Application Note

2500 Series®
Programmable Automation Control System

Building a Redundant System using the 2541 Redundant Processor Manager and 2500P-ACP1 Application Coprocessor

2500 Series® Systems from CTI can be configured with several levels of redundancy, depending on the needs of your application:

- Power Supply Redundancy
- Remote Base Controller Redundancy
- CPU Redundancy

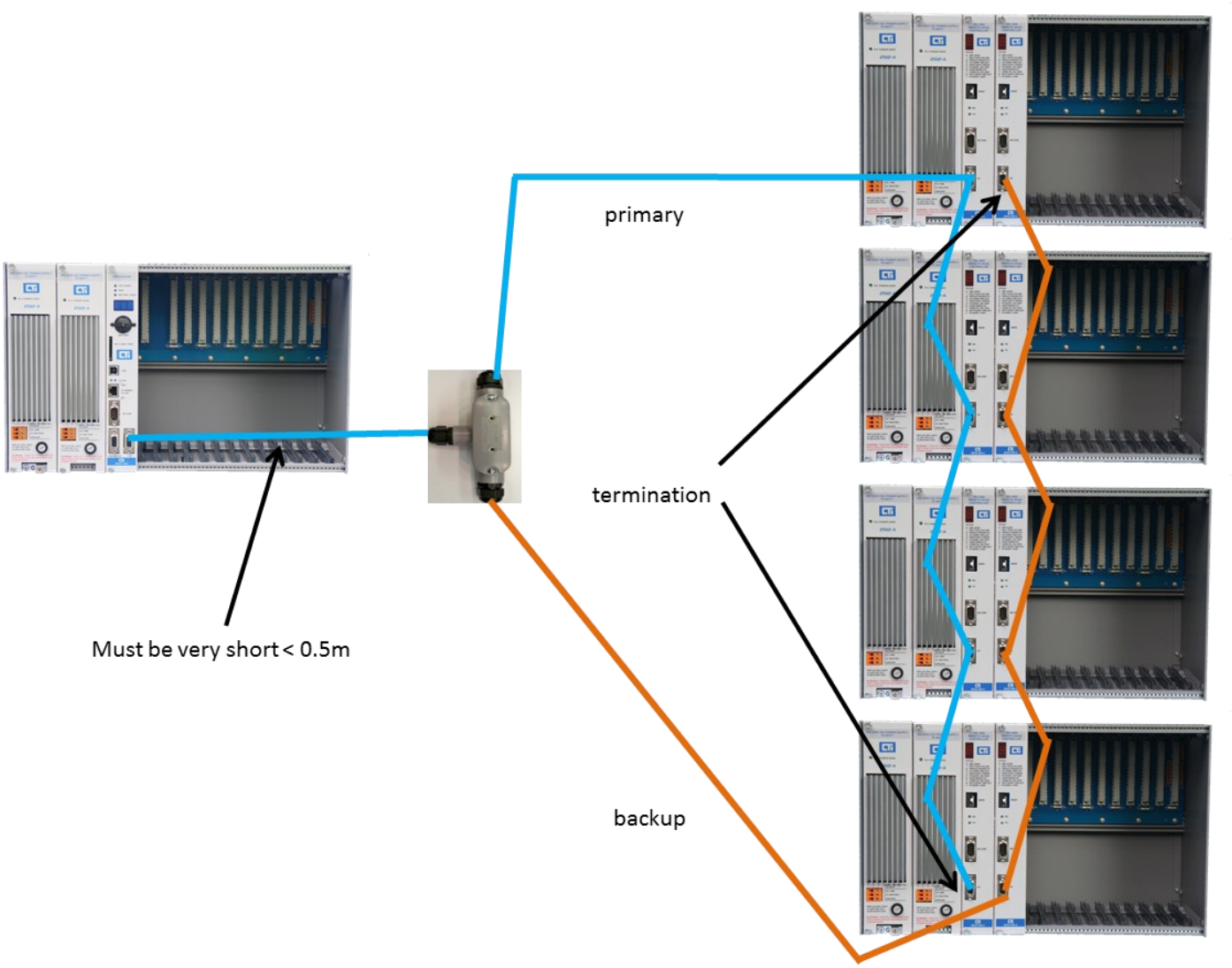
Power Supply Redundancy

Power Supply redundancy is achieved using the 2500-R11-A Eleven Slot Redundant Base and two 2512-A power supplies. This configuration can be used with either a CPU or a Remote Base Controller as shown in the Figure below.

Power supply redundancy for CPU and RBC

Remote Base Controller Redundancy

When used for a remote base, the 2500-R11-A base also permits the installation of a second RBC (2500-RIO -B only) which can provide redundancy in remote I/O cabling as well as the RBC. The figure below illustrates an arrangement with redundant cabling and redundant RBCs.



CPU Redundancy

For systems which cannot tolerate any downtime due to a Processor (CPU) failure, the 2500 Series® System supports the use of redundant CPUs in an "active / standby" arrangement. Processor health is monitored by the 2541 Redundant Processor Manager, which also provides for switching the remote I/O from the active to the standby Processor in the event of a failure. The 2541 is capable of mirroring all the process inputs to the standby PLC, and includes a mechanism for transferring data from active to standby PLC. An alternate arrangement can use a 2500P-ACP1 Application Coprocessor connected to each CPU to provide the data synchronization. This method has the advantage that it doesn't require any additional PLC programming to accomplish the data transfer. It also can reduce the PLC scan time, since each 2541 "virtual base" added to the system increases the scan time by up to 20msec.

The remainder of this Application Note describes the process of configuring a Redundant Processor System using 2541 and 2500P-ACP1. There is example code for the PLC and ACP1 which can be downloaded from the CTI website.

1. **Determine the Overall System Layout**. In this step, the overall layout of the redundant CPU system is determined, and IP address assignments are made. There are several options available:

- Option 1: Each CPU in a separate base. This option uses either 2500P-R4 or 2500-R11-A bases (depending on whether redundant power supplies are desired). Each base includes a power supply (two for the R11-A), CPU, and 2500P-ACP1 module. One base also includes the 2541. This is the recommended configuration because it completely isolates the two CPUs.

- Option 2: CPUs in the same base. This option, supported only by the 2500-R11-A, uses a single base which contains all the components: two 2512-A, two CPUs, two 2500P-ACP1s, and the 2541. The disadvantage of this option is that a failed CPU cannot be replaced without a planned shutdown of the system.

2. **Identifying critical data.** Redundancy using the 2541 is called "warm backup" because the active and standby processors are "free-running" and the scans are not synchronized. Both CPUs see all the process inputs; however, we must provide a way to synchronize other process parameters (like loop setpoints, recipe inputs, or other HMI / SCADA inputs) from the active to the backup PLC. Here are typical items to review in identifying critical data:

- Timers / Counters – may need to transfer TCC
- Drums – may need to transfer DSC
- Loops – may need to transfer loop setpoints, bias, V-flags, C-flags
- Alarms - may need to transfer alarm V-flags, C-flags, and acknowledgement flags
- Any items which are set by HMI / SCADA

3. **Configuring the RPM.** The RPM has numerous configuration options for controlling how the module operates. These options include:

- Failsafe switchover - which PLC becomes active if the 2541 fails
- Switchover conditions - I/O Update, Heartbeat, PLC Fatal Error, Checksum Match, PLC Logic Request, Pushbutton Request
- Timeout values
- Virtual Base Configuration, including Home Base
- Background V-Memory Transfer

A complete description of these setup options can be found in the 2541 Installation and Operation Guide.

4. **Configuring the ACP1**. In this step we will configure the two ACP1 units to read/write data from their individual PLCs and transfer between PLCs. We will also write a program in the ACP1 to control the direction of data transfer, depending on which PLC is in control.

EXAMPLE PROJECT

PLC Program

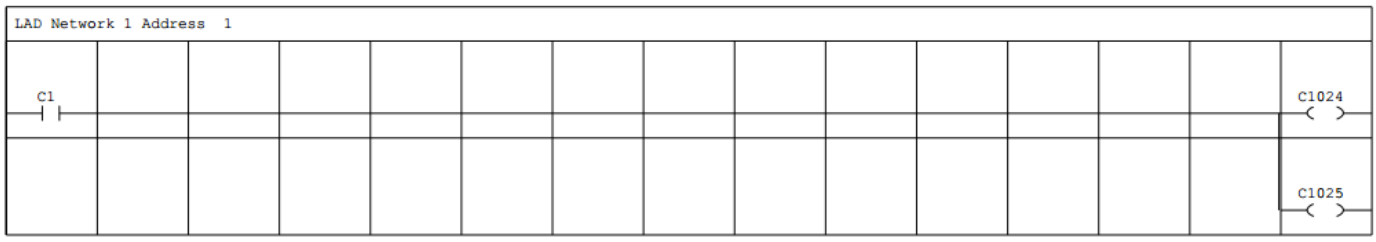
In this example project, the PLC program consists of two DRUMS operating on a 1-second cycle time, activating outputs Y1-Y31. In addition an SF program increments V1002 on each scan, and this value is also stored to V5000-V5009. The application uses System Layout Option #1. The following IP addresses are used:

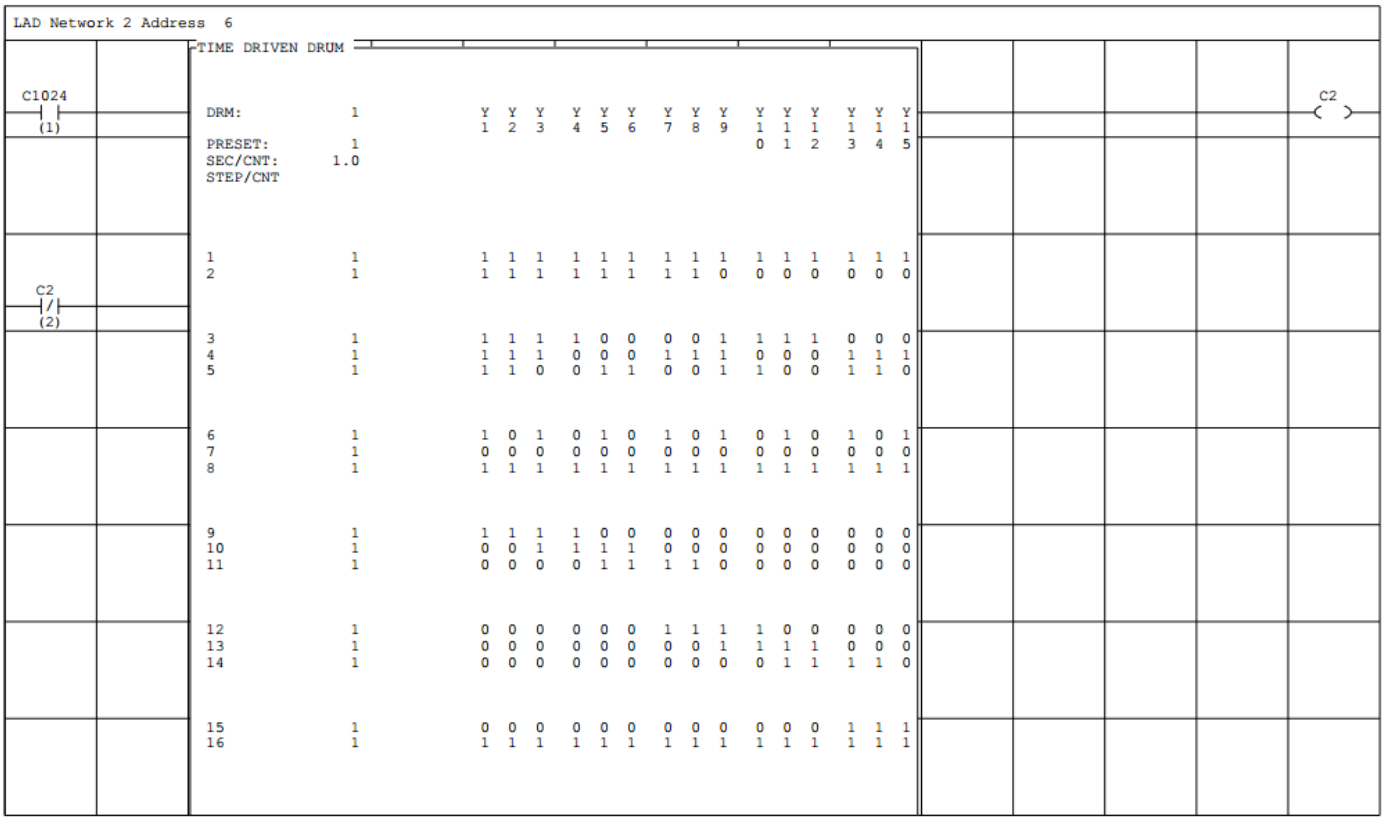
PLC-A	172.18.9.140
PLC-B	172.18.9.141
ACP1-A	172.18.9.152
ACP1-B	172.18.9.153

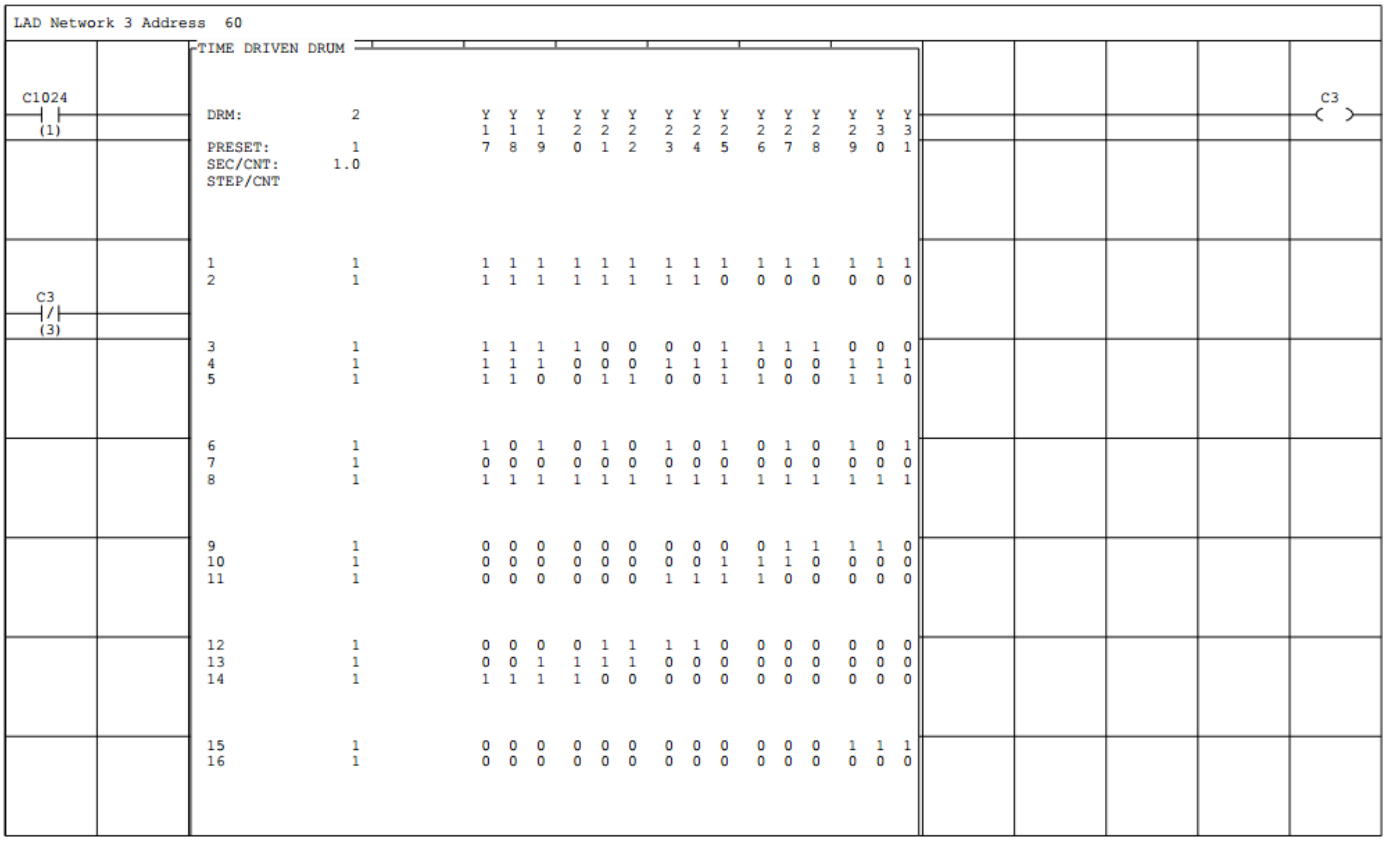
Program operation was first observed independently, and it was noted that over time the programs diverged because of differences in scan time, and the fact that execution of the programs cannot start at exactly the same instant. Therefore it was determined that the critical values to be transferred were:

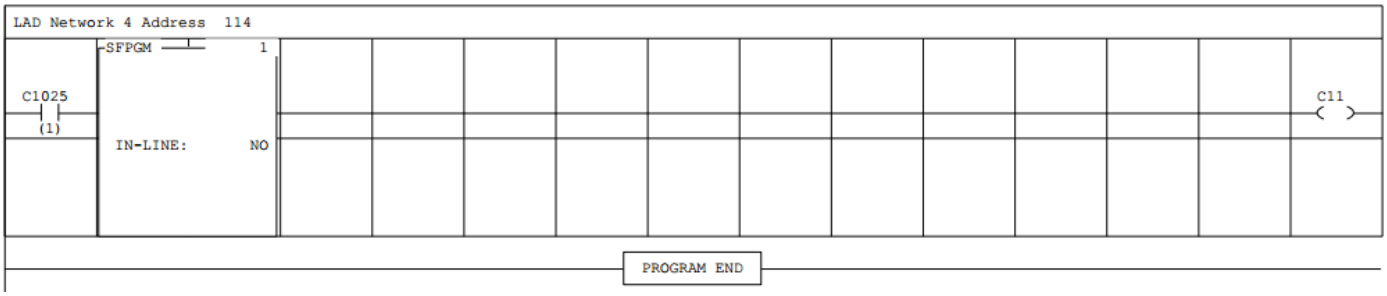
DSC1
DSC2
V1002

The example PLC program is shown below. The program is identical between the two PLCs.










```
SFP1
Program Title:   INC
Continue On Error:   Yes
Error Status Address:   None
Program Type:   Cyclic
Cycle Time (secs):   1
Enable Program:   Yes
Compiled:   Yes

00001   IMATH          V1002 := V1002 + 1
00002   FOR            COUNTER:                V1001
                       INITIAL VALUE:             0
                       INCREMENT:                 1
                       CONDITION:          V1001 < 11
00003   IMATH          V5000 ( V1001 ) := V1002
00004   NEXT
```

PROGRAM END

The PLC program includes documentation comments for the 2541 “home base” status variables and control bits. This data can be displayed using the chart template included.

2541 Configuration

For this example, the 2541 is configured as follows:

Normal Startup PLC - PLC A

Event Log - Wrap Around Events

Time Out Values:
I/O Update - 50ms
RBC Offline Declaration - 50ms

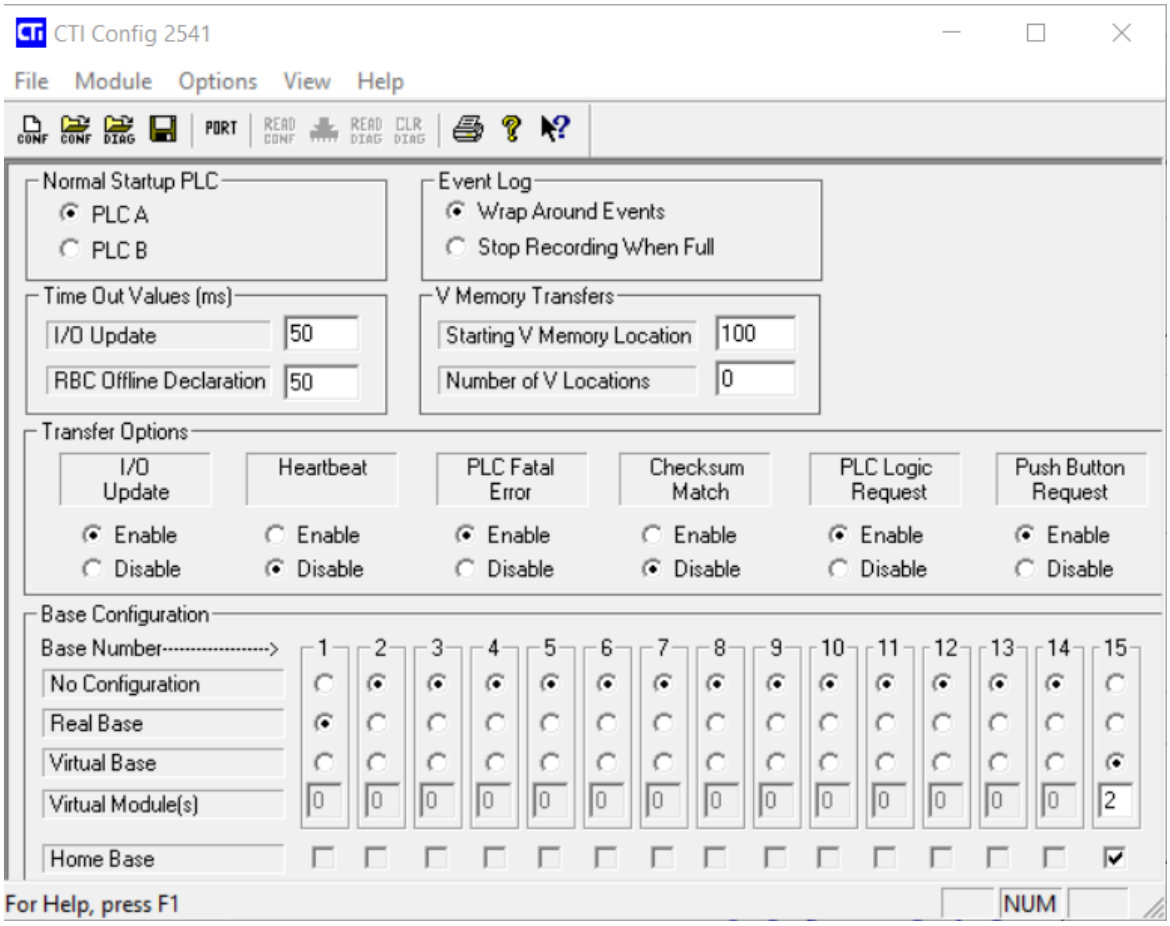
V Memory Transfers (disabled)
Starting V Memory Location - 100
Number of V Locations - 0

Transfer Options:
I/O Update - Enable
Heartbeat - Disable
PLC Fatal Error - Enable
Checksum Match - Disable
PLC Logic Request - Enable
Push Button Request - Enable

Base Configuration:
Base 1 - Real Base
Base 2-14 - No Configuration
Base 15 - 2 Virtual Modules, Home Base

The 2541 “home base” includes 32X in slot 1 and 32Y in slot 2. These inputs and outputs contain the status and control bits for the RPM as shown in the table below:

X33		PLC_A HAS CONTROL	ON D1
X34		PLC_B HAS CONTROL	OFF D1
X35		THIS PLC IS ACTIVE (1=YES)	OFF D1
X36		PLCA STATUS (1=OPERATIONAL)	ON D1
X37		PLC_B STATUS (1=OPERATIONAL)	ON D1
X38		CHECKSUM COMPARE (1=MATCH)	ON D1
X39		reserved	OFF D1
X40		reserved	OFF D1
X41		reserved	OFF D1
X42		NON-CRITICAL DATA TRANSFER COMPLETED	ON D1
X43		NON-CRITICAL DATA TRANSFER COMPLETED	OFF D1
X44		RPM HAS CONTROL	ON D1
X45		reserved	OFF D1
X46		RPM MODULE GOOD	ON D1
X47		reserved	OFF D1
X48		reserved	OFF D1
X49		I/O MONITOR (1=ENABLED)	ON D1
X50		HEARTBEAT MONITOR (1=ENABLED)	OFF D1
X51		PLC FATAL ERROR (1=ENABLED)	ON D1
X52		PLC LOGIC TRANSFER (1=ENABLED)	ON D1
X53		PLC PROGRAM CHECKSUM MATCH (1=ENABLED)	OFF D1
X54		FRONT PANEL PUSHBUTTON TRANSFER (1=ENABLED)	ON D1
X55		SWITCHOVER ENABLED	ON D1
Y65		REQUEST SWITCHOVER TO PLC_A	OFF D1
Y66		REQUEST SWITCHOVER TO PLC_B	OFF D1
Y67		HEARTBEAT BIT	OFF D1
Y68		SWITCHOVER INHIBIT	OFF D1



A copy of the 2541.CFG is included in the ZIP file for the example.

ACP1 Program

The ACP1 program consists of the following parts:

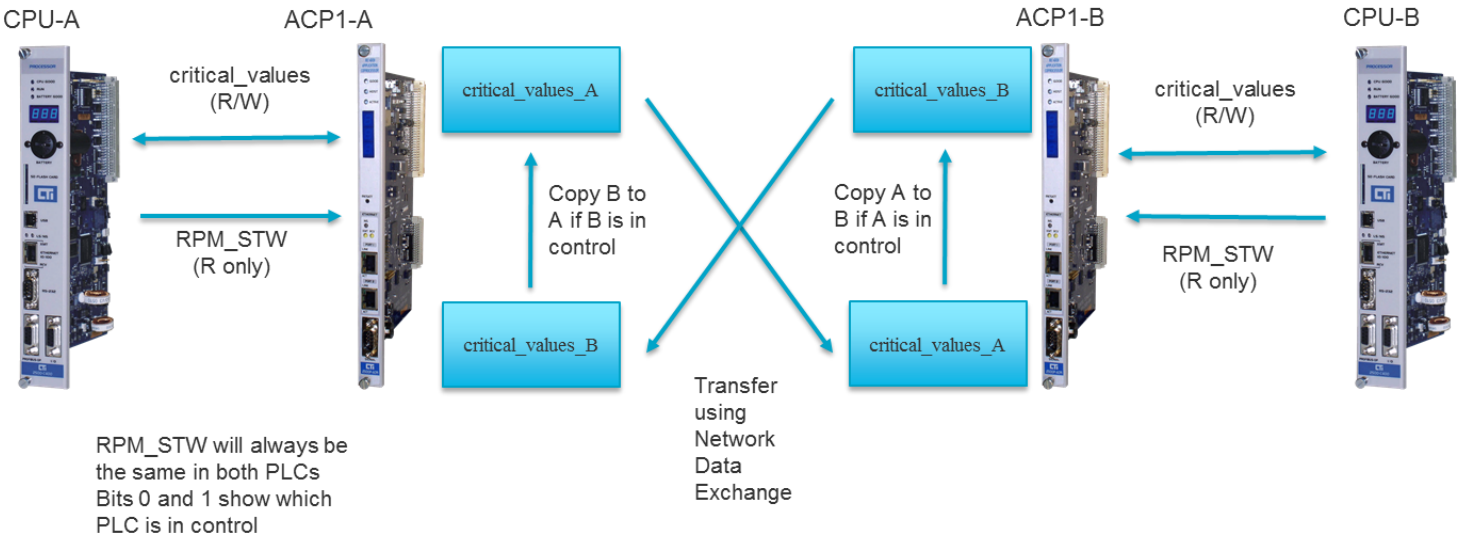
Variables - each ACP1 includes “local” and “remote” variables for DSC1, DSC2, and the COUNTER. The local variables are the values from the PLC that the ACP1 is attached to. The remote variables are the values from the other PLC. In addition, the ACP1 reads all the RPM status bits into variables.

Fieldbus configuration - is used in each ACP1 to read/write DSC1, DSC1, COUNTER, and read the RPM status variables.

Global binding configuration - is used to transfer the DSC1, DSC2, and COUNTER variables between ACP1 modules.

Copy_Critical_Values - program written in structured text which conditionally copies the “remote” values into the “local” values if this PLC/ACP1 is in the “standby” mode.

Operation of the ACP1 programs is shown below:

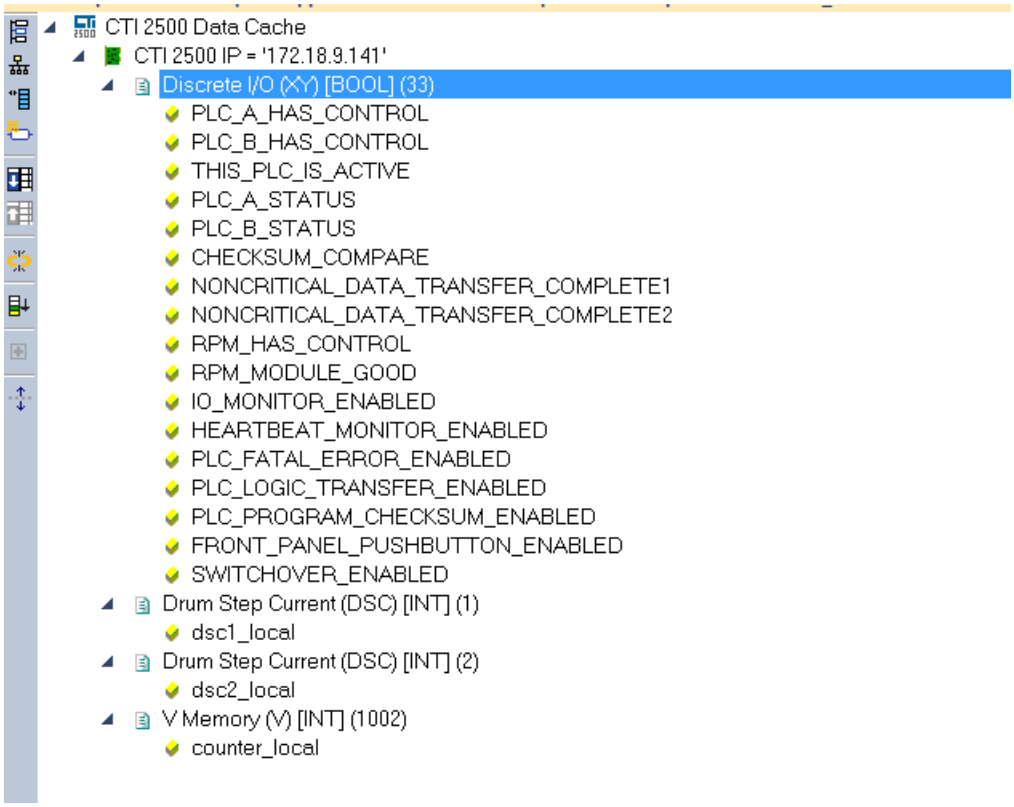


The Boolean variable THIS_PLC_IS_ACTIVE (read from X35 in each PLC) is used as the condition for copying remote data. Data is copied when this value is FALSE, mean the other PLC is in control. Since the other PLC is in control, we want its data to be the master for synchronization. For the example, we've also added a SYNCHRONIZE variable to allow the critical data synchronization to be turned off if desired. To disable the synchronization, set the SYNCHRONIZE variable to FALSE in either ACP1. This value is transferred between the ACP1s using Global Binding.

Variable List:

Global variables						
PLC_A_HAS_CONTROL	TRUE	BOOL			☐	
PLC_B_HAS_CONTROL	FALSE	BOOL			☐	
THIS_PLC_IS_ACTIVE	TRUE	BOOL			☐	
PLC_A_STATUS	TRUE	BOOL			☐	
PLC_B_STATUS	TRUE	BOOL			☐	
CHECKSUM_COMPARE	TRUE	BOOL			☐	
NONCRITICAL_DATA_TRANS...	TRUE	BOOL			☐	
NONCRITICAL_DATA_TRANS...	FALSE	BOOL			☐	
RPM_HAS_CONTROL	TRUE	BOOL			☐	
RPM_MODULE_GOOD	TRUE	BOOL			☐	
IO_MONITOR_ENABLED	TRUE	BOOL			☐	
HEARTBEAT_MONITOR_ENA...	FALSE	BOOL			☐	
PLC_LOGIC_TRANSFER_EN...	TRUE	BOOL			☐	
PLC_PROGRAM_CHECKSUM...	FALSE	BOOL			☐	
FRONT_PANEL_PUSHBUTTO...	TRUE	BOOL			☐	
SWITCHOVER_ENABLED	TRUE	BOOL			☐	
PLC_FATAL_ERROR_ENABL...	TRUE	BOOL			☐	
dsc1_local	11	INT			☐	
dsc1_remote	11	INT			☐	
dsc2_local	11	INT			☐	
dsc2_remote	11	INT			☐	
synchronize	TRUE	BOOL			☐	TRUE
counter_local	446	INT			☐	
counter_remote	446	INT			☐	

Fieldbus Configuration:



Symbol	Offset
PLC_A_HAS_CONTROL	0
PLC_B_HAS_CONTROL	1
THIS_PLC_IS_ACTIVE	2
PLC_A_STATUS	3
PLC_B_STATUS	4
CHECKSUM_COMPARE	5
NONCRITICAL_DATA_TRANSFER_COMPL...	9
NONCRITICAL_DATA_TRANSFER_COMPL...	10
RPM_HAS_CONTROL	11
RPM_MODULE_GOOD	13
IO_MONITOR_ENABLED	16
HEARTBEAT_MONITOR_ENABLED	17
PLC_FATAL_ERROR_ENABLED	18
PLC_LOGIC_TRANSFER_ENABLED	19
PLC_PROGRAM_CHECKSUM_ENABLED	20
FRONT_PANEL_PUSHBUTTON_ENABLED	21
SWITCHOVER_ENABLED	22

Global Binding Configuration:

Global Binding Editor - ACP1_A

	ACP1_A	ACP1_B
ACP1_A [172.18.9.152:9000]		
Connection Status		
11:dsc1_local		dsc1_remote
12:dsc2_local		dsc2_remote
13:counter_local		counter_remote
14:synchronize		synchronize
ACP1_B [172.18.9.153:9000]		
Connection Status		
11:dsc1_local	dsc1_remote	
12:dsc2_local	dsc2_remote	
13:counter_local	counter_remote	
14:synchronize	synchronize	

copy_critical_values Structured Text Program:

```
1 // If this PLC is not active (THIS_PLC_ACTIVE=0) and the SYNCHRONIZE switch is on, then
2 // we want to copy all the "remote" variables into the "local" variables
3 if THIS_PLC_IS_ACTIVE=0 and synchronize=1 then
4     dsc1_local:=dsc1_remote;
5     dsc2_local:=dsc2_remote;
6     counter_local:=counter_remote;
7 END_IF;
8
```

EXAMPLE PROJECT FILE

The example project file 2541_ACP1.zip can be downloaded from the CTI web site here:

http://www.controltechnology.com/Files/Products/2500-Classic/2541/other/2541_ACP1

It contains the following files:

This application note	pdf
2451_ACP1_Projects.zip	Workbench Workspace backup
PLC_A.FSS	Workshop file for PLC_A
PLC_B.FSS	Workshop file for PLC_B
PLC_A_DATA.wdt	Workshop data template for PLC_A
PLC_B_DATA.wdt	Workshop data template for PLC_B
2541.CFG	Configuration file for 2541

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