending outputs to the Genius devices. After three Genius I/O bus scans of not receiving data from the Genius Bus Controllers at Serial Bus Address 31, the Genius devices start driving data from Serial Bus Address 30 (the secondary unit) if available.

For example, if the system has a 200ms watchdog timeout and 5ms Genius bus scan time, and the primary unit main rack loses power, the Genius Bus Controllers in expansion racks will wait 400ms and then stop updating outputs on Genius devices. After 15ms, the devices will begin driving outputs based on data from the secondary unit. Note that any Genius Bus Controllers in the main rack would stop driving outputs immediately since they would also lose power. Genius devices on these buses would begin driving data from the secondary unit within 15ms.

Note: For fastest switching, all Genius Bus Controllers in the Hot Standby CPU Redundancy system should be installed in the main rack. This causes the Genius Bus Controllers to lose power at the same time that the CPU loses power. This, in turn, allows the secondary unit to gain full control of the I/O as soon as possible.

For single bus Genius networks, if outputs are not available on Serial Bus Address 30 or 31, the devices' outputs revert to default or hold last state (as configured).

For dual bus networks, if outputs are not available on Serial Bus Address 30 or 31, the BSM will switch to the other bus. If outputs are not available on either bus, then the block's outputs revert to default or hold last state (as configured).

Redundant IP Addresses

Each unit contains at least one Ethernet interface that is assigned a direct IP address, which is used to directly access the specific controller. A third, redundant, IP address can be assigned to the pair of Ethernet interfaces in the primary and secondary controller units. All data sent to the redundant IP address (including EGD produced to the redundant IP address) is handled by the active controller. When active, the Ethernet interface always initiates communications using the redundant IP address. When the controller is in the backup state, all communications are initiated through the direct IP address.

Each Ethernet interface in the system can be set up as part of a pair that shares a redundant IP address. Each unit can also include Ethernet interfaces that are not part of a redundant IP pair.

Validation and Activation of Redundant IP Addresses

Immediately after configuration, neither Ethernet interface responds to the redundant IP address. When notified by the CPU that the unit has become active, the Ethernet interface determines whether the redundant IP address is in use on the network. If the address is not in use on the network, the Ethernet interface activates the redundant IP address and sends out an address resolution protocol (ARP) message to force all other Ethernet devices on the network to update their ARP cache. This ARP message is sent so that communications to the redundant IP address will be directed to the newly active unit. At this point the Ethernet interface responds to both the redundant IP address and its direct IP address. When commanded to begin EGD production by the CPU, the Ethernet interface in the active unit verifies that it has successfully obtained the redundant IP address. EGD production does not begin until the Ethernet interface obtains the redundant IP address.

If the redundant IP address is in use by another device on the Ethernet network, the Ethernet interface periodically attempts to verify that the address is not in use. The Ethernet interface attempts to verify the redundant IP address until it determines the redundant IP address is no longer in use on the network or until the Ethernet interface transitions to backup due to either a notification from the CPU that the unit has become the backup unit or a failure that results in the Ethernet interface transitioning to backup.

Monitoring and Deactivation of Redundant IP Address

The Ethernet interface monitors the status of the CPU. If the Ethernet interface determines that it can no longer communicate with the CPU, it deactivates the redundant IP address. The Ethernet interface also deactivates the redundant IP address when notified by CPU that the active unit has transitioned to backup.

When the Ethernet interface deactivates the redundant IP address, it transitions to the backup state. In the backup state, the Ethernet interface no longer responds to the redundant IP address, but forwards any packets received by the interface destined for the redundant IP to the Ethernet interface in the active controller. If the backup unit continues to receive packets destined for the redundant IP address, it sends additional ARP messages on behalf of the active unit and after a number of time periods, it logs an exception, which is recorded in the controller CPU fault table as a LAN System Software Fault.

Operation of Redundant IP Address if both Redundancy Links Fail

For systems that contain redundantly controlled PROFINET I/O, if both redundancy links fail, the unit that was the synchronized active unit goes to STOP mode. As a result, the previously active unit relinquishes the redundant IP address and the newly active unit is able to obtain it.

For systems that use redundantly controlled Genius or ENIU I/O, if both redundancy links fail, both units can become non-synchronized active units. In this case, both units attempt to use the redundant IP address, but only one will succeed. If one of the two units was already active and responding to the redundant IP address, it continues to do so; the unit that was backup will not be able to activate the redundant IP address.

CAUTION

When using the redundant IP feature with Genius or ENIUs, the application should take steps to ensure that the CPU that owns the redundant IP address is the same CPU that maintains control of the outputs. This becomes an issue when both CPUs are operating as NSAUs (known as *split control*), since both units attempt to control the process independently.

Running both CPUs as NSAUs is not recommended and should be corrected as soon as possible. Refer to “On-Line Repair Recommendations” in chapter 7.

Additional details on the operation of the Ethernet Interface can be found in *TCP/IP Ethernet Communications for PACSystems,* GFK-2224.

Ethernet Global Data in an HSB Redundancy System

Note that two redundant units are not guaranteed to consume a given exchange on the same controller sweep when using redundant IP. When using Produce In Backup mode, the backup unit is not guaranteed to produce data on the direct IP at exactly the same time the active unit produces data on the redundant IP for a given exchange.

Ethernet Global Data Production

By default, only the active unit produces EGD exchanges. This reduces the amount of traffic on the Ethernet network and simplifies the handling of the exchanges by the consumer. In particular, the consumer is able to consume exchanges from the redundant system in the same way it consumes exchanges from simplex (non-redundant) systems.

Individual exchanges can be configured for Produce In Backup Mode. The backup unit produces these exchanges through the Ethernet module's direct IP address.

If the controller is set to Stop-IO Disabled mode, outputs are disabled on the active unit, and neither unit produces EGD.

In an Ethernet Interface pair with Redundant IP enabled, a newly active Ethernet interface arbitrates for the redundant IP address and delays EGD production accordingly. If both redundant units become non-synchronized active units (this can occur if no redundancy links are functioning), for each redundant pair, the Ethernet Interface that owns the redundant IP address will produce exchanges through the Redundant IP address.

If Redundant IP is not enabled, the Ethernet Interfaces in both units produce exchanges through their direct IP addresses.

The Producer ID as well as all production exchanges should be identical for both units. This allows the consumer to continue consuming exchanges from the redundant system when the backup unit becomes active.

Configuring Exchanges to be Produced in Backup Mode

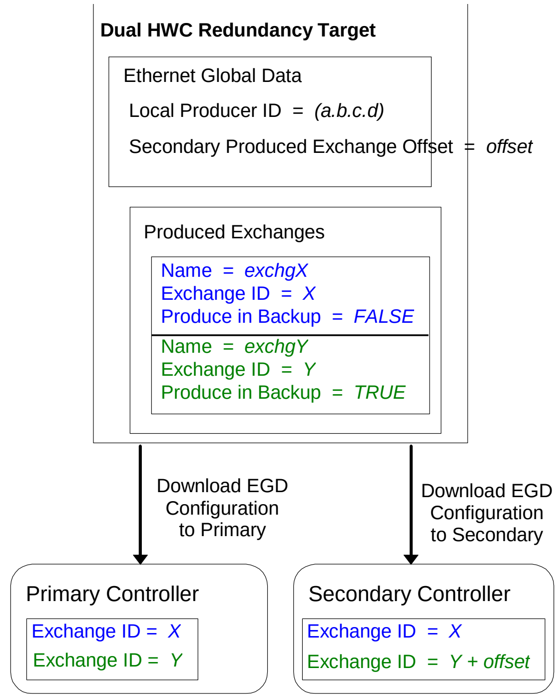
In Machine Edition, to configure a production exchange to be produced in backup mode, go to the Project view, expand the Ethernet Global Data folder, select the exchange and set its Produce in Backup Mode property to True.

To change the offset from the default value of 1000, select the Ethernet Global Data folder and set the Secondary Produced Exchange Offset property to the desired value.

For exchanges that are produced in backup mode, an offset must be added to the Exchange ID. This ensures that the Exchange ID is unique for those exchanges that are produced simultaneously by the active and backup controllers.

For an HSB system using dual HWC, one set of EGD configuration data is used to create EGD configuration files for both the primary and secondary controllers. When Machine Edition creates the EGD exchange files for download to the secondary controller, it adds the secondary offset to the Exchange ID for each exchange configured to produce in backup.

Note: For non dual HWC systems, it is the user's responsibility to ensure that the same offset value is specified in both the primary and secondary target projects.



Exchange ID Offset in Dual HWC HSB System

Ethernet Global Data Consumption

Both the active and backup units consume EGD exchanges in RUN mode, regardless of whether or not the units are synchronized.

It is recommended that all consumption exchanges be configured identically for both units. In addition, these exchanges must be configured as multicast or directed to the Redundant IP address.

The consumption of multicast exchanges occurs independently on the two units. The Ethernet modules obtain a copy of multicast exchanges at the same time, but reading of that exchange in the two CPUs may be phased by one sweep. This can result in the two units seeing different values for the same exchange in a given sweep. Only the active unit consumes exchanges directed to the Redundant IP address.

If data from the exchanges must be seen identically on the two units, the reference data for the exchanges can be transferred from the active unit to the backup unit during the input data transfer. That transfer occurs shortly after the EGD consumption portion of the CPU sweep. Exchange variables transferred must be placed into %I or %AI memory to participate in the input data transfer.

Chapter 7

Faults

This chapter describes how faults are handled in a Hot Standby CPU Redundancy system.

Fault Response

CAUTION

When using the redundant IP feature with ENIUs or Genius, the application should take steps to ensure that the CPU that owns the redundant IP address is the same CPU that maintains control of the outputs. This becomes an issue when both CPUs are operating as non-synchronized active units (NSAU), since both units attempt to control the process independently.

Running both CPUs as NSAUs is not recommended and should be fixed as soon as possible. Refer to "On-Line Repair Recommendations" on page 7-12.

The Hot Standby CPU Redundancy system detects and reports failures of all critical components so that appropriate control actions can be taken. All components that acquire or distribute I/O data or that are involved in execution of the control logic solution are considered critical components.

A ***fatal*** fault in the active unit causes a switch of control to the backup unit. A ***diagnostic*** fault allows the currently active system to continue operating as the active system.

Faults within the unit may be such that:

1. The CPU has a controlled shutdown,
2. The CPU has an uncontrolled shutdown, or
3. The CPU continues to operate.

If the CPU detects an internal fault and has a controlled shutdown, it logs a fault, goes to Stop/Fault mode, and notifies the other CPU. If the fault was detected on the active unit, the switchover does not normally occur until the next sweep. The exception is when the active unit detects a fatal fault during the input scan. In that case, the two units switch roles just before performing the input data transfer.

If the CPU has an uncontrolled shutdown, the CPU logs a fault if it can and proceeds as described above. When the backup CPU detects that the active CPU has failed (either by receiving notification, by detecting that both redundancy links have failed, or by detecting failure of the active CPU to rendezvous at the next synchronization point within the Fail Wait time) it becomes an unsynchronized active unit.

For cases where both redundancy links have failed, including the Fail Wait timeout case, refer to the “When the Last Redundancy Link Fails” section on page 7-11.

Faults for PROFINET I/O

When a redundantly-controlled PROFINET IO-Device reports a fault, that fault only appears in the unit that was active when the fault was reported. These faults do not appear in the backup unit. Examples of these faults are: Loss of I/O Module, Addition of I/O Module, Channel Diagnosis Appears (e.g. Power supply fault), and Channel Diagnosis Disappears.

However, whenever a controller loses communication with an entire PROFINET IO-Device, a Loss of Device fault will appear in that unit regardless of whether that unit is active or backup. The same is true for Addition of Device faults. Also, whenever a controller establishes a connection to an IO-Device, faults for missing and mismatched I/O modules will always appear in that controller regardless of whether it is active or backup.

When the CPU or rack have failed, faults detected at the PROFINET IO controller (PNC) are logged locally at the PNC module, but cannot be delivered to the CPU’s I/O Fault table.

Fault Actions

Fault actions in the Hot Standby CPU Redundancy System are handled differently than fault actions in a simplex (non-redundant) system. When the units are synchronized, the types of faults that are considered to be FATAL (i.e., cause the CPU to stop) are not configurable. The following types of faults are considered FATAL when the units are synchronized:

- Any failure that causes loss of control of I/O
- Any failure that degrades performance

Note: In a Hot Standby CPU redundancy system, a *Fatal* fault from an I/O Controller causes a synchronized unit to transition to *STOP/FAULT* mode. All *Diagnostic* faults allow the CPU to remain in Run mode.

Configuration of Fault Actions

You can configure whether certain faults are considered fatal when the CPUs are not synchronized.

The following should be considered when configuring the fault actions for a redundancy CPU. For a given fault that is fatal for the synchronized case, if you set the non-synchronized fault action to be diagnostic, there is a chance that a less healthy unit could remain the active unit even after a more healthy backup unit is placed in Run mode. For example, if you were to configure Loss of or Missing Rack failures as diagnostic, the following sequence of events could occur:

1. If an expansion rack fails when the units are synchronized, the unit with the rack failure will transition to STOP/FAULT mode and the other unit will become a non-synchronized active unit.
2. If an expansion rack fails in the non-synchronized active unit, a diagnostic fault will be logged but the unit will stay in RUN mode and continue to control the process.
3. If the first unit is repaired and then transitions to Run, the second unit with the failed expansion rack will stay in RUN mode and will remain in control of the process.

To prevent this situation, you could include logic to shut down the less healthy unit or request a role switch.

Also, a unit with the fault actions set to diagnostic can be placed in RUN mode and become the active unit even though it could have a diagnostic fault, which would be logged as fatal in a synchronized system.

For example, if an expansion rack fails while in STOP mode or while transitioning to RUN mode, a diagnostic fault is logged. However, the unit will still transition to RUN. In addition, if you have programmed a Preferred Master algorithm, this unit will become the active unit. To prevent this situation, you could include logic to shut down the less healthy unit or modify the role switch logic.

Configurable Fault Groups

The table below shows the configurable fault groups and their fault actions. There are three possible fault actions:

Fatal faults always stop the controller,

Diagnostic faults never stop the controller, and

Conditionally Fatal faults stop the controller if and only if the I/O Controller indicates that the fault is fatal.

Group	Name	Table Type	Non-Synchronized Fault Action		Synchronized Fault Action (fixed)
			Default	Configurable	
1	Loss of or Missing Rack	Controller	Diagnostic	Yes	Fatal
2	Loss of or Missing I/O Controller	I/O	Diagnostic	Yes [1]	Fatal
3	Loss of or Missing I/O Module	I/O	Diagnostic	Yes	Diagnostic
4	Loss of or Missing Option Module	Controller	Diagnostic	Yes	Diagnostic
9	IOC or I/O Bus Fault	I/O	Diagnostic	Yes	Conditionally Fatal[2]
11	System Configuration Mismatch	Both	Fatal	Yes	Diagnostic
12	System Bus Error	Controller	Fatal	Yes	Fatal
15	IOC Software Failure	I/O	Diagnostic	Uses LOSS_IOC setting	Conditionally Fatal[2]
24	CPU Over Temperature	Controller	Diagnostic	Yes	Fatal
38	Recoverable Local Memory Error	Controller	Diagnostic	Yes	Diagnostic

[1] Even if the non-synchronized fault action for the Loss of IOC fault group is configured as Fatal, the Controller will not go to STOP/FAULT mode unless *both* Genius Bus Controllers of a dual bus pair fail.

[2] Conditionally Fatal: When an I/O Controller logs a fault in one of these fault groups, it notifies the Controller whether it can continue to operate or not by placing “Diagnostic” or “Fatal” in the fault’s *fault action* field. For the cases where the table above indicates “Conditionally Fatal,” the Controller applies the fault action selected by the I/O Controller.

Non-Configurable Fault Groups

The table below shows the non-configurable fault groups and their fault actions. There are two possible fault actions: *Fatal and Diagnostic*. Fatal faults always stop the controller; Diagnostic faults never stop the controller.

Group	Name	Table Type	Fault Action
5	Addition of or Extra Rack	Controller	Diagnostic
6	Addition of, Reset of, or Extra IOC	I/O	Diagnostic
7	Addition of, Reset of, or Extra I/O Module	I/O	Diagnostic
8	Addition of, Reset of, or Extra Option Module	Controller	Diagnostic
10	I/O Module Fault	I/O	Diagnostic
12	System Bus Error	Controller	Fatal
13	CPU Hardware Failure	Controller	Fatal
14	Module Non-Fatal Hardware Error	Controller	Diagnostic
16	Option Module Software Failure	Controller	Diagnostic
17	Program Block Checksum Mismatch	Controller	Fatal
18	Low Battery	Controller	Diagnostic
19	Constant Sweep Time Exceeded	Controller	Diagnostic
20	Controller Fault Table Full	Controller	Diagnostic
21	I/O Fault Table Full	Controller	Diagnostic
22	User Application Fault	Controller	Diagnostic
129	No User Program Present at Powerup	Controller	Diagnostic
130	Corrupted User Memory	Controller	Fatal
131	Window Completion Failure	Controller	Diagnostic
132	Password Access Failure	Controller	Diagnostic
134	NULL System Configuration for RUN Mode	Controller	Diagnostic
135	CPU Software Failure	Controller	Fatal
137	Controller Sequence Store Failure: *Communication* failure during a store operation by the programmer. This fault results when the start-of-store sequence was received but not an end-of-store sequence.	Controller	Fatal
138	Redundancy Informational Message	Controller	Informational

Fatal Faults on Both Units in the Same Sweep

It is very unlikely that a fatal fault would occur on both units in the same sweep. If that should happen, however, the first CPU to detect a fatal fault will use the synchronized fault action table. The other CPU will use the non-synchronized fault action table. This allows one of the units to stay in Run mode when the synchronized fault action is Fatal and the non-synchronized fault action is diagnostic.

Controller Fault Table Messages for Redundancy

The following table lists messages, descriptions, and corrective actions for error codes associated with the redundancy fault group. These error codes can be viewed in the Fault Tables provided by Machine Edition. The entire fault data (including these error codes) can also be accessed using SVC_REQ 15 and 20.

Redundancy Fault Group (138)

Error Code	Message	Fault Description	Corrective Action
1	Primary unit is active and secondary unit is backup.	The primary and secondary units have switched roles, the secondary transitioned to Run after the primary, or both units transitioned to Run at the same time.	None required.
2	Secondary unit is active and primary unit is backup.	The secondary and primary units have switched roles, or the primary transitioned to Run after the secondary.	None required.
3	Primary unit is active; no backup unit available.	The primary unit has transitioned to Run mode or secondary unit was put into Stop mode. The primary unit is running without a backup.	To have a synchronized system, the secondary unit ***must*** be placed in RUN mode with a compatible configuration.
4	Secondary unit is active; no backup unit available.	The secondary unit has transitioned to RUN mode or primary unit was put into Stop mode. The secondary unit is running without a backup.	To have a synchronized system, the primary unit ***must*** be placed in RUN mode with a compatible configuration.
5	Primary unit has failed; secondary unit is active w/o backup.	The primary unit has recorded a fatal fault or the secondary has lost communications with the primary. The secondary unit is running without a backup.	If primary unit has also logged the fault *Secondary Unit Has Failed: Primary Unit is Active w/o Backup,* communications is broken between the two units and must be repaired. If a fatal fault has been logged in the primary unit, the indicated fault must be repaired. Power may have to be cycled on one of the units in order to re-establish communications and return to a synchronized system.
6	Secondary unit has failed; primary unit is active w/o backup.	The secondary unit has recorded a fatal fault, or the primary unit has lost communications with the secondary. The primary unit is running without a backup.	If secondary unit has also logged the fault *Primary Unit Has Failed: Secondary Unit is Active w/o Backup,* communications has been broken between the two units and must be repaired. If a fatal fault has been logged in the secondary unit, the indicated fault must be repaired. Power may have to be cycled on one of the units in order to re-establish communications and return to a synchronized system.
8	Unable to Switch Redundancy Roles	An attempt to switch redundancy roles was made when it was not possible to perform the switch.	None required.

Error Code	Message	Fault Description	Corrective Action
9	Primary and secondary units are incompatible	This unit could not be placed into RUN mode because the configurations were not compatible.	Correct the configurations so that the CPUs have compatible transfer lists and the same point faults enabled setting. In addition, if one CPU has redundantly controlled PROFINET I/O configured, the other CPU must also have redundantly controlled PROFINET I/O configured.
10	CPU to CPU communications terminated	Synchronization protocol has been violated.	Contact Technical Support. If the fault is accompanied by a Loss of Module fault, see corrective action for Loss of Module' fault. The link can be restored to service by power cycling either unit or storing configuration to either unit.
11	Redundant Link has timed out	The CPU has timed out while waiting on communications from the other unit.	Contact Technical Support. The link can be restored to service by power cycling either unit or storing configuration to either unit.
12	Units Are Not Fully Synchronized	Due to actions taken by the user, the two units in a CPU redundant system are not fully synchronized. This means the backup unit is not executing with the same inputs and/or outputs as the active unit while the units are synchronized due to data transfers being disabled.	Disable the logic that executes SVC_REQ 43.
14	Redundant link communication failure	Communications with the other CPU over this link has failed.	If the other unit failed or lost power, power cycle it. Verify one CPU is configured for primary and the other for secondary. Check the cable connections between the two RMX modules. If the fault is accompanied by a Loss of Module fault, see corrective action for Loss of Module fault. Otherwise, contact Technical Support.
15	Fail Wait time exceeded	The other CPU failed to rendezvous at a synchronization point within the Fail Wait time.	Increase the configured Fail Wait time.
17	Could not synchronize with remote.	The remote unit is unable to synchronize with the local unit because it is performing an RMS.	Attempt to synchronize after the remote unit completes its RMS.
18	No Redundancy Links; Secondary took control	The Primary unit stopped because the last redundancy link failed and the Secondary unit took control of the I/O.	Repair the redundancy links. See page 7-10.
19	No Redundancy Links; Primary took control	The Secondary unit stopped because the last redundancy link failed and the Primary unit took control of the I/O.	Repair the redundancy links. See page 7-10.

Other Fault Groups

The following table lists messages, descriptions, and corrective actions for error codes associated with redundancy in other fault groups.

Group	Error Code	Message	Fault Description	Corrective Action
Loss of IOC (2)	None	Loss of IOC	The CPU generates this error when it cannot communicate with an I/O Controller and an entry for the IOC exists in the configuration file.	Install the missing module or correct the configuration. Otherwise, replace the module and contact Technical Support.
Loss of Option Module (4)	Various	Loss of or missing option module or Redundant link hard failure occurred	The module is missing or the CPU has determined that the module has failed.	Install the missing module or correct the configuration. Otherwise, replace the module and contact Technical Support.
I/O Bus Fault (9)	None	SBA conflict. *(RX7i only)*	The bus controller has detected that another device on the Genius network is already using the same serial bus address.	Verify that one CPU is configured for primary and one for secondary. Correct the configuration of the Genius devices.
	1	Invalid module configuration	CPU or PNC versions might not support redundant.ly controlled PROFINET I/O.	Update to latest CPU and PNC firmware version.
	2	Unsupported module configuration detected		
	5	Error processing backplane interrupt	CRU does not support IO module interrupts.	Remove I/O interrupts from configuration.
	10	Multiple Media Redundancy Managers MRMs) detected	Multiple MRMs have been detected on the ring network. There must be exactly one manager.	Identify and remove the extra MRM.
	11	Multiple MRMs resolved	Multiple MRMs are no longer present on the ring network.	None required.
	12	Redundant Ethernet network ring broken (open)	The MRM has detected that the network ring is broken. Possible causes: pulled or broken network cable, device in the ring failed, etc.	Locate and repair the network break.
	13	Redundant Ethernet network ring okay (closed)	The MRM has detected that the network ring is closed.	None required.
	Various	Internal runtime error	Software error at PNC module	Contact Technical Support.

Group	Error Code	Message	Fault Description	Corrective Action
CPU System Software (135)	148	Units contain mismatched firmware; update recommended.	The redundant CPUs have different firmware revision levels. Having different revisions of firmware in the CPUs is intended for short-term synchronization only.	Upgrade the CPUs so that they have the same revision of firmware according to the firmware upgrade procedure.
Configuration Mismatch (11)	75	ECC jumper should be enabled, but is disabled	When redundancy firmware is installed in the CPU module, the ECC jumper must be in the enabled position.	Set the ECC jumper to the enabled position (jumper on both pins). See the instructions provided with the firmware upgrade kit.
Recoverable Local Memory Error (26)	1	Recoverable local memory error	A single-bit error was encountered and corrected. %SA00006 is set.	The CPU may need to be replaced. Contact Technical Support.
CPU Hardware (13)	169	Fatal local memory error	Multiple bit ECC error.	Replace the CPU and contact Technical Support.

Redundancy Link Failures

There are distinct differences between losing a redundancy link and faulting an RMX module.

Redundancy Memory Xchange Module Hardware Failure

Failures such as backplane errors are considered hardware failures of the RMX module. The following actions are taken when such an error is detected:

- Either a Loss of or Missing Option Module or a Redundant Link Hard Failure Occurred fault is logged in the Controller Fault Table
- A Redundant Link Communications Failure fault is logged in both units.
- All LEDs on the RMX module are turned OFF.
- The fault locating references that correspond to the module are set (i.e. the SLOT_00XX fault contact is set, where XX is the slot number for the RMX module).
- The corresponding redundancy link is no longer used. If the other link is still operating, that link is used for all further data transfer, and the units can remain in synchronization. If the other redundancy link is not available, refer to the "When the Last Redundancy Link Fails" section on page 7-11.

Power must by cycled on the rack to restore a faulted RMX module to service.

Redundancy Link Communications Failures

The following errors are reported as failures of the redundancy link:

- The other unit has lost power or failed such that it can no longer communicate.
- One or both cables between the two RMX modules have failed or are disconnected.
- A network error was detected on the fiber optic link that connects the two RMX modules. (This includes data checks on mismatches, protocol errors, and rogue packets.)
- Failure of the other CPU to rendezvous at the next synchronization point within the Fail Wait time.

The following actions are taken when a redundancy link communications failure occurs:

1. Either a Redundant Link Communications Failure or Fail Wait Time Exceeded fault is logged in the Controller Fault Table of both units.
2. The LINK OK LEDs on both RMX modules are turned off.
3. The fault locating references that correspond to the module are set (i.e. the SLOT_00XX fault contact is set, where XX is the slot number for the RMX module).
4. The corresponding redundancy link is no longer used. If the other link is still operating, that link is used for all further data transfer, and the units can remain in synchronization. If the other redundancy link is not available or a Fail Wait Timeout occurred, refer to the "When the Last Redundancy Link Fails" section on page 7-11.

If the RMX modules' OK LEDs are still ON, the link can be restored to service by power cycling either unit or storing a hardware configuration to either unit. If either OK LED is OFF, power must be cycled on the rack to restore that RMX module to service.

When the Last Redundancy Link Fails

This section describes how the system will behave when the last healthy redundancy link between a pair of synchronized controllers fails. This includes the case where one CPU does not rendezvous at a synchronization point within the Fail Wait time.

PROFINET I/O Systems

When the last redundancy link fails, the backup unit assumes that the active unit has failed and takes control of the redundant I/O. As long as at least one redundantly controlled PROFINET IO-Device is online with both units, the active unit will detect that it has lost control of the redundant I/O: it logs a *No Redundancy Links; Secondary [or Primary] took control* fault and goes to Stop mode. The backup unit becomes an NSAU and takes control of the redundantly controlled I/O devices.

However, if ***no*** redundantly controlled IO-Devices are online with ***both*** units when the last redundancy link fails, both units remain in Run mode and proceed as NSAUs. Each unit controls any redundantly controlled IO-Devices with which it is currently connected.

When one unit is powered off, or when its CPU or rack completely fails, the other unit becomes an NSAU and takes control of the redundantly controlled IO-Devices.

When both units are powered off at the same time, or when the only functioning unit is powered off, the PROFINET IO-Devices have no connections to any controller. The PROFINET IO-Devices set their outputs to default states.

Genius and ENIU I/O Systems

When the last redundancy link fails, both units log faults and proceed as non-synchronized active units. In this case both units attempt to control the process independently. The redundant Genius devices that are connected to both units will prefer the output values sent by the primary unit.

Online Repair and System Upgrade

With a Hot Standby CPU Redundancy system, most system component failures can be repaired by replacing the failed component while the system is online. You could choose to replace components for other reasons, such as upgrading to a new model of a module. CPUs in both units must have the same model types and firmware version.

On-Line Repair Recommendations

Note: If the LOCAL ACTIVE LEDs are ON and the REMOTE ACTIVE LEDs are OFF on both units, the system is operating under *split control,* that is, with both units operating as NSAUs. Do not use this procedure if this condition exists, since neither unit has the backup role. Additionally, in a system that uses ENIU I/O, there is no guarantee that all ENIUs are taking outputs from the same controller. See "Repair of a Non-Synchronized Active Unit (NSAU) Split Control System" on page 7-14.

To replace a component online, it is strongly recommended that you follow this procedure:

1. Make sure the unit to be repaired is the backup unit. (The LOCAL ACTIVE LED should be OFF and the REMOTE ACTIVE LED should be ON. You can also confirm this by viewing the Redundancy tab of the programmer's online status dialog box.) If the unit to be repaired is already in Stop mode, skip this step. If the unit to be repaired is active, activate the Role Switch on the RMX module.
2. Power-off the unit to be repaired.
3. Replace the defective component.
4. On the CPU of the repaired unit, place the Run/Stop switch in the Stop position.
5. Power on the repaired unit.
6. After several seconds, verify that the LINK OK LEDs are ON for all RMX modules in both units. If the LINK OK LEDs are not on, see the Controller Fault Table.
7. If the repaired CPU is in Stop/Fault mode, verify that there are no unexpected faults and then clear the Fault Tables.
8. Place the repaired unit into RUN mode by putting the Run/Stop switch in the Run position.

Hot Swapping of Modules (RX3i Systems Only)

RX3i redundancy systems support hot swapping of modules to the same extent allowed in simplex systems. Modules that support hot swapping can be removed and replaced in the RX3i main rack and in ENIU remote racks while the rack is powered up.

Hot Swapping RMX 128 Modules

The RX3i RMX128 module supports hot insertion and removal. However, the redundancy communication link associated with a hot swapped RMX module will not be restored automatically. The LINK OK indicator on both RMX modules in the link will be OFF.

To restore the link while the system is in operation, first determine which unit is the backup unit, and if possible, cycle power or store hardware configuration to that unit.

If either RMX module's OK indicator is OFF, power must be cycled on the rack to restore the RMX module to service.

System CPU Upgrade

If you are upgrading your redundancy system with new CPU models, you will need to replace the CPUs in both units. To replace the CPUs in your redundancy system, follow the steps in "On-Line Repair Recommendations." When you have replaced the CPU in the backup unit and returned it to RUN mode, activate the Role Switch on the RMX module and repeat steps 1–8 for the other unit.

Caution

During normal operation, the primary and secondary units in an HSB redundancy system must have the same CPU model type. Extended operation with dissimilar CPU types is not allowed. Continued use of dissimilar CPU types can result in timing issues during synchronization.

The primary and secondary units with dissimilar CPU model types can be synchronized for a limited time, for the purpose of system upgrade only. Fail wait times for the higher performance CPU in a dissimilar redundant pair might need to be increased to allow synchronization. It does not matter whether the newer model is in the primary or secondary unit.

Online Repair of the Genius Bus

Single Bus Networks

The Genius bus of a single bus network can be repaired without disturbing power to either unit. However, repairing the bus without taking the entire Hot Standby CPU Redundancy system offline is not recommended because all devices on that bus will be disconnected from the controllers while the bus is being repaired.

Dual Bus Networks

The Genius bus of a dual bus network can be repaired without disturbing power to either unit. It is recommended that you disconnect the failed bus from the GBCs before you attempt to repair it.

Repair of a Non-Synchronized Active Unit (NSAU) Split Control System

When Redundancy CPUs lose all redundancy links and become NSAUs, there is a possibility of split control or of a failed rack controlling outputs.

In a split control situation, some of the Remote IO devices are taking outputs from one Redundancy CPU and the other Remote IO devices are taking outputs from the other CPU. In this situation turning off one of the controllers could result in defaulting the outputs of some of the Remote IO devices.

A situation where a failed rack controls the outputs occurs when the failed RMX module is contained in the same rack as the CPU that is currently controlling Remote Device outputs.

The procedures given in this section discusses ways to reduce the chance of defaulting outputs on some of the Remote IO devices controlled by the Redundancy CPU pair. Although these procedures might prevent defaulting outputs, they might also involve a short disruption in the outputs as the Remote IO devices switch to taking outputs from the other CPU. It is incumbent on the user to know which CPU is controlling outputs on a specific Remote IO Device and determine whether it is acceptable to allow those outputs to default or to be disrupted.

Initial Steps for all Systems

Determine the source of the Redundancy link failure, which can either be the fiber optic cable or a failed RMX module.

1. Check the OK LEDs on the RMX modules. If the RMX's OK LED is off, the RMX module has failed.

   If there is a failed RMX module, the rack containing the module will have to be taken offline in order to do the repair.

2. If all RMX OK LEDs are on, check the Signal Detect LEDs on the RMX modules. If the Signal Detect LED is off, it might indicate that the fiber optic cable connected to the RX input has failed.

   If there is a failed fiber optic cable, you will need to choose which CPU to take offline to recover the redundancy link(s). Before taking one of the Redundancy CPUs offline, follow the steps given below for the particular I/O system.

Genius I/O Systems

If the Genius Bus Controllers on both the Primary and Secondary CPUs are OK and actively sending outputs to the Genius devices, it is preferable to power off the Secondary CPU rack because the Genius devices prefer the Primary CPU.

- If an RMX module has failed the rack containing the failed module must be powered off, even if it is the Primary CPU rack.
- If it has been determined that the problem is due to a failed fiber cable only, you can choose to take the Secondary CPU offline.

Note: If there is a problem with Genius Bus Controller connectivity to any of the Genius I/O Devices, this should be fixed before proceeding to the next steps.

Caution

Because the Redundancy CPUs are not synchronized, taking a CPU offline can cause a disruption in the outputs. You must be prepared to handle this condition.

ENIU I/O Systems

1. Using the ENIU status data, you should determine whether all ENIUs have network connectivity to both Redundancy CPUs. For details on using the ENIU status information, refer to the *PACSystems RX3i Ethernet NIU User's Manual,* GFK-2439.

Note: If there is a problem with network connectivity to either CPU from any ENIU, this should be fixed prior to proceeding to the next steps.

2. Using the ENIU status data, determine which CPU is controlling outputs on each ENIU.
   - If all ENIUs are taking outputs from one CPU (normally it will be the Primary on LAN A), it is preferable to take the Redundancy CPU that is not currently controlling outputs offline.
   - If it has been determined that the problem is due only to a failed fiber cable, you can choose to take the CPU not controlling outputs offline.
   - If there are some ENIUs taking outputs from one CPU and some taking outputs from the other CPU or you need to take the CPU that is currently controlling outputs offline, for example if it contains the failed RMX module, take the desired CPU offline.

Caution

Because the Redundancy CPUs are not synchronized, taking a CPU offline can cause a disruption in the outputs. You must be prepared to handle this condition.

Final Steps for All Systems

RX7i Systems: When a module has failed, the CPU will have to be taken offline by powering off the rack.

RX3i Systems: Because the RX3i system supports Hot Swap of modules, the CPU can be taken offline by either powering off the rack or by stopping the CPU.

- After taking the Redundancy CPU offline, replace the defective RMX module or cable and bring the CPU back online.
- If the CPU was powered off and retained its logic and configuration and is configured to Run after a power cycle, the Redundancy CPUs will automatically re-establish the redundancy links and resynchronize.
- If the CPU was stopped, use the programmer to download logic and configuration and put the CPU into Run mode. This will cause the CPUs to re-establish the redundancy links and resynchronize. After the CPUs are resynchronized, the steps given in "On-Line Repair Recommendations" on page on page 7-12 can be followed to fix any other failed modules in the Redundancy CPU racks.

Appendix A

RX3i Dual Genius Bus Overview

This chapter provides an overview of PACSystems RX3i Dual Bus Genius. Please refer to the *PACSystems RX3i Dual Genius Bus Quick Start Guide* (provided with the RX3i Dual Bus Templates) for more information.

RX3i Dual Bus Genius is provided by a set of program blocks that coordinate the operation of I/O on Dual Genius Buses to provide cable redundancy.

Templates (Proficy Machine Edition folders) are available on the Support Website as a starting point to implement applications using RX3i Dual Bus Genius.

Note: The current offering supports only VersaMax Genius Network Interface Units (GNIUs).

Features

- Simplex and redundant controller support
- Support for 2 dual Genius buses
- Up to 29 remote I/O devices per dual Genius bus
- Up to 7500 discrete inputs and 7500 discrete outputs
- Up to 3200 analog inputs and 3200 analog outputs
- Templates to facilitate system configuration
- Support for VersaMax Genius Network Interface Units (GNIU)

Templates

Template names are of the form: GENIUS_1DB_3iSC_10SBA

1DB – indicates one dual bus. Choices are 1, 2

3iSC – indicates RX3i Simplex Controller. Choices are Simplex (SC), Redundant (RC)

10SBA – indicates 10 remote I/O devices. Choices are 2, 10, 20

Note: All SBAs in the templates are VersaMax GNIUs.

The templates support up to 7500 discrete inputs and up to 3200 analog inputs.

The quantity of discrete outputs and analog outputs is determined by the amount of %Q and %AQ the remote I/O can accommodate.

The templates come with a target for the controller(s) and a target for each remote I/O device.

The GBCs in the RX3i are preconfigured with the number of GNIUs in the template. Default addressing for Inputs and Outputs is preconfigured. Templates with 10 GNIUs have all the GNIUs on a single Dual Genius Bus. Templates with 20 GNIUS have 2 Dual Genius Buses and 10 GNIUs are on each dual bus. The default I/O addressing used in the templates is in the following table.

Default addressing for Inputs and Outputs

First Dual Bus SBA #	***%I***	***%Q***	***%AI***	***%AQ***
1	1-200	1-200	1-50	1-50
2	201-400	201-400	51-100	51-100
3	401-600	401-600	101-150	101-150
4	601-800	601-800	151-200	151-200
5	801-1000	801-1000	201-250	201-250
6	1001-1200	1001-1200	251-300	251-300
7	1201-1400	1201-1400	301-350	301-350
8	1401-1600	1401-1600	351-400	351-400
9	1601-1800	1601-1800	401-450	401-450
10	1801-2000	1801-2000	451-500	451-500
Second Dual Bus SBA #	***%I***	***%Q***	***%AI***	***%AQ***
1	2001-2200	2001-2200	501-550	501-550
2	2201-2400	2201-2400	551-600	551-600
3	2401-2600	2401-2600	601-650	601-650
4	2601-2800	2601-2800	651-700	651-700
5	2801-3000	2801-3000	701-750	701-750
6	3001-3200	3001-3200	751-800	751-800
7	3201-3400	3201-3400	801-850	801-850
8	3401-3600	3401-3600	851-900	851-900
9	3601-3800	3601-3800	901-950	901-950
10	3801-4000	3801-4000	951-1000	951-1000

The default addresses for I/O are provided for convenience. All four addresses and the lengths can be changed in the configuration for the remote I/O. The only rules are:

- Each reference address type for a given remote I/O device must use contiguous addressing.
- Addresses must be in the range of 1–7500 for %I and 1–3200 for %AI
- Discrete address, %I and %Q, must start on byte boundaries
- %I and %Q lengths must be a multiple of 8
- The address for a remote I/O device should not conflict with other remote I/O devices.

Note: The same output addresses can be used in multiple remote I/O devices if the application so requires.

Available Templates

GENIUS_1DB_3iRC_2SBA	This template is intended for demo use. It is a fully functional Redundant Controller, 2 Remote I/O Devices, 1 Dual Genius Bus template
GENIUS_1DB_3iSC_10SBA	Simplex Controller, 10 Remote I/O Devices, 1 Dual Genius Bus
GENIUS_2DB_3iSC_20SBA	Simplex Controller, 20 Remote I/O Devices, 2 Dual Genius Buses
GENIUS_1DB_3iRC_10SBA	Redundant Controller, 10 Remote I/O Devices, 1 Dual Genius Bus
GENIUS_2DB_3iRC_20SBA	Redundant Controller, 20 Remote I/O Devices, 2 Dual Genius Buses

How to Choose a Template

Steps to choose a template

1. Decide between a simplex controller and a redundant controller.
2. Determine the number of Genius remote I/O devices in your system. Choose a template that supports the number of remote devices or greater.
3. Determine how many Dual Genius Buses are in your system.

RX3i Dual Bus Genius Functionality

Dual Bus Genius provides cable redundancy from the controller(s) to the remote I/O devices. This is achieved by two GBCs in the Controller (or two in each Controller for Redundant Controllers). Each GBC has an associated cable network that connects to all the remote I/O devices. The remote I/O devices are connected to both cable networks through a single interface that decides which cable network to communicate on. The remote I/O devices automatically switch from one cable network to the other if communication is lost on the first cable network. Additionally the Controller can be programmed to command the remote I/O devices to switch to the other cable network. The Controller has status bits for each remote I/O device indicating if a remote I/O device is on one or the other cable network.

Inputs and Outputs can be configured to Hold Last State or go to zero if communication is lost.

In the event of a remote I/O device switching from one cable network to the other, the Inputs and Outputs will Hold Last State while the switch over occurs. After a selectable timeout of 2.5 or 10 seconds the inputs and outputs will go to Hold Last State or Zero if communication is not re-established.

Point Faults – When point fault references are enabled in the controller’s hardware configuration, the RX3i Dual Bus Genius templates support a subset of the functionality that is available with PACSystems controller rack I/O. If communication is lost to a remote I/O device, the Point Faults for all Inputs configured for that remote I/O device will be set. The functionality of setting a Point Fault for a specific Input Point, such as an Analog Input if it has an alarm, is not supported.

Automatic Role Switch (for Redundant Controllers only) – The RX3i Dual Bus Genius templates can be set up to request a role switch when the active controller can not communicate with all the remote I/O devices AND the backup controller can communicate with all the remote I/O devices. The role switch will make the backup controller the active controller. If this behavior is desired, this option must be explicitly enabled in the template’s logic.

Appendix B Switching Control to the Backup Unit when it has Better PROFINET Connectivity than the Active Unit

Overview

Users may want their Hot Standby CPU Redundancy with PROFINET applications to detect the condition where the backup unit has better connectivity to the I/O devices than the active unit and switch control to the backup unit when this condition occurs. A difference in connectivity can occur when more than one link or node in a ring topology fails *or* when a single link or node in a star topology fails. When the backup unit has better connectivity than the active unit, switching control to the backup unit allows the application to control that better set of I/O devices. The criteria for deciding which unit has “better” connectivity is application-specific and therefore must be defined by the application developer.

This appendix provides two logic block examples that:

(1) compare the number of redundantly-controlled devices connected to each unit, and

(2) initiate a role switch when the backup unit has more devices connected than the active unit.

In these examples, logic in each unit calculates the number of devices it is connected to by invoking the PNIO_Dev_Comm block for each one of its devices. The active unit transfers its count to the backup unit. With the count from both units, logic in the backup unit determines whether it has more devices connected than the active unit. If so, logic in the backup unit requests a role switch. A Ladder Logic example and a Structured Text example are provided.

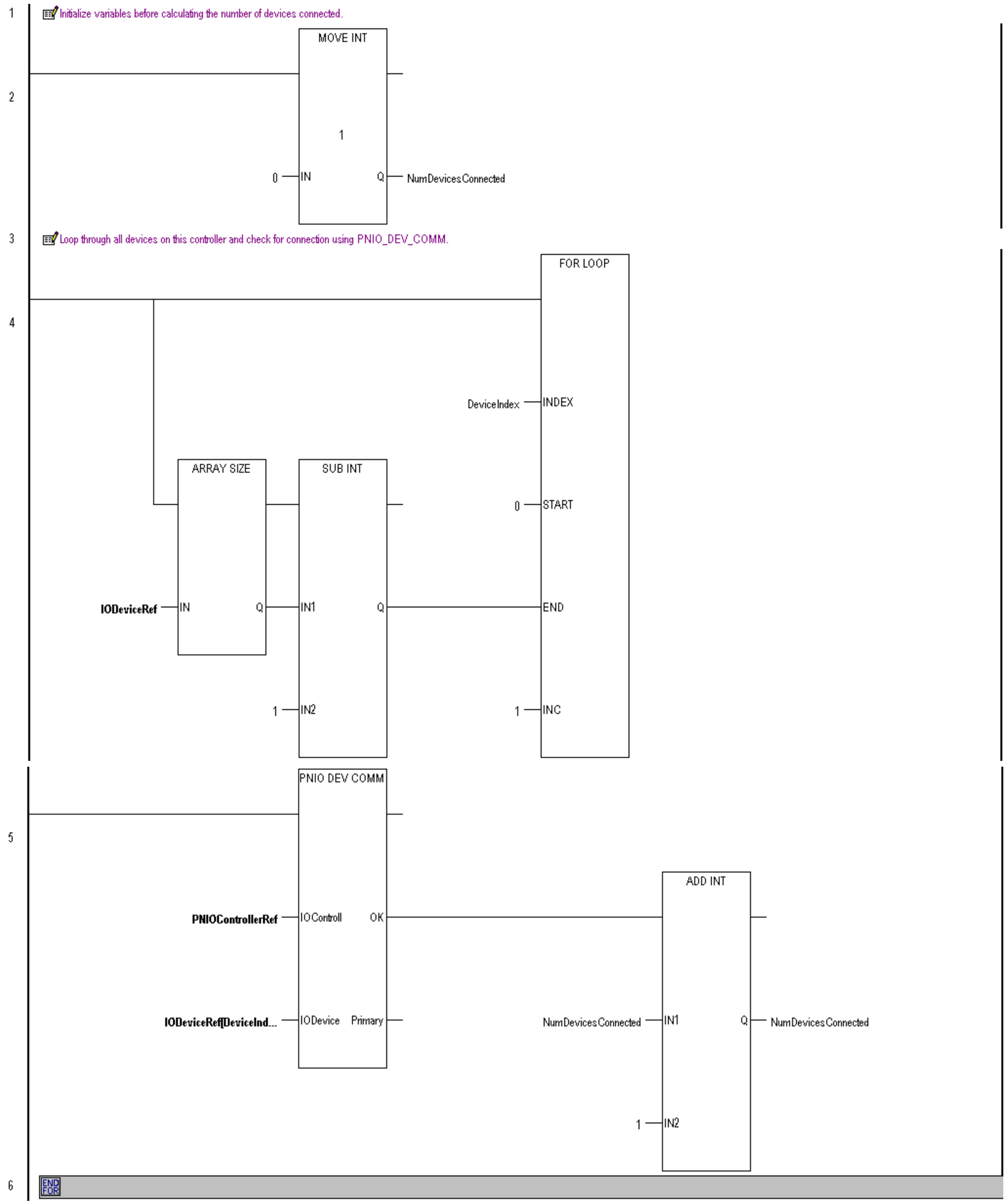
Application Examples

Important information regarding these examples:

- The *ActiveUnitNumDevicesConnected* variable must be included in either the Input or the Output Transfer List.
- These examples assume only one PROFINET IO-Controller module is used in each controller. If you have more than one PROFINET IO-Controller in each unit, you will need to extend the algorithm to account for the additional PNCs.
- These examples use an array of device Reference Variables. The array is named *IODeviceRef[]*. Each element of this array is a device reference variable that is assigned to a unique PROFINET IO device. Here is one way to create and assign elements of this array:
  - In the Navigator window, select the first I/O device listed in the hardware configuration of the Primary unit.
  - In the Inspector window, click on the drop down menu for to the *Reference Variable* parameter and select <Create>. PME will create a new device reference variable and give it a name.
  - In the Navigator window, select the Variables Table and locate the variable that PME created in the previous step.
  - Change the variable’s name if desired.
  - In the Inspector window, change the *Array Dimension 1* property of this variable to be the number of redundantly-controlled devices controlled by this PNC.
  - For each redundantly-controlled device, set the Reference Variable parameter to a unique element of the array you created in the previous step.The array indicies range from 0 to the total number of elements minus 1.
- Each controller independently connects to each device when devices power-up, network links are restored, controllers power-up, and configuration is downloaded. You may want your logic to give the active unit some time to complete these connections before requesting the role switch. These examples use a *NetworkSettleTime* timer to do that. If you use the *NetworkSettleTime* timer, select a time that is appropriate for the size and topology of your network.
- The controllers will not switch roles until it has been at least 10 seconds since the previous role switch.

```
//Initialize variables before calculating the number of devices
connected.
NumDevicesConnected := 0;
BackupHasMoreDevices := 0;
//Loop through all devices on this controller and check for connection
using PNIO_DEV_COMM.
for DeviceIndex := 0 to (ARRAY_SIZE(In := IODeviceRef) - 1) By 1 do
   PNIO_DEV_COMM(IOController := PNIOControllerRef, IODevice :=
IODeviceRef[DeviceIndex], OK => OK, Primary => PRI);
   if OK then
         NumDevicesConnected := NumDevicesConnected + 1;
   end_if;
end_for;
(*If this code is running on the active unit, move the number of devices
connected to a
variable that is transferred to the backup unit in the Output Transfer
List.*)
if (#LOC_ACT) then
   ActiveUnitNumDevicesConnected := NumDevicesConnected;
end_if;
//On the backup unit, check to see if more devices are connected than on
the active unit.
if (#REM_ACT and  NumDevicesConnected > ActiveUnitNumDevicesConnected)
then
   BackupHasMoreDevices := 1;
end_if;
(*If more devices are connected to the backup unit than the active unit,
start a Time On Delay(TON)
timer to wait a specified time(NetworkSettleTime)before requesting a
manual roleswitch.  The
NetworkSettleTime(in milliseconds)should be configured by the user to
allow enough time for
device connections to settle out after a network event has occurred.*)
NetworkSettleTON(IN := BackupHasMoreDevices, PT := NetworkSettleTime, ET
=> ElapsedTime);
(*If the backup unit has more devices connected than the active unit for
the given NetworkSettleTime,
then perform a manual role switch.*)
if (NetworkSettleTON.Q) then
   SVC_REQ(FNC := 26, PRM := RoleSwitchParam);
end_if;
```

Figure B-1 – Structured Text Example



FigureB- 2 – Ladder Logic Example

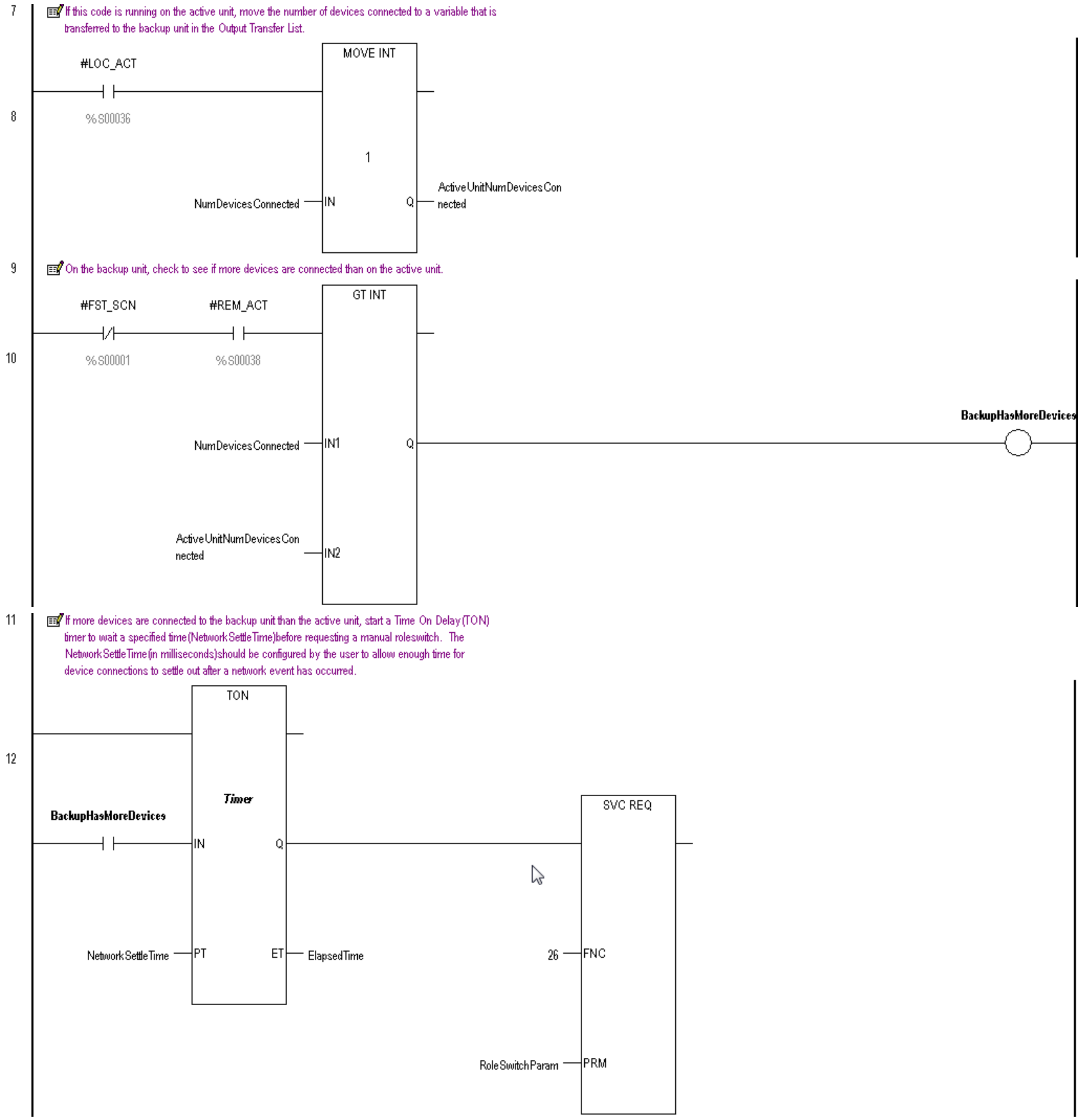


Figure B-2 – Ladder Logic Example, continued

Q

R

S

T

U

W