



Application Note

Using the PCD's Directional Power Relay to Automatically Supervise Protection Settings

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Introduction

It is becoming more common to set up loop systems using reclosers to maximize circuit reliability and solve unique loading problems. Most loop systems have a normally open point with automatic reconfiguration logic. Some have a normally open point, which is manually closed for reconfiguration due to load conditions or fault isolation. On occasion, closed loop systems are employed. Setting up a loop system introduces the challenge of setting the correct protection settings for proper coordination in either direction. Two protection groups (a primary and an alternate) are typically required.

Considering the need for multiple setting groups, when a tie recloser is manually closed locally, it is not always apparent to the operator which protection group should be used. Even with a SCADA close to tie feeders together, it is not always apparent which direction the current will flow. Furthermore, while the ABB automated loop system has logic to automatically change protection settings depending on which side loses voltage, there are situations where the utility manually reconfigures the automated feeders, and as a result, the loop system doesn't automatically set the protective group.

To address these issues, it is useful to detect the direction of power flow and automatically change the settings accordingly. When performing this coordination, difficulties may arise. This paper addresses how to handle the coordination problem with the PCD control programmed with a simple logic scheme. This feature can be used in conjunction with the automated loop scheme that ABB offers.

The following are requirements for the successful application of the directional power relay (32P):

- Knowledge of the normal power flow phase angle (leading or lagging angle)
- Knowledge of the phase rotation (ABC or ACB)
- Three voltage transformers on one side of the recloser
- PCD controlled recloser
- WinPCDT2 configuration software
- Desired protective settings for each direction of power flow

The PCD has an advanced programmable logic feature giving flexibility to create protective schemes to match virtually any application. The 32 protection relay is easy to activate and apply in steady state conditions, however it must have "memory" of its state, so when there is a multiple operation fault, it remembers the desired state through the complete sequence. The PCD has this capability. This application note addresses how the PCD handles this requirement.

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Follow these steps for programming the directional power flow element:

1. Determine the normal power flow angle. This is determined from the relationship between V1 and I1. The primary protection group should be used for the normal power flow conditions. The protective element 32P is set to detect a reverse power condition, and therefore should be set 180 degrees from this angle (this will be the “ideal” angle for the 32P element). The 32 element will then pick-up within approximately +/- 90 degrees of this ideal value. The pickup will be immediate. The programmed logic will have a post delay time to keep the setting held for reclose sequences.
2. Open WinPCDT2 and add a unit. Communicate with the PCD while programming and send the settings to the PCD as you proceed.
3. Program the 32 relay in the Primary and Alternate Protection Groups with the following settings:
 - a. 32P Phase Directional Power Flow Function: select Enable
 - b. 32P Torque Angle: Ideal angle for the 32P. This setting must be set from 0 – 355 degrees increasing counter. In this example, assume normal power flow has unity power factor where the positive sequence current is in phase with the positive sequence voltage. Therefore, the ideal torque angle is 180 degrees (see Figure 1 below).
 - c. 32N Neutral Directional Power Flow Function: Not Used
 - d. Note that the Primary and Alternate 1 settings are to be set exactly the same with respect to the 32P function. The protection settings are what is required for that direction of power flow.

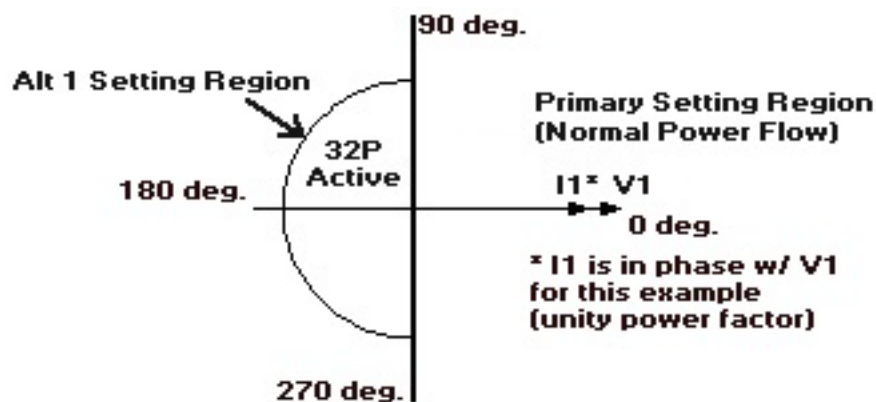


Figure 1: Torque Angle Selection

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The programmable inputs and outputs must be programmed as follows:

1. From the main menu, select Settings – Programmable Inputs. There are a number of feedback contacts called FB1, FB2, etc. on the top row. Three of these feedbacks must be available. If not, proceed to step 2, otherwise skip to step 3.
2. To attain additional feedbacks, from the Main Menu, select Settings – Feedback Allocation Mask. Under this menu, assign the last three contacts as Feedbacks. Send to the unit. Next, go back to the Programmable Inputs menu.
3. With the programmable inputs/outputs menu, build a set-reset latch to latch in the 32P element. If reverse power flow is detected, the PCD will switch immediately and latch in to Alternate 1 settings. The latch will subsequently be removed if the power flow is in the forward direction for a defined amount of time (latching time). This time is selected based on the greatest open time interval in the Alternate 1 settings. For example, if the greatest open time is after the third trip and is 15 seconds, it is recommended to choose a latch time of 16 seconds or greater.
4. The logic diagram describing the desired operation is shown in Figure 2. This group of logic gates can be implemented using the programmable input/output logic of the PCD programmable I/O.

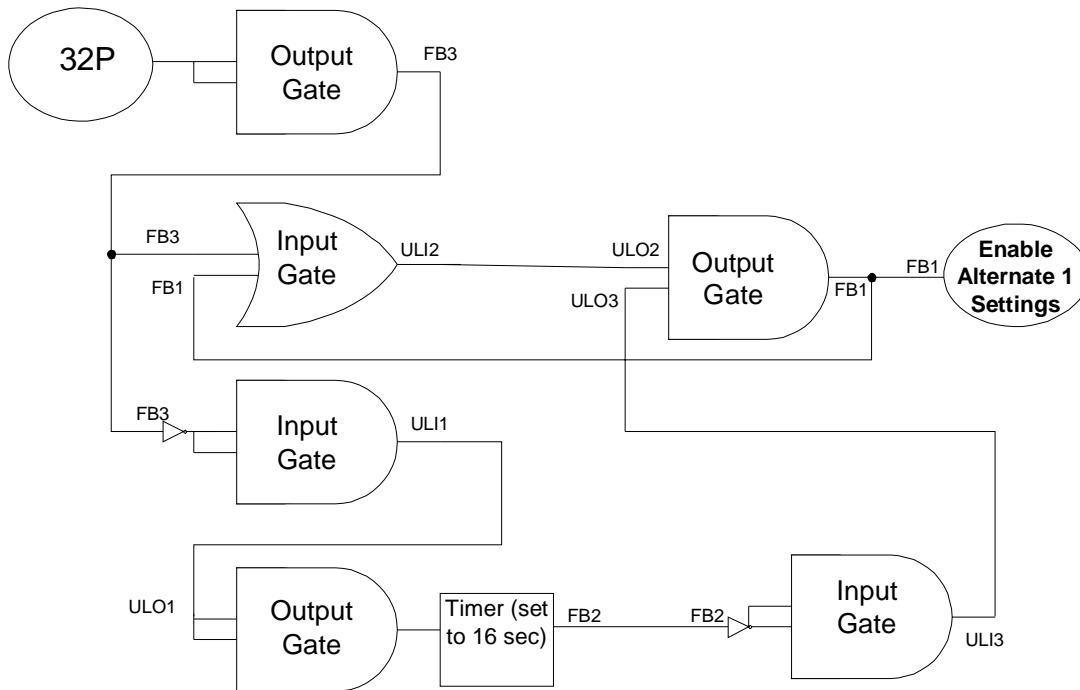


Figure 2: Logic Diagram for 32P Latching

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5. The programmable Inputs table for this logic scheme is shown in Figure 3.

	Logic	In1b	In2b	In3b	In4b	In5b	In6b	In7b	In8b	In1c	In2c	In3c	In4c	FB4	FB3	FB2	FB1
Names:															32 Set	Reset	Latch
52aA	AND	C															
52aB	AND		C														
52aC	AND			C													
52bA	AND				C												
52bB	AND					C											
52bC	AND						C										
52A	AND							C									
52B	AND								C								
ULI1	AND													0			
ULI2	OR													C			C
ULI3	AND														0		
ALT1	AND																C
----	AND																
----	AND																
----	AND																
----	AND																

C = Enable = Closed, Disable = Opened
 0 = Enable = Opened, Disable = Closed

Receive Data from Database Receive Data from Unit Send Data to Unit Send Data to Database Print... Back

Figure 3: WinPCD Programmable Inputs Table

6. The programmable Outputs table for this logic scheme is shown in Figure 4.

	Out1b	Out2b	Out3b	Out4b	Out5b	Out6b	Out7b	Out8b	Out1c	Out2c	Out3c	Out4c	FB4	FB3	FB2	FB1	
Timers:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16	0.00	
Names:															32 Set	Reset	Latch
Logic:	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	AND	AND	AND
TRIPA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CLOSEA	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TRIPB	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CLOSEB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TRIPC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CLOSEC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TRIP	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CLOSE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32P	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ULO1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ULO2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ULO3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
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----	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Receive Data from Database Receive Data from Unit Edit Timer... Send Data to Unit Send Data to Database Print... Back

Figure 4: WinPCD Programmable Outputs Table

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Testing the programmable logic:

1. Once programmed, test the logic by using a three-phase test set. In addition to observing the status of the Alternate 1 LED, you can use WinPCD's Test – Logical Output menu to observe the behavior of the 32P element.
2. To choose the torque angle, compare the positive sequence current I1 with the positive sequence voltage V1 (see Figure 5). This is the metered value from the PCD displayed on the metering screen (also displayed in the PCD's HMI). Also note that this figure shows the phase rotation as ABC, i.e., B lags A by 120 degrees and C lags B by 120 degrees.

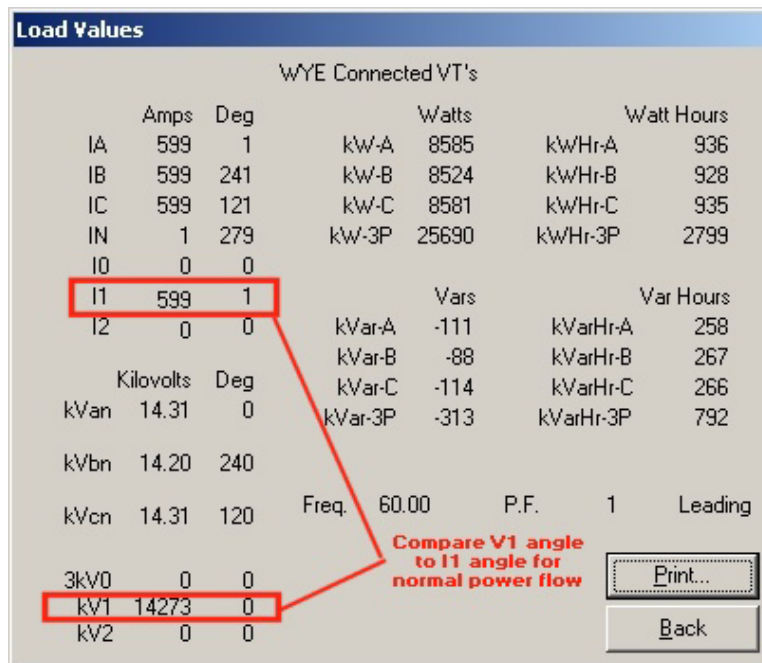


Figure 5: WinPCD Metering Screen

3. Figure 6 shows the corresponding input screen from an Omicron Test Set, the source for our “normal power flow” metered values shown in Figure 5. This test set allows the user to observe the behavior of the 32P across the range of phase angles.

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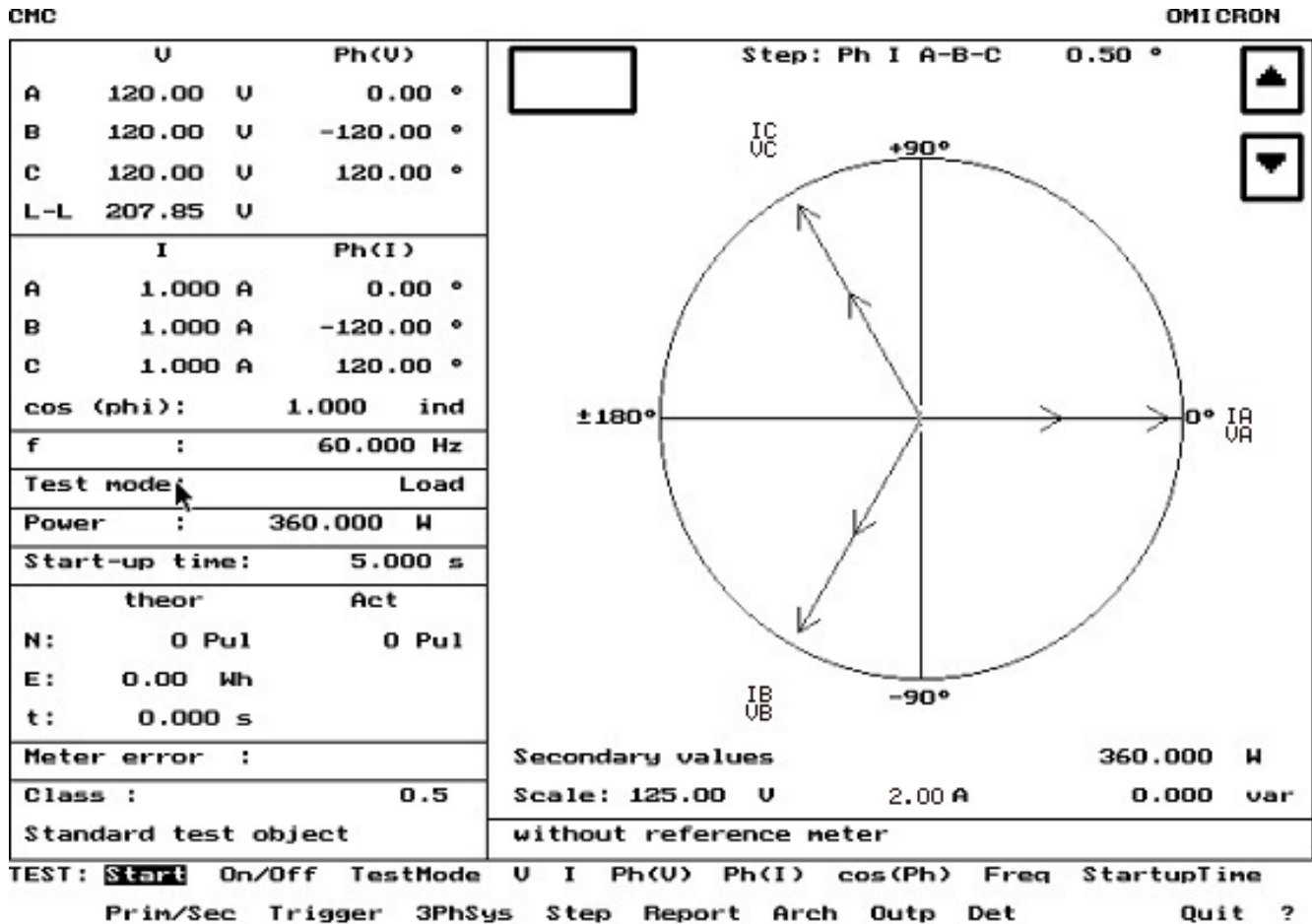


Figure 6: Omicron Metering Screen

- While testing the PCD's directional elements and logic, the Test menu of WinPCD will allow you to monitor the 32P status (Logical Output Status) and the status of the contacts (Physical Output Status). This is a useful tool for testing this functionality.

The latest information on the PCD control can be found at our website at www.abb.com/mediumvoltage. (Select PCD from the dropdown Shortcuts menu.)

For additional support or information please call ABB Inc. at 1-800-929-7947 Ext. 5 then 1 or +1-407-732-2000 Ext. 2510.

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