SIEMENS

APPLICATION DATA

AD353-109
Rev 2
November 2005

Procidia™ Control Solutions
Dedicated Backup in a Single Variable Control Loop

In critical control applications, a dedicated backup controller can provide increased security. This paper provides guidelines for designing, wiring, and configuring a single variable process control loop that includes a dedicated backup controller. The controllers shown are Model 353 Process Automation Controllers[1], highly reliable, multiple-loop controllers frequently used in process control applications. See Figure 1.

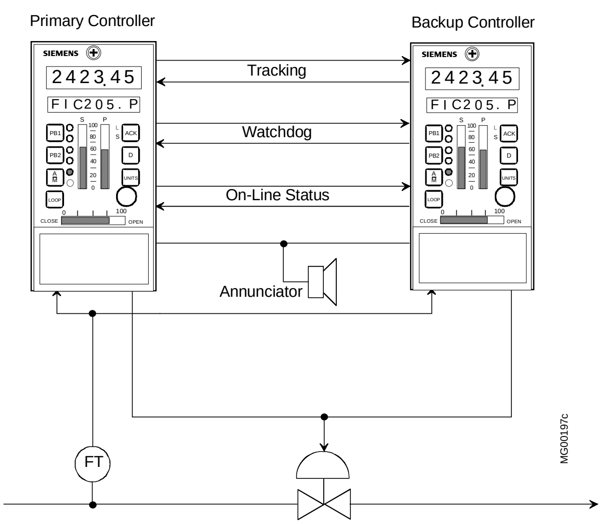


Figure 1 Dedicated Backup

Application features include:

- Watchdog monitoring of both primary and backup controllers
- Controlled element variable output signal tracking for bumpless control transfer
- Setpoint tracking
- Controller on-line and off-line transfer configuration

[1] See Application Support at the back of this publication for a list of controllers.

Operation

A single variable process control loop consists of one measured variable (e.g. flow rate) and one controlled element variable (e.g. flow control valve). In a dedicated backup controller application, both the primary and backup controllers monitor the measured variable. The primary controller generates the controlled variable output signal while the backup controller tracks the signal. Since both controller outputs are wired to the control valve, the backup controller is configured to disconnect its analog output block from the load. This prevents the backup controller from interfering with the process.

The primary controller controls the process while the backup controller is off-line. While off-line, the backup controller tracks both the output variable and setpoint signals from the primary controller. Tracking these signals allows for a bumpless transfer.

Watchdog monitoring is critical to a back up control system. In this application, each controller monitors the status of the other. For example, if the primary controller fails, the watchdog status changes. The backup controller reads the status change, switches to on-line mode to take control of the process control loop, and activates an external alarm to notify operating personnel. Since the dedicated backup control strategy depends on a functioning backup controller, the primary controller monitors the backup controller's watchdog status and activates an alarm if there is a failure.

Hardware Requirements

Hardware requirements are modest. Two Model 353 Process Automation Controllers with the I/O Expander Board option are needed.

Several hardware options are available. Specifying the Ethernet Communication Board for each controller can reduce station-to-station wiring by transferring the output tracking, setpoint tracking, and on-line status values across the Ethernet network.

Some process applications can consume a portion of the controller's internal I/O needed for the dedicated backup circuits. External Ethernet I/O modules can be added when the Ethernet Communication Board option is selected.

WIRING AND CONFIGURATION

Figure 2 shows the basic wiring needed for this application. Additional connections will be needed for either controller to operate and for the options discussed above. Refer to the controller's User's Manual for additional information.

Figure 3 shows the configuration for primary and backup controllers. Either controller can be the primary or backup. The on-line controller is identified by the lighted green LED next to PB1 on its faceplate. Table 1 itemizes the I/O requirements for a single variable control loop with dedicated backup.

The transmitter is also connected to the analog input 1 function block, AIN1+, in both controllers. A voltage signal is needed so a precision 250Ω resistor is installed to convert the transmitter's 4-20 mA signal to 1-5 Vdc.

Controlled Element Output Signal

The single-variable control configuration uses analog output 1 function block, AOUT1, to manipulate the controlled element. The output is a 4-20 mA signal. As only one controller's output signal may regulate the controlled element, the off-line controller disconnects its analog output signal from the load. AOUT1 is disconnected when the "not on-line" state, NOT3, is high (1). The configuration allows only one controller to be on-line at a time, otherwise current summing would occur.

Setpoint and Output Variable Tracking

Tracking signals are wired from one controller to the other. The setpoint tracking signal is wired from AOUT2 to AIN2 and the output tracking signal is wired from AOUT3 to AIN3. These current output signals are converted to a voltage by precision 250Ω resistors.

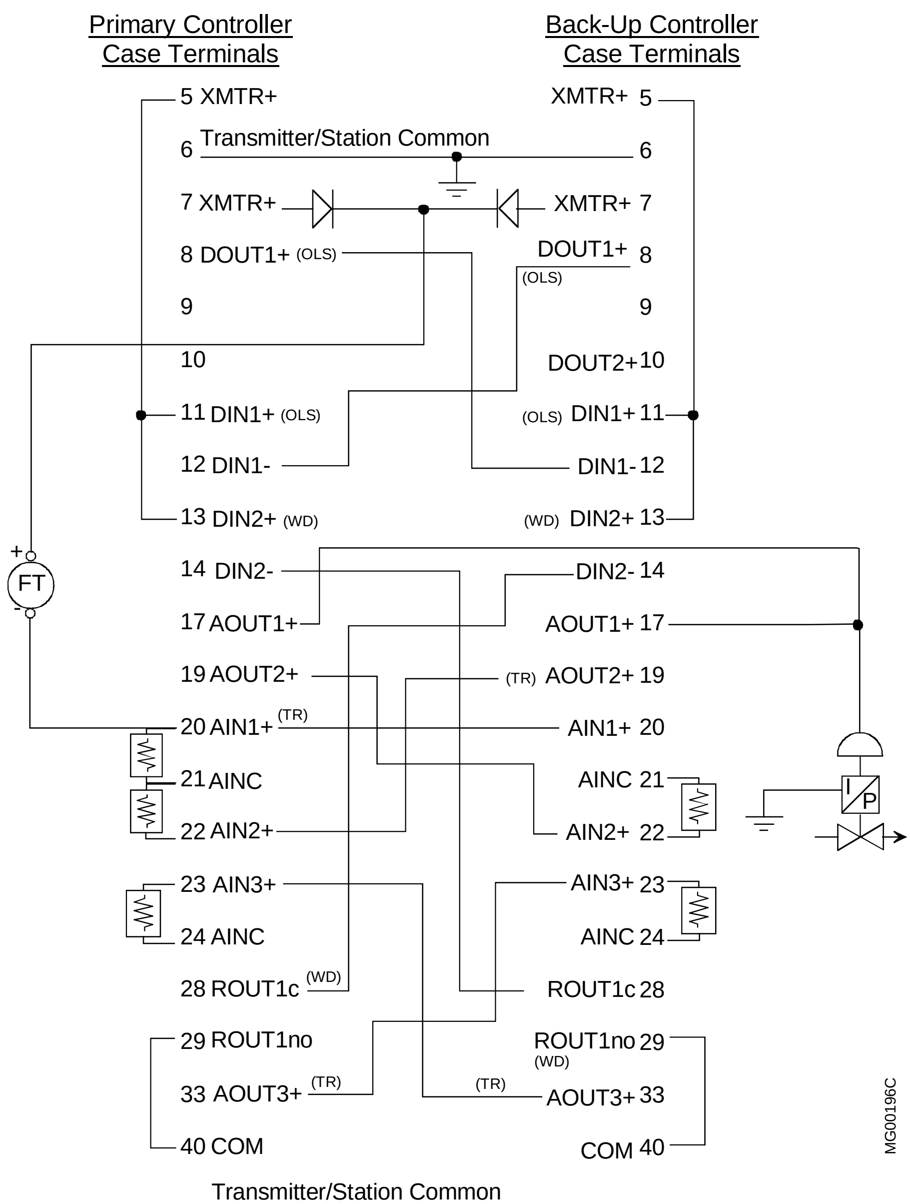
SIGNAL	PRIMARY	BACKUP
Measured Variable	AIN1	AIN1
Setpoint Tracking	AIN2	AIN2
Output Variable Tracking	AIN3	AIN3
Controller Element Variable Output	AOUT1	AOUT1
Setpoint	AOUT2	AOUT2
Output Variable	AOUT3	AOUT3
On-Line Status Monitoring	DIN1	DIN1
Watchdog	DIN2	DIN2
On-Line Status	DOUT1	DOUT1
Controller OK Status	ROUT1	ROUT1
External Alarm	ROUT2	ROUT2

Table 1 I/O Requirements

Measured Variable

In this application example, the measured variable is supplied by a 2-wire transmitter (FT) that is powered through a diode OR circuit connected to both controllers. If the 26 Vdc power supply of one controller fails, the remaining controller will power the transmitter.

The backup controller is in an off-line "stand-by and track" mode. In Figure 3, the "not on-line" state, NOT3, maintains the A/M and SETPT blocks in a stand-by and track mode. The A/M block tracks the time delayed output from DTM2, and the SETPT block tracks the time delayed setpoint from DTM1. When the controller goes on-line, the A/M and PID blocks go into automatic mode and the external signal relay is energized.

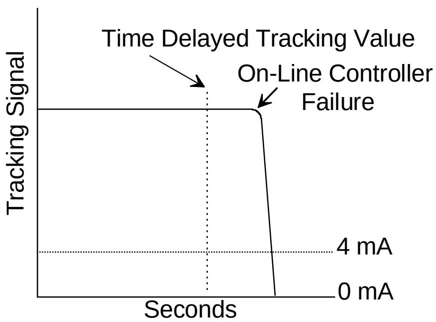


Notes:

1. Transmitter/Station Common ground connection shown by
2. Range Resistor, typically 250 Ohms, shown by
3. Terminal numbers are for Models 353 and 354. Model 352P terminal numbers will be different. Only the terminals used in this application are shown. Controller must have an I/O Expander Board.
4. Function block IDs are for Models 352P, 353 and 354.
5. TR = Tracking; WD = Watchdog; OLS = On-Line Status

Figure 2 Basic Wiring

The variable tracking and setpoint tracking values in the backup controller are time delayed a few seconds. As shown below, in the event of failure of the on-line controller, the backup controller has access to the tracking data produced seconds before the on-line controller failed and uses this data when it goes on-line. This minimizes the bump that can occur when there is a transfer of control.



Tracked values are saved in a dead-time table function block, DTM (see Figure 3). The DTM block has a minimum dead time of 0.1 minutes. The table is subdivided into 50 registers and the value in any register can be accessed by specifying the appropriate AT Input value. To configure a time delay of 3 seconds, for example, set the dead time in the DTM block to 0.1 minutes and set the value in HOLD block, HLD1, to 25.

Watchdog and On-Line Status:

The watchdog circuit monitors the status of the primary and backup controllers. If the primary controller goes off-line, the watchdog signals the on-line status circuit to initiate a bumpless switchover to the backup controller. The watchdog also provides a relay transition to annunciate the event. If the backup controller fails, the watchdog annunciates the event so that the system can be serviced.

Each controller has two internal relays: ROUT1 and ROUT2. ROUT1 is used in the watchdog circuit and ROUT2 is used in the annunciation circuit.

The watchdog signal is a closed circuit from one controller through the contacts of the second controller's ROUT1 relay. Each controller holds ROUT1 energized so the normally open contacts are closed. Should the primary controller's power supply or microprocessor fail, for example, the relay de-energizes and the watchdog circuit opens. The backup controller reads the open circuit, goes on-line, and activates an external alarm to notify operating personnel.

The on-line status circuit includes digital output 1, DOUT1, and digital input 1, DIN1. It allows the transfer of control of the process from one controller to the other. DOUT1 is a switching gate that pulls DIN1-low to initiate switchover.

As shown in Figure 3, watchdog logic includes a NOT block, NOT1, that enables the controller's OK status, ROUT1. The watchdog input, DIN2, monitors the other controller's OK status. If the status goes low, the external alarm, ROUT2, is annunciated and a message is flashed on the alphanumeric display, using the U1 input of the ODC block.

The on-line control logic is key to the dedicated backup control strategy. Once a primary or backup controller failure is detected, the functioning controller will maintain control of the process. This permits the replacement of a failed controller without shutting down the process.

A controller will go on-line when one of the following occurs:

- the watchdog signal goes low
- the other controller goes off line
- an operator pushes On-Line Toggle pushbutton PB1

A controller will go off-line when one of the following occurs:

- the other controller goes on-line
- an operator pushes the On-Line Toggle pushbuttom PB1, and the other controller's OK status is high

The On-Line Control logic consists of a Set-Reset Flip-Flop block, SRF1, two AND blocks and a NOT block. The AND blocks filter input signals to either the S or R input depending on the state of the SRF block. This is the basis of the toggle configuration. The NOT3 block is used to enable the AND1 gate. Note that the ESN[2] number of NOT3 is less than that of SRF1. This forces a one scan cycle break in the logic and prevents the SRF block from resetting itself. When using an SRF block, logic needs to be initiated from a change of state event rather than the state of a logic condition. Rising Edge Trigger, RTG, and Falling Edge Trigger, FTG, blocks provide the transitions.

Controller Scan Time Consideration

When the primary controller is taken off-line or experiences a power failure, the analog output signal to the controlled element is interrupted. It takes the backup controller at least two scan cycles to restore the control signal to the control element. Depending on the

[2] Execution Sequence Number

response characteristic of the control element, it is important to consider the signal interruption that occurs during the control transfer. The control strategy for a single-variable control loop, as illustrated in figure 3, has a scan cycle time of 40 milliseconds.

The loss of the watchdog or on-line status signal of the primary controller is the event that triggers the transfer of control. This event can occur anytime during a scan cycle of the backup controller. After the first complete scan cycle, the backup controller's "on-line state" block, SRF1, goes high. After completion of the second scan cycle, the controller is in automatic mode and the controlled variable output block has been enabled. Note that the ESN of the "not on-line state" block, NOT3, is lower than that of the SETPT, PID and A/M blocks.

There are a few instances where both controller outputs are enabled causing a momentary current summing spike. The duration of the spike will depend on the difference in scan cycle times between the primary and backup controllers. If the backup controller is brought on-line by pressing the PB1 pushbutton, it may be in control before the primary controller can disconnect its analog output block.

Start-Up Considerations

Several process start-up scenarios can be developed through configuration alternatives and setting of the controller's Real Time Clock jumper for a warm or a cold start.

When primary and backup controllers are configured for a cold start and have had input power removed, both controllers will power up in the off-line state, because that is the power up state of the SRF block. They will both track a value of zero for the setpoint and output variable. Put the primary controller on-line by pressing On-Line Toggle pushbutton PB1 and adjusting the setpoint to the desired value.

Application Support

Other Application Data sheets in this series can be found at the Siemens public Internet site. Detailed information about function blocks mentioned in this publication can be found in the User's Manual for each controller.

Siemens sales representatives in the United States and globally are available to provide additional application support.

The configuration(s) shown in this publication were created in Siemens i|config™ Graphical Configuration Software. Those with CF353 in parenthesis in the Figure title are available on the Siemens public Internet site.

The configuration(s) in this publication can be created in these controllers: Model 353 Process Automation Controller, Model 353R Rack Mount Process Automation Controller (i|pac™ Internet Control System), Model 352*Plus*™ Single-Loop Digital Controller, Model 354 Universal Control Station, and Model 354N Universal Loop Controller (model series 354 discontinued).

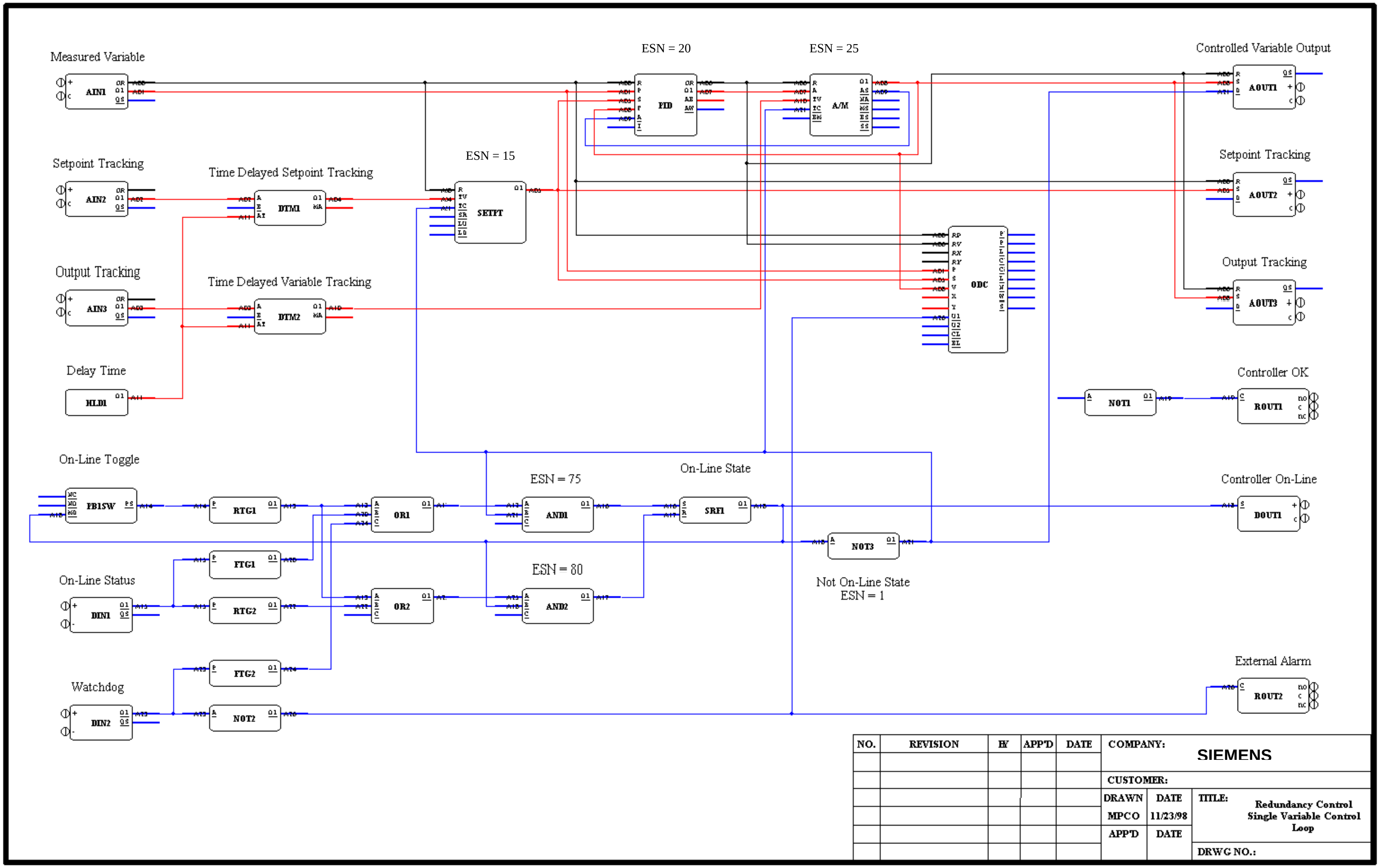


Figure 3 Controller Configuration (CF353-109)