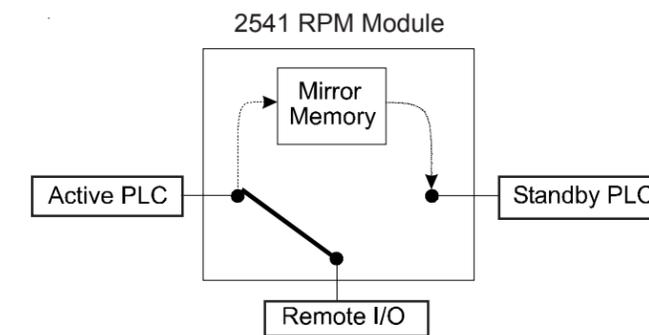


Getting Started with the Model 2541 Redundant Processor Manager

Overview

The 2541 Redundant Processor Manager RPM allows the control engineer to build a warm backup system for CTI 2500 Series or Simatic® 505 PLCs. Both the primary PLC and standby PLC operate in run mode asynchronously. To prevent divergence of the controllers, critical variables may be transferred to the standby PLC every scan. The primary and standby PLCs are physically connected to the remote bases via the RPM. Both PLCs communicate to the RPM over the remote I/O communications channel. The RPM monitors the communication transactions on the remote I/O link and mirrors the information to the standby PLC when the standby PLC requests the status of remote I/O points. The RPM product appears to the control system as a remote base in the I/O memory map. In addition the RPM may be configured as multiple virtual remote bases. These remote bases contain virtual I/O slots of up to sixteen 32 WX/WY pairs. These virtual I/O points may be used to transfer critical variables to the standby PLC each scan. The primary PLC moves defined critical data to unused WY address space and the standby PLC moves data from unused WX address space to the associated data element. Once the critical data is mapped to the remote I/O link, the PLC guarantees the data to be transferred each PLC scan.



Hardware required: 2541, 555 PLC (2 ea.), RBC CTI 2500-RIO or 505-6851-A plus I/O racks and power supplies

Software required: 2541 Configuration program

PLC programming software: Workshop, TiSoft, or APT

Documentation: 2541 Installation and Operations Manual part no. 62-229-11

Home base

The RPM is the Home base. This base consists of 32X and 32Y I/O points with an optional 14 sets of 32WX/32WY pairs. The discrete inputs provide status information to the primary and standby PLCs. The input points are used to steer ladder logic and to monitor if checksums have changed in the PLCs. The discrete outputs are used as control bits in the ladder logic program to initiate transfers, and to generate “heartbeat” pulses. These pulses are monitored by the RPM to detect scan failures or a transition to programming mode. The WX/WY pairs are used to transfer the critical variables. One I/O pair may be used to transfer 32 memory registers or up to a total of 512 discrete points, such as control relays.



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Concept of virtual bases

Unused physical bases may be designated as virtual bases in the RPM. Each of these virtual bases consist of sixteen 32WX/32WY virtual I/O slots. Each slot may be used to map critical variables into the remote I/O communications link. Counting Home base, the maximum number of virtual bases supported is 15 minus the number of physical bases.

Determining the critical variables in your system

Data is transferred between each PLC every scan to keep the programs from diverging. In the event of a switchover to the backup PLC, the data transfers will prevent undesirable behavior in the backup PLC. For instance, we want to prevent any I/O from being bumped. High-speed counters must preserve current counts. Drum sequencer current steps and current counts of the step should be transferred. Any interlocking control relays that directly affect outputs will also need to be transferred. Any calculations that result in direct control will also need to be transferred. A good practice is to transfer all “C” control relays and “Y” output.

Retrofitting an existing program

Examine the current ladder program and determine which variables are critical to the system. Additional ladder logic will be required to transfer these variables to a V memory table. These changes will be appended to move data to V memory and then to transfer to WY addresses. Critical variables may be transferred to a V memory table or directly to a WY address. Each defined variable in the PLC will need to have additional ladder logic to move the register for transfer. In addition the ladder program will have to be altered to fetch the variable when in stand-by mode and update the register in the PLC. In the active PLC the variables are transferred from the PLC to WY address space. In the stand-by PLC the variables are transferred from a WX address and copied to the corresponding location in the PLC.

Logic bypass

In order to lessen the chance of program diversion, the backup PLC scan time needs to be less than the primary scan time. This is accomplished with conditional ladder logic that allows large amounts of the ladder program to be skipped based on a status bit from the RPM. With logic bypassing, the scan time of the backup PLC can be an order of magnitude shorter than the primary PLC.

Calculate the number of words to transfer

Data is transferred in WX/WY pairs through the remote I/O network. The Home base consists of multiple slots of these WX/WY pairs. Each slot can transfer 32 V memory locations or 512 discrete memory locations. We will need to know how many total WX/WY slots will be needed to transfer all of the defined critical variables. This information will determine the number of virtual bases that the RPM will represent in the system.

C and Y discrete variables

These discrete I/O points can be mapped 16 to a V memory location or directly to and from WX/WY memory addresses. Therefore, each slot can transfer 512 discrete variables.

Loop variables

Up to eight loop variables may be moved to V memory using the PACK instruction in ladder logic. The UNPACK instruction may be used in the standby PLC.

V memory

These registers may be directly moved to WX/WY address space. Once a table of V memory has been fully updated by the active PLC the ladder logic can use the MOVW instruction to move the data directly to the WY address space. In the stand-by PLC the reverse process is used to move the data from the WX address space to a V memory table.

Planning the installation

The RPM may be installed in either the primary or standby PLC rack or even in an external rack if desired. The remote I/O connections from both PLCs are connected to the RPM and the connections to all remote physical bases are connected to the front wiring connector on the 2541. Before installing the RPM in rack B, set the fail-safe switch to A. In the event that the power supply in the B rack fails, the switch will allow the PLC in the A rack to operate and control the remote I/O.

This feature is DISABLED if the “Number of V Locations” field of the configuration is 0. To ENABLE this feature, enter a starting location in the “Starting V Memory Location” field of the configuration and enter a number of 15 or greater in the “Number of V Memory Locations” field of the configuration.

Note: The number you enter here must be at least 15. The configuration software will not permit you to enter a number from 1 to 14. The maximum number of V memory locations that may be transferred is 8000. Exceeding this value may produce unexpected results. Also, make sure that the number of V memory locations to transfer does not exceed the total number of V memory locations configured in the PLC.

It should also be noted that the larger the block of V memory being transferred, the longer it would take to transfer the entire block of V memory. The transfer time is dependent on the scan times of the Primary and Secondary PLCs. For instance, with PLC scan times of 50 milliseconds, the V memory transfer rate is typically around 125 words per second. At this rate, a block of 1000 V memory locations would take approximately 8 seconds to transfer the entire block.

Conclusion

Advance planning is essential to implementing a successful backup strategy. Careful thought is required by the control engineer to identify any critical variables in the control system and to ensure that these are transferred to the standby PLC every scan. There are situations that can be avoided. Understanding how the RPM module does its job and avoiding possible pitfalls will result in a successful installation. Among these, the on-line editing results in the most number of complaints. On-line edits extend the PLC scan time and may result in a switchover if the I/O update time-out value is set too short. Catch 22 scenarios can cause aggravation. In this case the checksum must match for a switchover but the configuration settings prevent it due to checksum mismatch. The result is a locked up and lost control system.

Always configure WX/WY slots in multiples of two, i.e., do not configure just one WX/WY slot or three WX/WY slots. You must configure two, or four, or six.....and so on.

The “virtual” I/O that is configured in the 2541 module must also be configured in the PLC’s I/O configuration just as if it were “real” I/O. For this reason, the total amount of “virtual” I/O configured in the 2541 and the total amount of “real” I/O required for the application detracts from the total I/O available in the PLC module you are using. You should make sure that the total of “real” I/O and “virtual” I/O do not exceed the total I/O available in the PLC.

Affects of virtual bases on PLC scan time

Configuring “virtual” bases in the 2541 is the same as adding “real” I/O bases to the PLC system. For this reason, the addition of “virtual” bases can significantly increase the PLC’s scan time.

Each “virtual” base added to the system can add from 15 to 20 milliseconds to the total PLC scan time. This should be considered when designing the warm backup system, especially where PLC scan times are critical to the process.

Setting the 2541 I/O update time

This setting specifies the amount of time (in milliseconds) that must elapse before the 2541 module logs an I/O timeout and transfers control to the Standby PLC if I/O Update is selected as a transfer option. Typically, it is recommended that this value be set slightly higher than the maximum PLC scan time expected.

There are certain procedures, such as ONLINE EDITS from TiSoft or ONLINE compiles and downloads from APT, which can significantly increase the PLC scan time during the procedure. If I/O Update is selected as a transfer option and the I/O Update time is set close to the PLC’s normal scan time, then this may cause the 2541 to switch control to the Standby PLC if these procedures are applied to the Primary PLC.

It is recommended that the I/O Update transfer option be disabled in the 2541 module before doing ONLINE edits or downloads to the Primary PLC to prevent an unexpected transfer of control to the Standby PLC.

Checksum Match Enable option

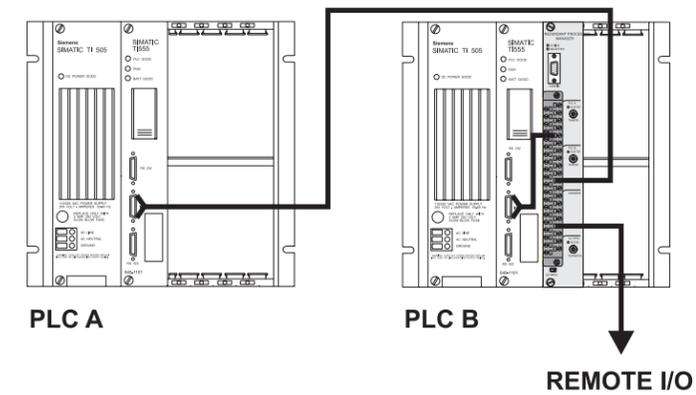
If this option is ENABLED, it should be noted that if a ladder edit is done in the Primary PLC then the ladder checksum match will fail and the 2541 will deem the Standby PLC unavailable for transfer. The “PLC ACTIVE” LED corresponding to the designated “Standby” PLC will go OFF indicating that the Standby PLC is not operational. Also, since changes to the Primary PLC RLL are not automatically transferred to the Standby PLC, any changes in RLL must be done to each PLC independently.

Heartbeat option

If this option is to be used, ladder logic must be implemented to toggle the heartbeat bit in the 2541 (Y3 of the control bits). If ENABLED, the 2541 will switch control to the Standby PLC in the event that the Primary PLC stops executing ladder logic, such as will occur if the Primary PLC is switched from RUN mode to PROGRAM mode. Also, if the Standby PLC is placed in PROGRAM mode, the 2541 will deem the Standby PLC not operational and unavailable for transfer.

V Memory Transfer option

This option allows the transfer of a block of V memory from the Primary PLC to the Standby PLC over multiple PLC scans. This method may be used to transfer data that has been deemed by the user as **non-critical** data. This method is slower than the **critical** data transfer which uses “virtual” WX and WY locations to transfer data on every PLC scan, but is adequate for transferring the majority of data in most applications. The V memory transfer option does not require any additional ladder logic to implement, as the **critical** data transfer method does.



Typical RPM Installation

Steps Required to Configure the RPM

Use the 2541 configuration software to setup the RPM module as Home base. Home base will be configured with a starting X address point. All the remaining addresses for the base will be relative to that address. Use the configuration software to define the normal startup PLC, and the definition of Home base, any virtual bases, and all physical bases. The RPM will appear to the programming software as at least one remote base and up to a maximum of (15 - the total number of physical bases).

Configure all bases in the RPM

The RPM must know the status of all 15 possible remote bases in the system. For each base configure the base as either not configured, as a real base, as a virtual base, or as Home base.

Home base

The Home base in the system logs into the PLC as 32 X, 32 Y, and up to fourteen 32 WX/WY pairs of modules. You must configure the RPM as the home base and as a virtual base. Assign a remote base number to the RPM. The total number of modules in the base must also be configured in the RPM. These must be configured in multiples of two. The number of modules configured must be exactly duplicated with the programming software in the PLC.

Configure all other virtual bases

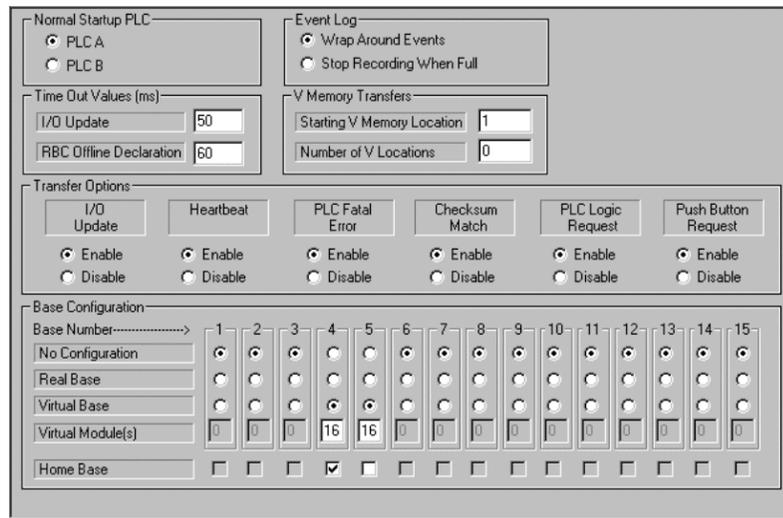
If additional variables are required to be transferred such that all of the modules in the Home base are used, then virtual bases consisting of sixteen 32 WX/WY pairs may be configured in the RPM. Each base must be designated as a Virtual base with the configuration software. Modules must be configured in the virtual base. These modules must be configured in multiples of two.

Configure transfer options: There are user defined options for transfer to the standby PLC.

Enable or disable the following transfer options: I/O update, Heartbeat pulse, PLC fatal error detection, Checksum mismatch, PLC ladder logic request, or Front panel push-button. During startup it is recommended that checksum mismatch be disabled. These options may be monitored as X inputs in the Home base.

Define time out values

Time out values may be defined for loss of I/O update and for RBC communication problems. Run time edits of the ladder program will cause I/O update times to increase dramatically. During startup since run time program changes are often made, values of 250 msec or longer should be used.



2541 Configuration Display

Cycle power on RPM to enable configuration changes

Once all changes have been made in the RPM, power should be cycled to the RPM module. Firmware release V1.4 and higher also allow the RPM module to be reset from the configuration software.

Use TiSoft, Workshop, or APT to configure rest of system

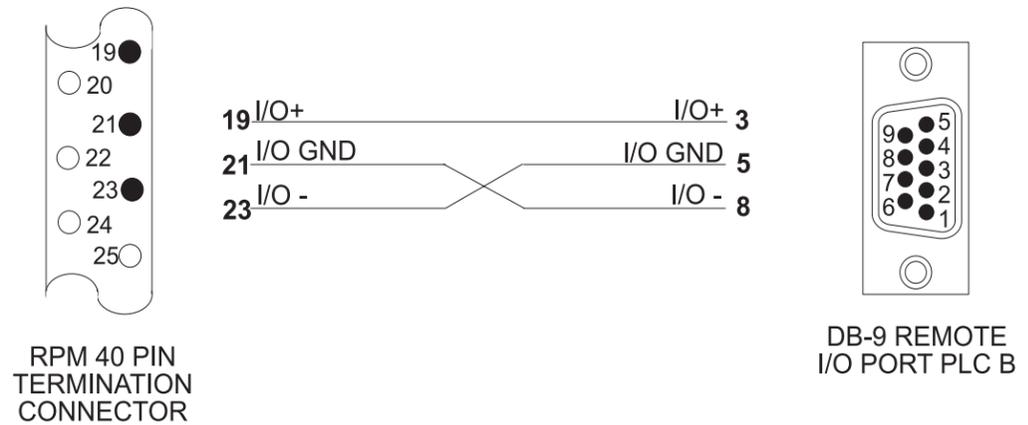
After the RPM is fully configured, the module must be reset to load the configuration parameters into RAM. Using the PLC programming software, TiSoft, Workshop, or APT, the rest of the PLC system can be initialized. There are library functions available from third parties (ISD) to support the APT programming software. Contact your CTI regional manager for more information.

Log the RPM and the rest of the I/O into the PLC

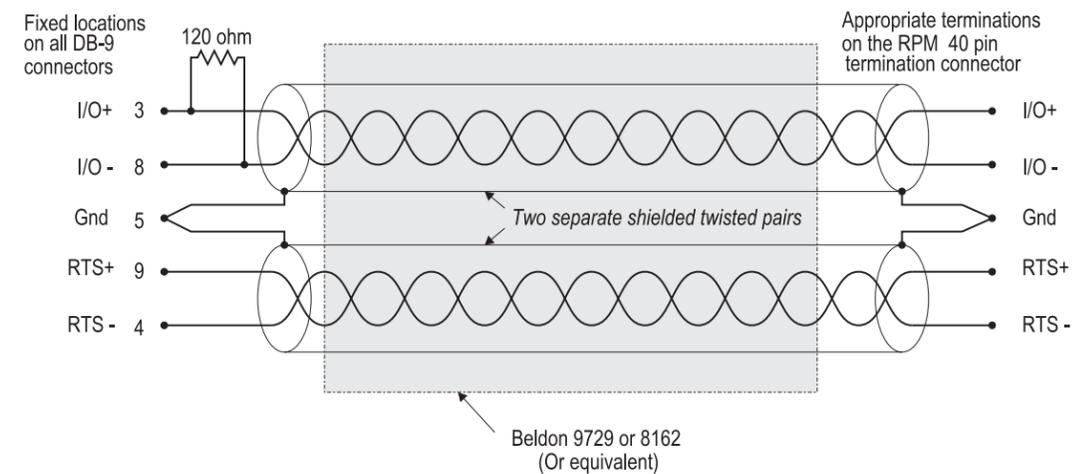
The RPM logs into the PLC as a Home base and optional virtual remote bases. Ensure that the programming software and the PLC recognize the RPM by issuing a READ Base command. The data reported for the Home base and any optional virtual base should match exactly with the information stored in the RPM with the configuration software. Using the programming software, configure the I/O addresses of each module in the home base and each module in any virtual base. All addresses in the home base are relative to the starting addresses.

The following table is useful in assigning I/O addresses:

SLOT	I/O ADDRESS	X	Y	WX	WY
1	0001	32			
2	0033		32		
3	0001			32	32
4	0065			32	32
5	0129			32	32
6	0193			32	32
7	0257			32	32
8	0321			32	32
9	0385			32	32
10	0449			32	32
11	0513			32	32
12	0577			32	32
13	0641			32	32
14	0705			32	32
15	0769			32	32
16	0833			32	32



Typical RF Converter Remote I/O Cable from PLC B to the RPM



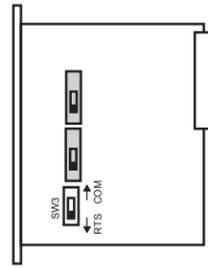
Typical Wiring and Specifications for Remote I/O Cables When Using RF Converters

Considerations when using the 2541 Redundant Processor Module

Configuring virtual bases in the 2541

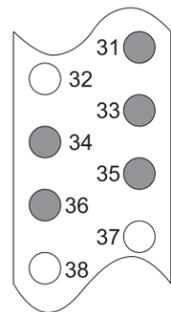
In order for the 2541 to operate, “virtual” bases must be configured in the module. (“Virtual” bases reside in the 2541 module.) These “virtual” bases look like “real” I/O bases to the PLC. (“Real” bases are actual bases that contain real I/O used in the control of the process.) For this reason, some thought should be given to the “real” I/O requirements of the application, “virtual” I/O requirements for critical data transfer and operation of the 2541, and available I/O of the PLC model you are using.

The PLC can support one local base (base in which the PLC resides) and up to 15 remote bases. In a warm backup application, there must be at least one “real” base configured. Up to 14 “virtual” bases can be configured in the 2541 module. The 2541 requires a minimum of one “virtual home base” to be configured. The first slot of the “virtual home base” logs in to the PLC’s I/O as a 32-point discrete input. The second slot logs in as a 32-point discrete output. These X and Y points are used for monitoring and control of the 2541 during operation. The remaining 14 slots may be configured for high-density 32WX/32WY word I/O points. Subsequent “virtual” bases added may have all 16 slots configured as WX/WY word I/O. The WX and WY points are used for transferring data from the Primary PLC to the Standby PLC by the Critical Data Transfer method. As few as two 32WX/32WY slots may be configured in a “virtual base”.

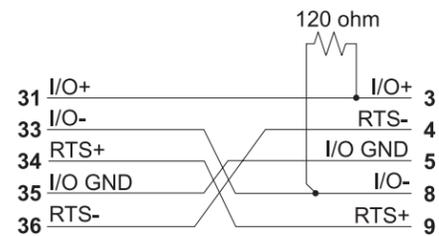


RTS COM Switch Location

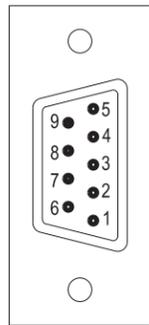
Termination Resistors and Handshakes



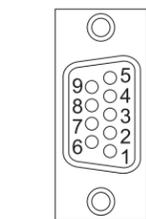
RPM 40 PIN TERMINATION CONNECTOR



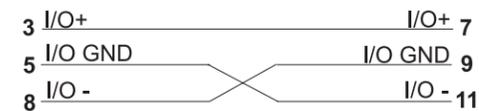
Typical Remote I/O Cable from RF Converter to the RPM



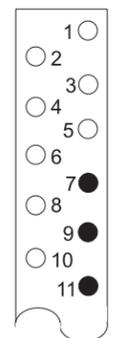
DB-9 RF CONVERTER



DB-9 REMOTE I/O PORT PLC A



Typical RF Converter Remote I/O Cable from PLC A to the RPM



RPM 40 PIN TERMINATION CONNECTOR

Note that slots 1 and 2 are reserved for RPM use only. Do not assign any critical variables to these addresses. Begin all WX/WY addressing at slot 3 in the Home base. The RPM will automatically assign the WX/WY pairs. Therefore, the above table shows the following WX/WY pairs:

WX1/WY33	WX/321/WY353	WX641/WY673
WX65/WY97	WX385/WY417	WX705/WY737
WX129/WY161	WX449/WY481	WX769/WY801
WX193/WY225	WX513/WY545	WX833/WY865
WX257/WY289	WX577/WY609	

Wiring the front connector

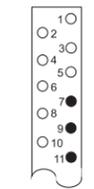
Remote I/O connections



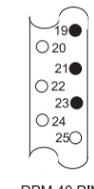
DB-9 REMOTE I/O PORT PLC A



Typical Remote I/O Cable from PLC A to the RPM



RPM 40 PIN TERMINATION CONNECTOR



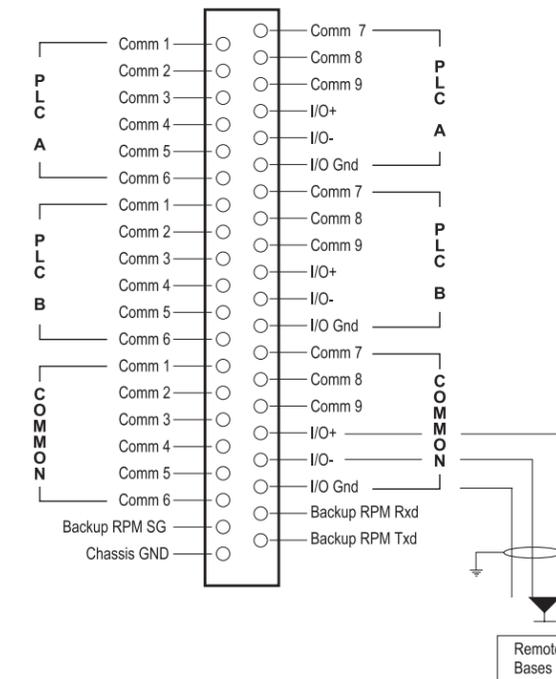
RPM 40 PIN TERMINATION CONNECTOR



Typical Remote I/O Cable from PLC B to the RPM



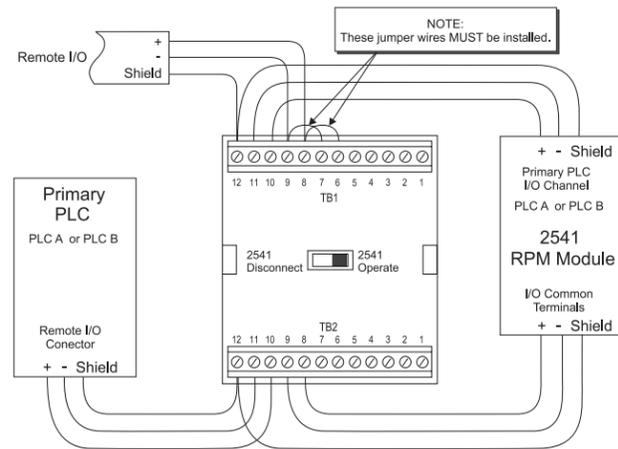
DB-9 REMOTE I/O PORT PLC B



RPM Front Panel 40-Pin Termination Connector

Including a maintenance disconnect switch

The 2541 may be removed from the control system for maintenance by using the 2541-LIB. The external switch allows the 2541 to be removed without having to power down the control system.



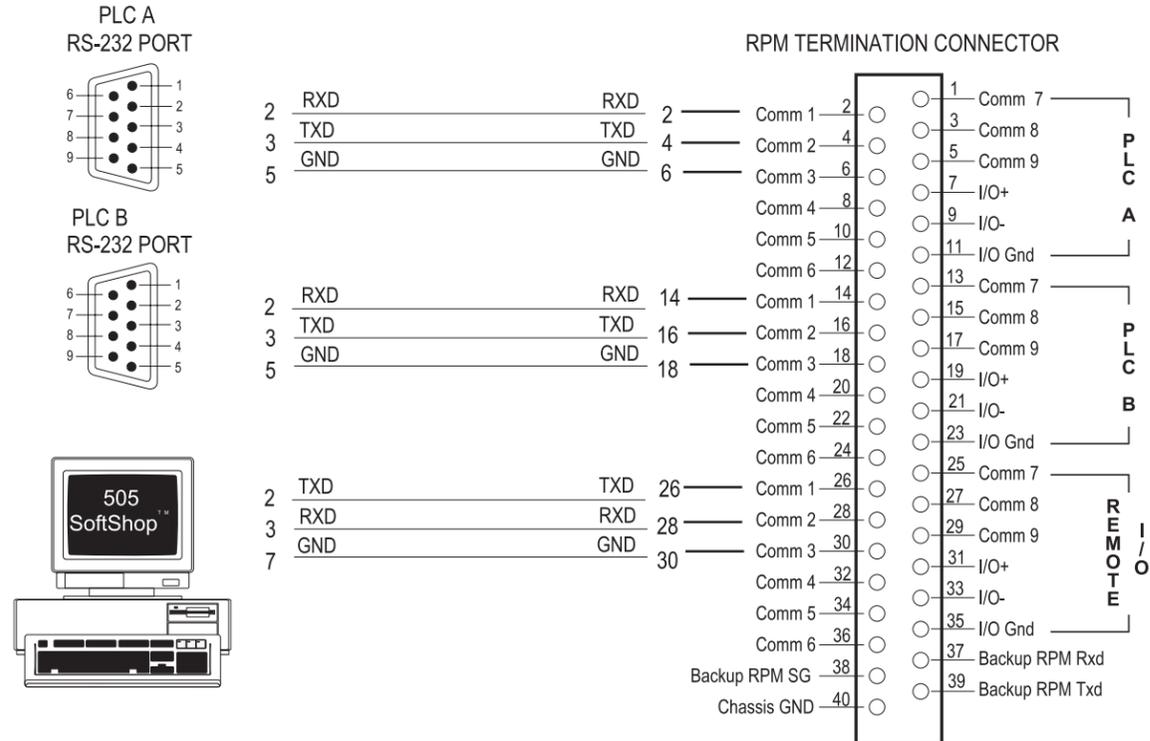
Typical 2541-LIB Bypass Wiring Diagram

Using the user switch contacts

There are nine user contacts available on the front connector labeled Comm1 - Comm9 that can switch signals during PLC switchover. These are signal grade contacts that may be used to transfer communications signals from a programming device or an operator interface.

Backing up the serial ports on the PLC

An operator interface station attached to one of the programming ports on the PLC may be transferred to the backup PLC during switchover. This prevents the operator from losing control.



Serial Device Cabling Example

Alternative Methods to Transfer Critical Variables

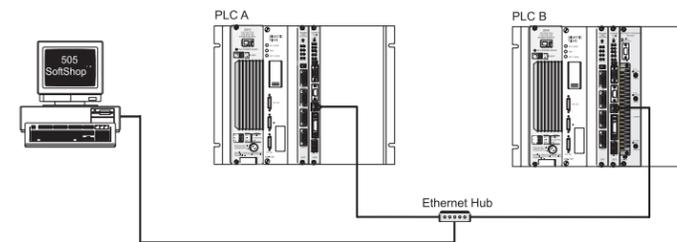
There are other methods that can be used to transfer variables to the standby PLC instead of mapping them into the I/O address space. The RPM can transfer blocks of V memory over multiple scans. This may be enabled with the configuration program. High-speed links between the PLCs may be constructed with the 2573-TCM2 or the 2573-MOD or the 505-CP2572 to move blocks of memory to the standby PLC.

Task codes transferring V memory

This is easily enabled in the configuration program of the RPM. Select the start of the V memory block to transfer and the number of locations to transfer. The RPM will use NITP task codes in the communications time slice of the remote I/O transfer to move the block of V memory to the standby PLC. This operation can move 50-100 words per PLC scan. A minimum value of 15 or a maximum value of up to 8000 may be entered in the configuration of the 2541.

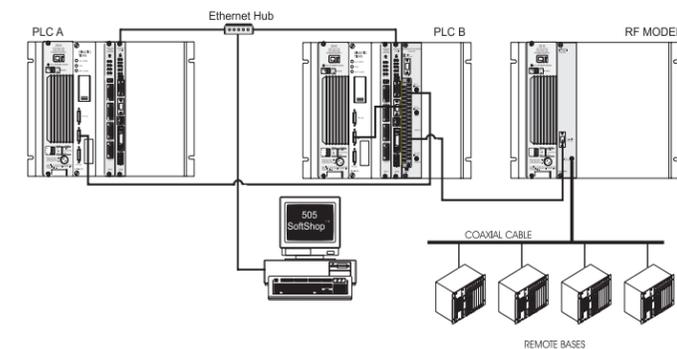
Ethernet TCP/IP client operation

The 505-CP2572 may be used in client mode to move blocks of V memory at a much faster rate between the PLCs. Remote programming over Ethernet as well as operator interface functions may be added with this technology. See the CTI Web site for Application Notes and Manuals for performing client operations.



Coaxial Support for Series 500 I/O Installations

RTS/COM selector switch



Support for Coaxial Cabling to Remote Bases with the 505-6860 RS485/RF I/O Channel Converter

Older installations of the TI Series 500 I/O may be supported with the addition of the 505-6860 RS485/RF I/O channel converter and the 2541. SW3 on the printed circuit board must be set to the RTS position for handshake to the modem. In order to support the 505-6860 RF channel converter additional cabling and termination resistors are required. The channel converter requires a handshake signal from the PLC. Refer to the 545/555/575 systems manual for a complete discussion of the RF channel converter.

Using the Diagnostics Software to Track Operations

Tracking the events in the 2541

The 2541 configuration software also may serve as a diagnostics tool to aid the control engineer during startup and during switchover conditions. Power up the control system and verify that the diagnostics software recognizes the active and standby PLCs.

Examine the event log to determine reasons for switchover

The event log is useful in determining the reason that a switchover occurs. Use the recessed switch on the front of the RPM to transfer to the standby PLC. If this has been enabled during configuration, the RPM will transfer control of the I/O to the standby PLC. This can be examined in the event log. Sometimes a condition will exist that may cause a switchover condition but an inhibitor is in effect that prevents the transfer. This information will be indicated in the event log.

Read software revision numbers

The diagnostics software may be used to interrogate the RPM for the firmware revision, hardware revision, date of manufacture, and the unit serial #. All of this information is useful when calling CTI for product technical support.

The screenshot shows the 'RPM Configuration Program Diagnostic Display' with the following sections:

- Module Information:**
 - Module Name: 2541-RPM
 - Product Description: Redundant Processor Manager
 - Firmware Version: 01.04
 - Board Revision: A
 - Manufacturing Date: 07/31/97
 - Firmware Date: 09/23/97
 - Serial Number: 0000000001
- PLC A - Information:**
 - Scan Type: Variable
 - Operation Mode: Program
 - Fatal Error Present: None
 - Scan Time (ms): 0
 - Max Between Msgs (ms): 32771
 - Battery Low: Ok
- PLC B - Information:**
 - Scan Type: Variable
 - Operation Mode: Program
 - Fatal Error Present: None
 - Scan Time (ms): 0
 - Max Delay Between Msgs: 32772
 - Battery: Ok
- Event Log Records:**

Event	Initial State	New State	Inhibitor
Configuration Change	PLC A	PLC A	
Scan Timeout	PLC A	PLC A	Standby Scan Timeout

note: most recent event on top

RPM Configuration Program Diagnostic Display

A sample ladder logic program

Download the sample ladder program from the CTI Web site.

Testing the operation of the program

Writing the Ladder Logic

Using status bits from the Home base to control transfer of critical variables

There are up to 32 possible status bits (not all currently used) that the RPM module reports to the PLC. These inputs are used by the ladder program to determine which PLC is active and which PLC is standby, and to report RPM operational status and selected transfer options.

Offset	Description
0	PLC A has active control (1 = Yes, 0 = No)
1	PLC B has active control (1 = Yes, 0 = No)
2	PLC Active Flag (1 = this PLC is active, 0 = this PLC is standby)
3	PLC A Status (1 = Operational, 0 = Not Operational)
4	PLC B Status (1 = Operational, 0 = Not Operational)
5	Checksum Compare (1 = Checksums match, 0 = Checksums do not match)
6 - 8	Reserved
9	Non-Critical Data Transfer Completed - Alternates with offset 10
10	Non-Critical Data Transfer Completed - Alternates with offset 9
11	RPM has control (reflects I/O update monitoring status, 1 = enabled, 0 = disabled)
12	Reserved for future use
13	RPM module is good (operational)
15*	Secondary RPM module is good. (Not currently implemented)
16*	True = I/O Update Monitor enabled
17*	True = Heartbeat Monitor enabled
18*	True = PLC Fatal Error Monitor enabled
19*	True = PLC Logic Transfer enabled
20*	True = Program Checksum Match enabled
21*	True = Front Panel Pushbutton Transfer enabled
22*	True = Switchover Enabled (<i>Switchover Inhibit NOT enabled</i>)
23 - 32	Reserved for future use

PLC control bits

The control bits are used to generate a heartbeat pulse and to effect a switchover via PLC control.

Offset	Description
0	Request Switchover to PLC A
1	Request Switchover to PLC B
2	Heartbeat bit. PLC Logic must transition this bit every scan
3*	Switchover Inhibit Mode enabled
4*	Request RPM transfer to backup RPM (not currently used)
5 - 32	Reserved for future use

Note: Status and control bits with an "" are available in firmware versions 1.4 and higher.*

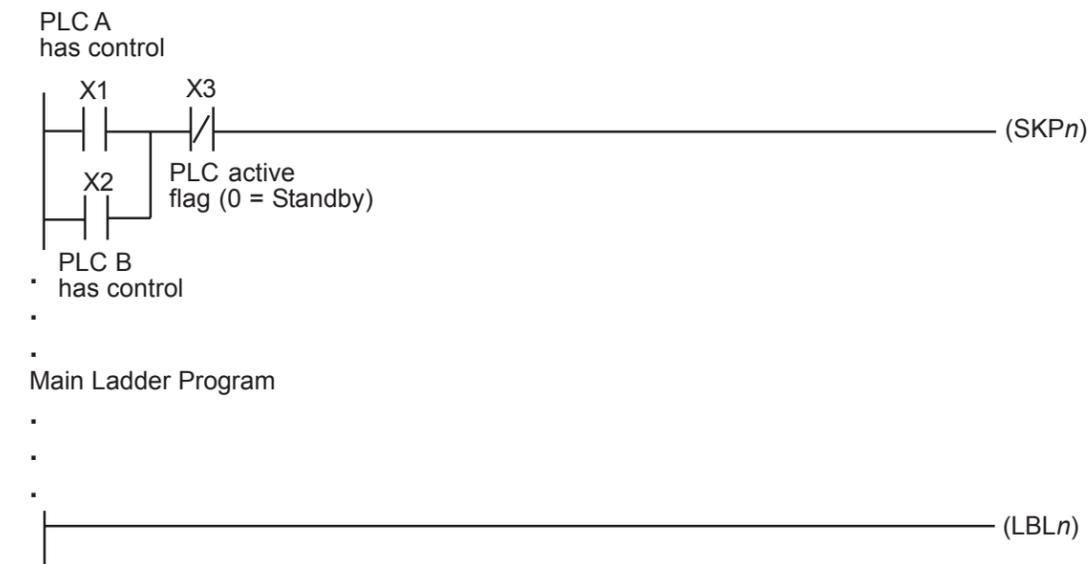
The heartbeat pulse

The active and standby PLC must write to this relative output point every scan cycle. The RPM uses this information to determine if the PLC has failed or if the PLC has been put into a programming mode. The heartbeat pulse is enabled or disabled with the configuration software.



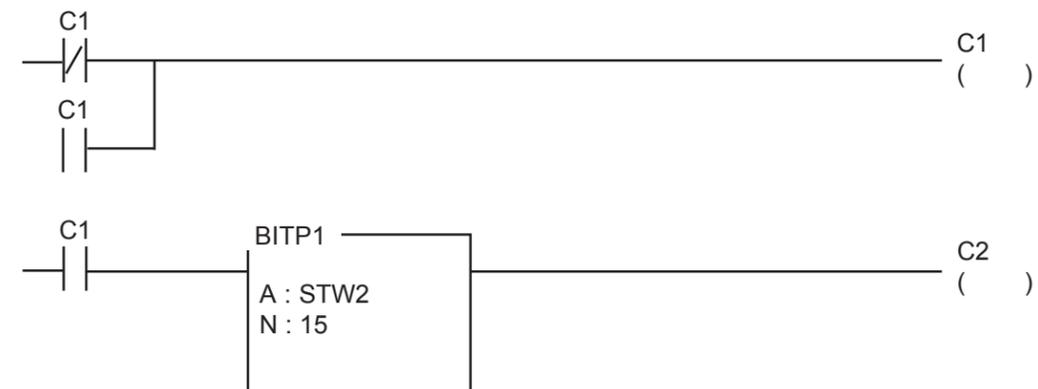
Skipping sections of the ladder program

The standby PLC can guarantee less divergence in the program by skipping a large portion of the ladder program and using critical data transfers to update all memory elements affected by the skip. The status bits in the RPM allow the PLC to skip the logic. Note that the changes in the value reported to each PLC are based on whether the PLC is active or standby.

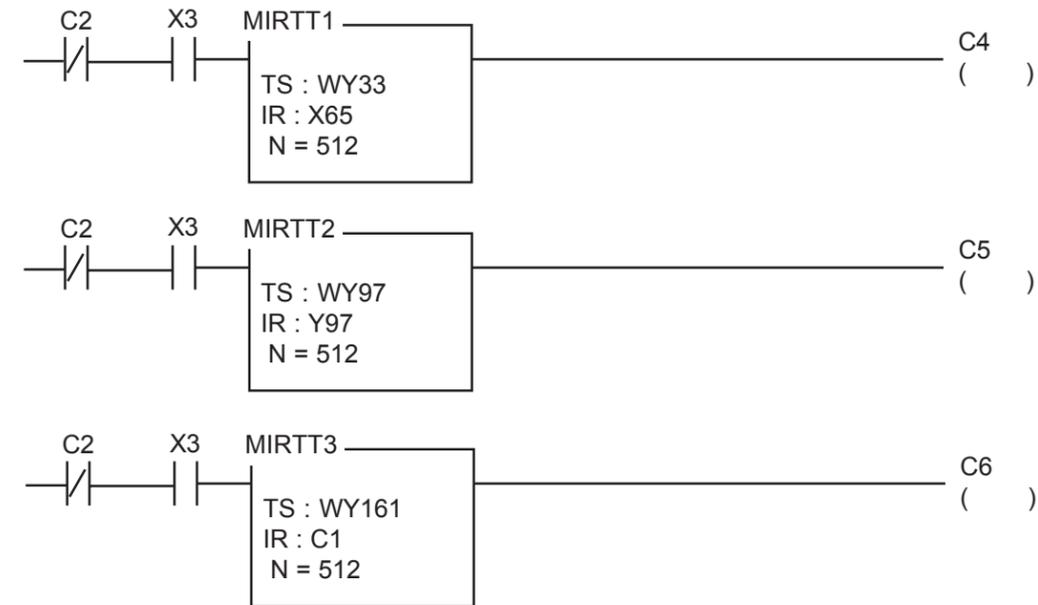


Testing for Home base failure

A BITP ladder logic instruction may be used to test the status of the RPM. STW2 reports the status condition of all remote bases. This information may be used to conditionally transfer critical variables to and from the WX/WY addresses.



Ladder logic to transfer control relays, inputs, and outputs to WY address space



Ladder logic for other types of variables

