Application Note

Substation Automation and Protection Division

Logic Programming for the DPU2000R Feeder Protection Relay

The DPU2000R has extensive logic processing capability that allows the user great flexibility in creating protection and control schemes. The logic building blocks inside of the DPU2000R can be combined with external devices (switches, relays etc.) to implement most substation applications. Using the Windows-based software program, WinECP, the configuration of the relay inputs and outputs can be accomplished quickly and easily. This Application Note describes the building blocks and programming techniques required for the creation of customized protection and control logic schemes.

Physical I/O

The DPU2000R can interface with all of the common substation control devices. The DPU2000R comes equipped with terminations on the rear of the unit for connection of physical input and output control wiring. The relay has terminations for eight inputs and eight outputs. Six of eight the outputs are available for customized schemes. Two of the eight are pre-programmed for the Master Trip, and Self Check alarm functions. For more information on the Master Trip and Self Check Alarm, please see Section 6 of the Instruction Book, “Programmable Input and Output Contacts”.

Logical I/O

The DPU2000R has several “logical” inputs and outputs that can be used in creating control schemes. These Logical I/O are “soft” control and status points that are asserted by physical inputs and mapped to physical outputs to turn on output relays. The Techniques for mapping these logical points is the focus of this paper. A complete list defining all of the available logical I/O points for the DPU2000R can be found in Section 6 of the Instruction Book, “Programmable Input and Output Contacts”.

Logical Inputs:
Logical Inputs can be mapped to physical inputs to either enable a protective feature, initiate a control algorithm, or provide status information to the DPU2000R. Examples of the different types of Logical Inputs are listed below in Tables 1, 2 and 3.

Table 1 - Enable / Disable Protective Function Logical Inputs

GRD	Enables 51N, 50N-1, 50N-2. When the GRD input is a logical 1, all ground overcurrent protection except 50N-3 is enabled. GRD defaults to a 1 (enabled) if not mapped to a physical input or feedback term.
PH3	Enables 51P, 50P-1, 50P-2. When the PH3 input is a logical 1, all phase overcurrent protection except 50P-3 is enabled. PH3 defaults to a 1 (enabled) if not mapped to a physical input or feedback term.
67N	Enables the directional ground time overcurrent function. When the 67N input is a logical 1, 67N time overcurrent protection is enabled. 67N defaults to a 1 (enabled) if not mapped to a physical input or feedback term.

Table 2 - Control Function Initiate Logical Inputs

79S	Single Shot Reclosing. Initiates a single shot of reclosing when the DPU2000R determines that the breaker has been opened by an external means. When the 79S input is a logical 1, single shot reclosing will be initiated. 79S defaults to a 0 (disabled) if not mapped to a physical input or feedback term.
OPEN	Initiates Master Trip output. When OPEN is a logical 1, a trip is issued to the Master Trip output. OPEN defaults to a 0 (disabled) if not mapped to a physical input or feedback term.
BFI	Breaker Fail Initiate. When the BFI input is a logical 1, the Breaker Fail Trip Logic will be initiated. BFI defaults to a 0 (disabled) if not mapped to a physical input or feedback term.

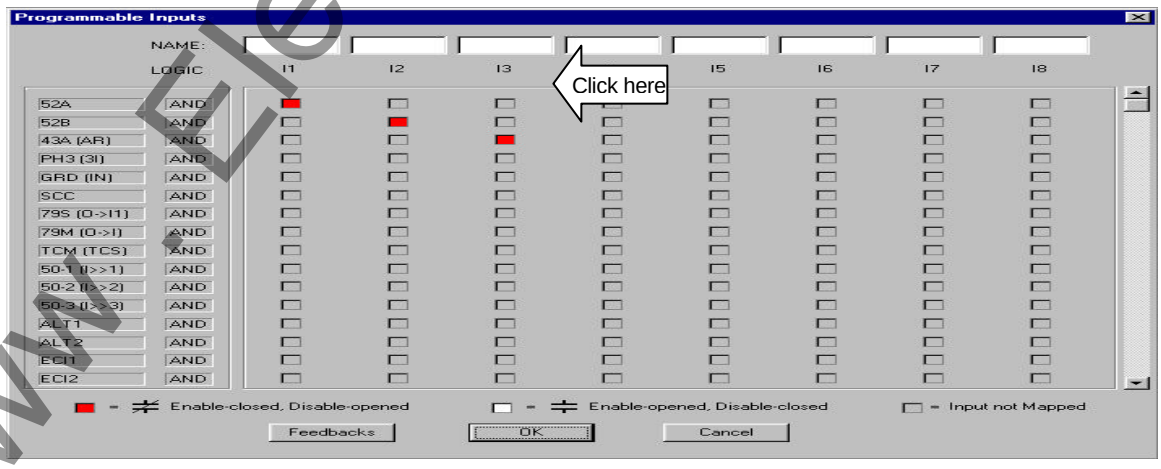
Table 3 - Status Logical Inputs

52A	Breaker Position Input. Required by the DPU2000R (except when in MDT Mode) to determine circuit breaker state for initiation of OPEN, CLOSE, Trip Fail and Close Fail Logical Outputs. When the 52A input is a logical 1 (and 52B is a logical 0), the relay assumes a closed breaker condition.
52B	Breaker Position Input. Required by the DPU2000R (except when in MDT Mode) to determine circuit breaker state for initiation of OPEN, CLOSE, Trip Fail and Close Fail Logical Outputs. When the 52B input is a logical 1 (and 52A is a logical 0), the relay assumes an open breaker condition.
TCM	Trip Circuit Monitor. Assign to a double-ended input (IN7 or IN8) to monitor continuity of the circuit breaker trip path. When TCM is a logical 1, the relay assumes the trip path is healthy. If TCM becomes a logical 0, the relay assumes a break has occurred in the trip path, and the TCFA (Trip Coil Fail Alarm) Logical Output asserts. TCM defaults to a 1 (trip path healthy) if not mapped to a physical input or feedback term.

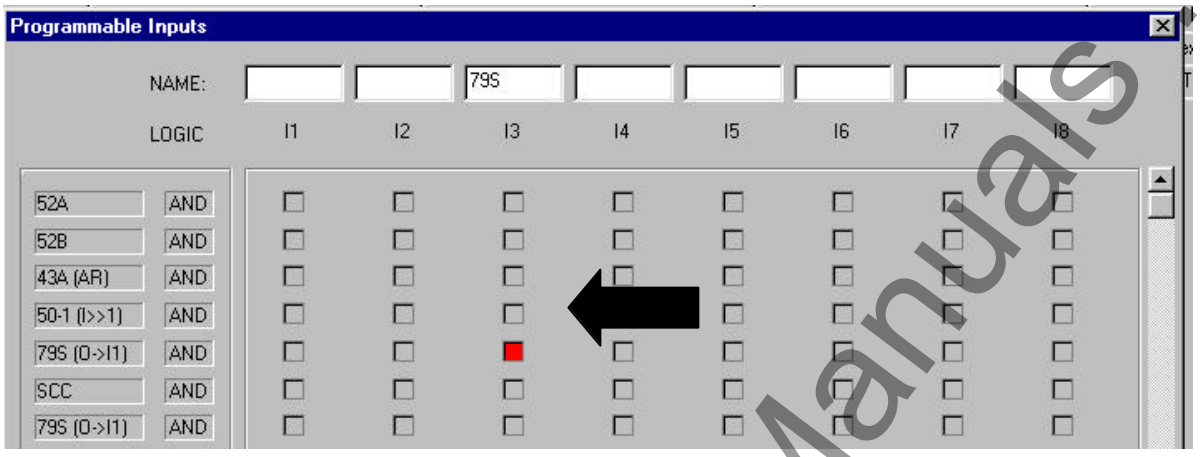
Logical Inputs can be mapped with Enabled Open or Enabled Closed logic. Enabled Open Logic will assert the Logical Input when voltage is present on the associated physical input, and Enabled Closed Logic will assert the Logical Input when no voltage is present. In this way, NOT logic is accomplished by choosing Enabled Open Logic in the Programmable Input Map. The logic can be changed by repeated clicks of the left mouse button with the cursor positioned in the square adjacent to the Logical Input.

The following programming examples show how to map the various Logical Inputs discussed so far.

Example 1: Mapping a Control Function



The screen capture below shows how to map the Single Shot Reclose (79S) to a physical input to initiate a single reclose. See Section 5 of the Instruction Book, “Interfacing with the Relay” for instructions on how to install and use WinECP.

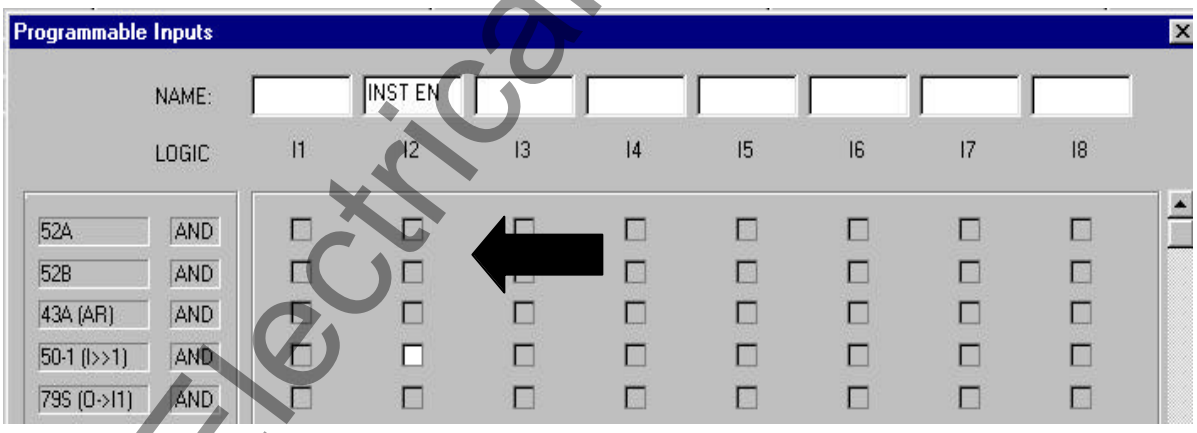


Logical input 79S will be asserted when physical input I3 receives a positive voltage. The Boolean Logic expression for the above map is:

79S INITIATE = I3

Example 2: Enabling a protective function.

The following screen capture shows how to enable the level 1 phase and ground instantaneous overcurrent element (50-1) by mapping it to a physical input.

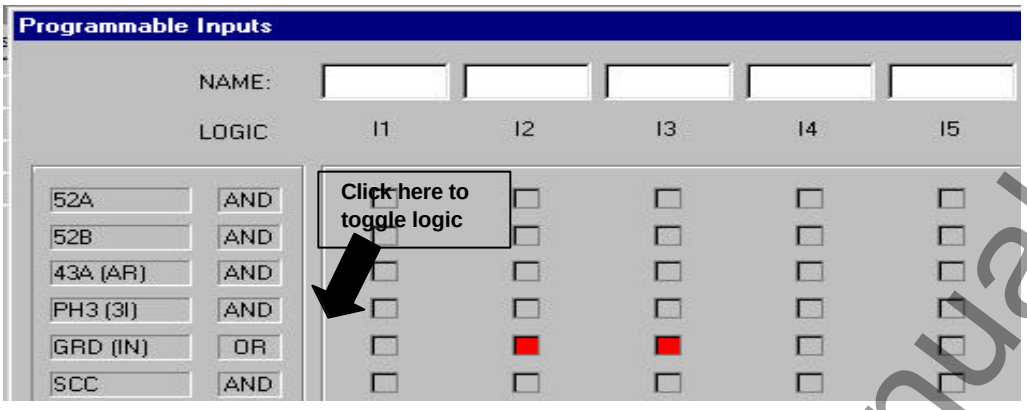


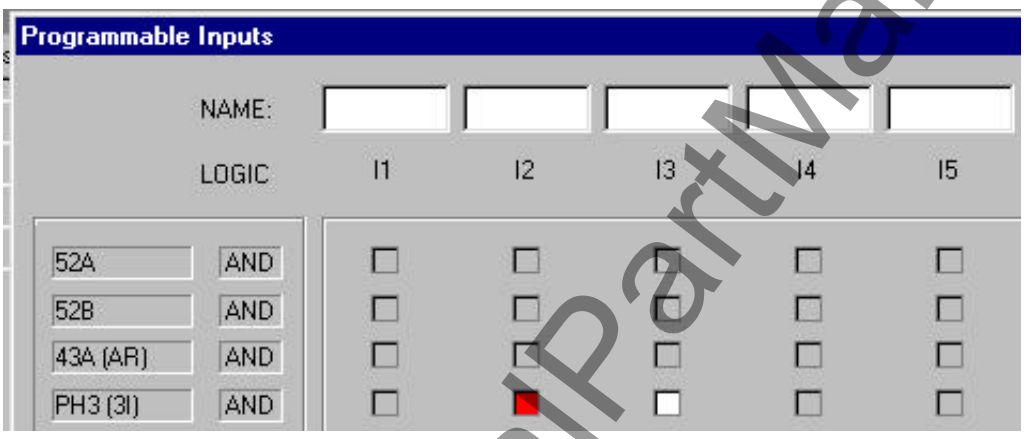
The instantaneous overcurrent elements will be enabled when I2 has no voltage applied, and disabled when I2 has positive voltage applied. Note the use of NOT logic (the square is white in color) in the mapping. The Boolean Logic expression for the above map is:

50-1 ENABLE = NOT I2

Logical Inputs can also be combined with physical inputs using AND or OR logic. The Logic field on the Input Map can be toggled from AND to OR by left-clicking in the field. The physical inputs are combined with either AND logic or OR logic across the horizontal selection field on the Input Map.

Example 3: Using AND/OR Input Logic Mapping





The Boolean expression is **PH3 = I2 AND NOT I3**

Logical Outputs:
Logical Outputs are used for control, or indication and alarm functions. Some Indication points are sealed in by the DPU2000R to capture rapidly changing points (such as overcurrent element pickups). Logical Outputs are mapped to physical outputs to send signals to external equipment such as breakers, communication gear, RTUs, or annunciators etc. Examples of the different types of Logical Outputs are listed in Tables 4 and 5. A complete list can be found in Section 6 of the Instruction Book.

Table 4 - Status Logical Outputs

CLOSE	Breaker Close Output. Assign to the physical output connected to the circuit breaker circuit. Close is initiated by the reclosing function, the CLOSE command through the relay interface, or the CLOSE Logical Input. Close is a logical 1 when the relay issues a close command, and remains asserted until the Close Fail Timer expires or the 52A and 52B Logical Inputs indicate a closed breaker.
BFT	Breaker Fail Trip. Operates when the Breaker Fail Logic in the DPU2000R issues a breaker fail trip signal.
25	Synch Check Output. When 25 is a logical 1, all conditions for synch check have been met.

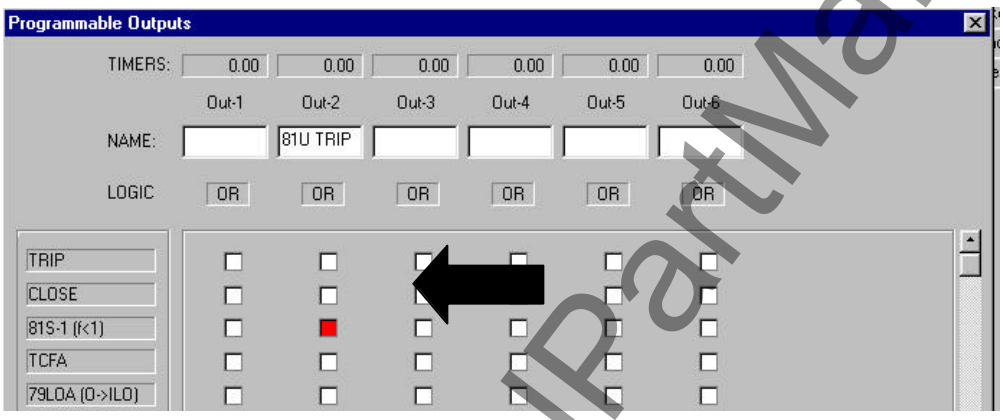
Table 5 - Indication and Alarm Logical Outputs

BFA	Breaker Fail Alarm. Asserts when a breaker fail to trip condition is detected.
51P*	Phase Time Overcurrent Seal-In Alarm. Asserts when the phase time overcurrent element (51P) picks up. 51P* stays asserted until a Reset Sealed-in Alarms command is issued through the front panel MMI or WinECP.
TCFA	Trip Circuit Fail Alarm. Asserted when the DPU2000R determines that the trip circuit has been opened. TCFA is dependent on the condition of the TCM input. When TCM is a logical 0, TCFA is a logical 1.

The following programming examples show how to map the various types of Logical Outputs.

Example 4: Mapping Under Frequency Load Shed tripping

A tripping function such as 81U can be mapped to a physical output to control a breaker using WinECP.

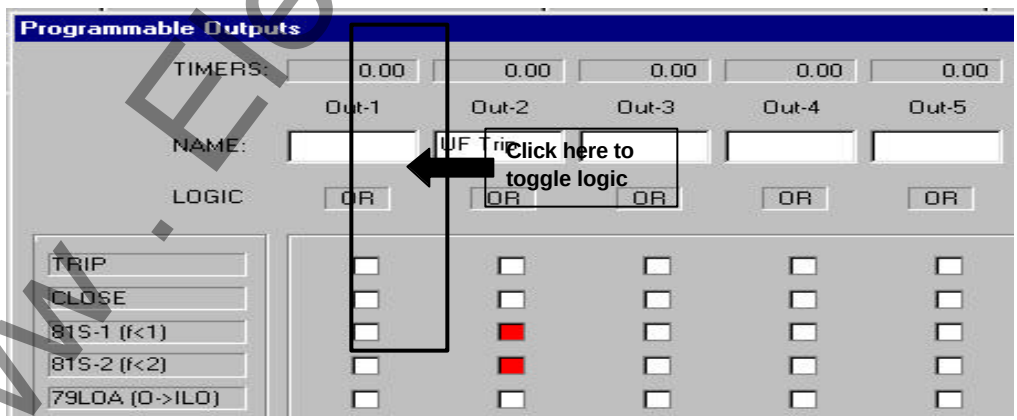


The Boolean Logic expression for the above map is: **OUT3 = 81S-1** (81U Load Shed).

Logical Outputs can also be combined with physical outputs using AND / OR logic. The Logic field on the Output Map can be toggled from AND to OR by left-clicking in the field. The physical inputs are combined with either AND logic or OR logic across the vertical selection field on the Input Map.

Example 5: Using AND/OR Output Logic Mapping

The Boolean expression is: **Out-2 = 81S-1 OR 81S-2**



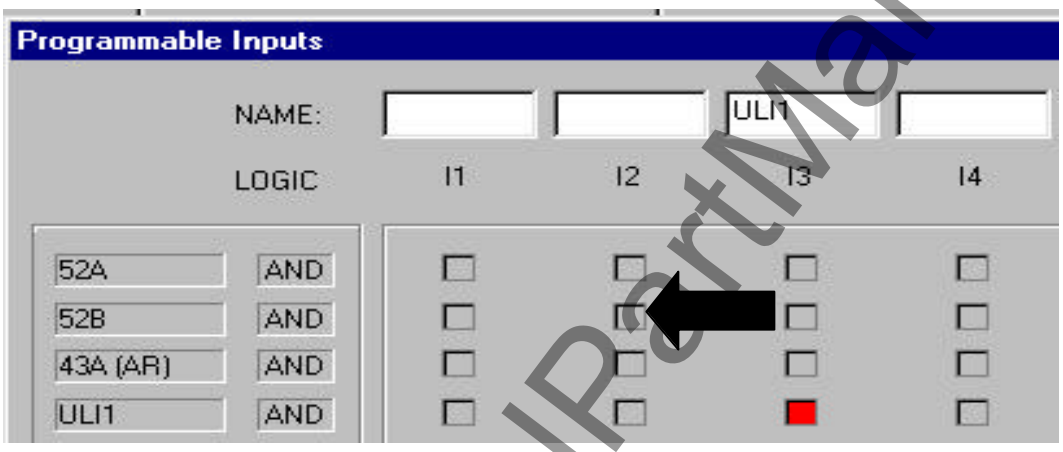
User Logical Inputs and Outputs

The DPU2000R comes standard with nine pairs of user-programmable inputs and outputs called *User Logical I/O.* The User Logical Inputs are abbreviated "ULI", and the outputs are abbreviated "ULO". Any physical input or output can be mapped to a ULI or ULO using WinECP.

ULI and ULO logicals are used to transfer a physical input through to a physical output. ULIs are connected to ULOs in WinECP to "feed forward" a physical input. WinECP allows the option of connecting a ULI to a ULO. The following example shows how to connect a physical input to a physical output using a ULI and ULO.

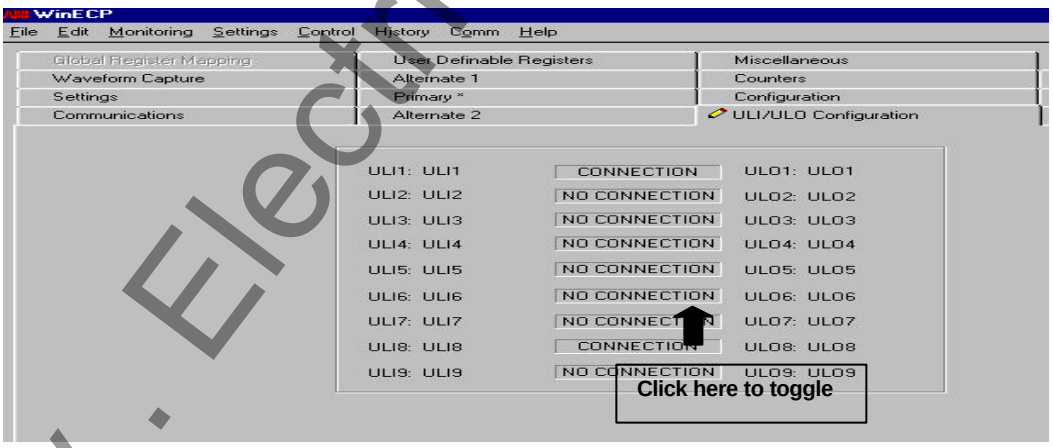
Example 6: Feed-forward logic using ULI and ULO Logical I/O

Step1: Map the physical input.

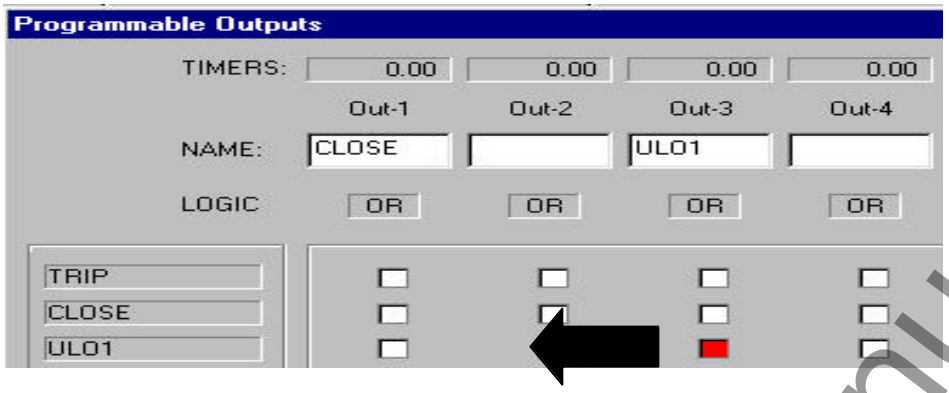


Step 2: Connect the ULI to the ULO.

Do this in WinECP by left-clicking in the Connection Box in the ULI/ULO Configuration screen.



Step 3: Map the physical output.



The Boolean expression for this example is:

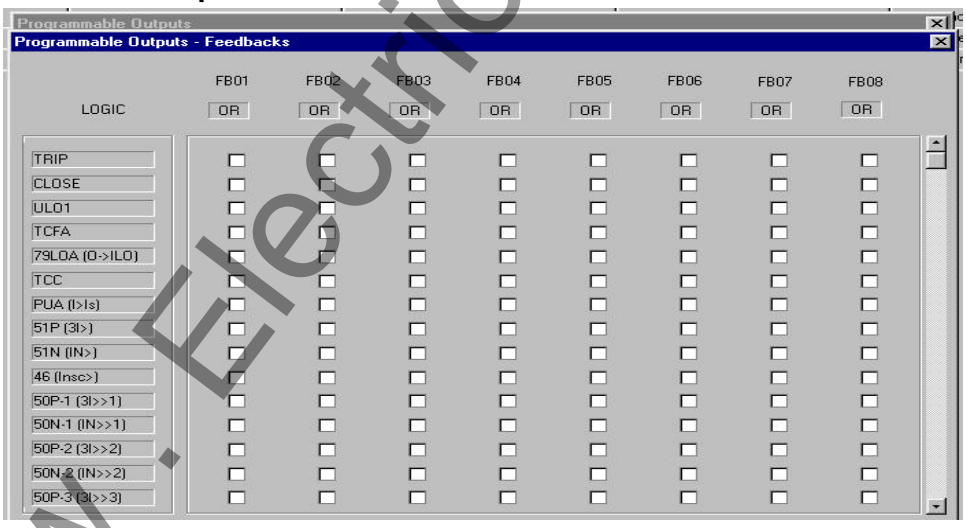
I3 = Out-3 and I3 = ULI1, Out-3=ULO1, and ULI1=ULO1

Feedback Logic

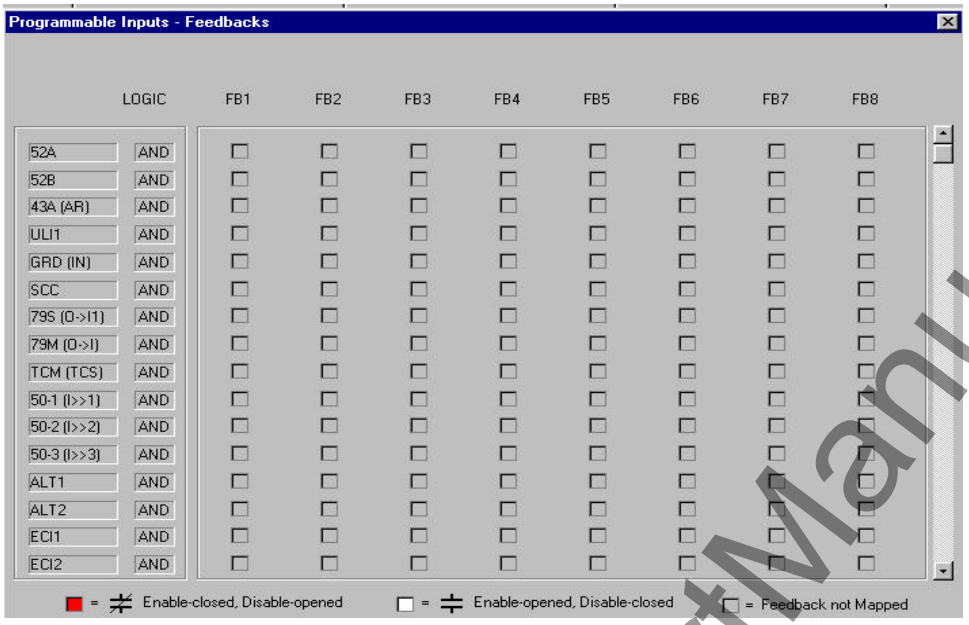
The DPU2000R comes standard with eight pairs of inputs and outputs called *Feedback I/O.* The Feedback Inputs are abbreviated “FB”, and Feedback Outputs are abbreviated “FBO”. Each Feedback Input is connected to its corresponding Feedback Output through a software connection inside the DPU2000R. Any Logical Input or Logical Output can be mapped to a Feedback using WinECP.

Feedback Inputs are used to transfer Logical Inputs to the Logical Output map, while Feedback Outputs are used to transfer Logical Outputs to the Logical Input map. The Feedback I/O can be mapped in WinECP by clicking the “Feedbacks” button in the Programmable Inputs or Outputs screen.

Feedback Output Screen



Feedback Input Screen



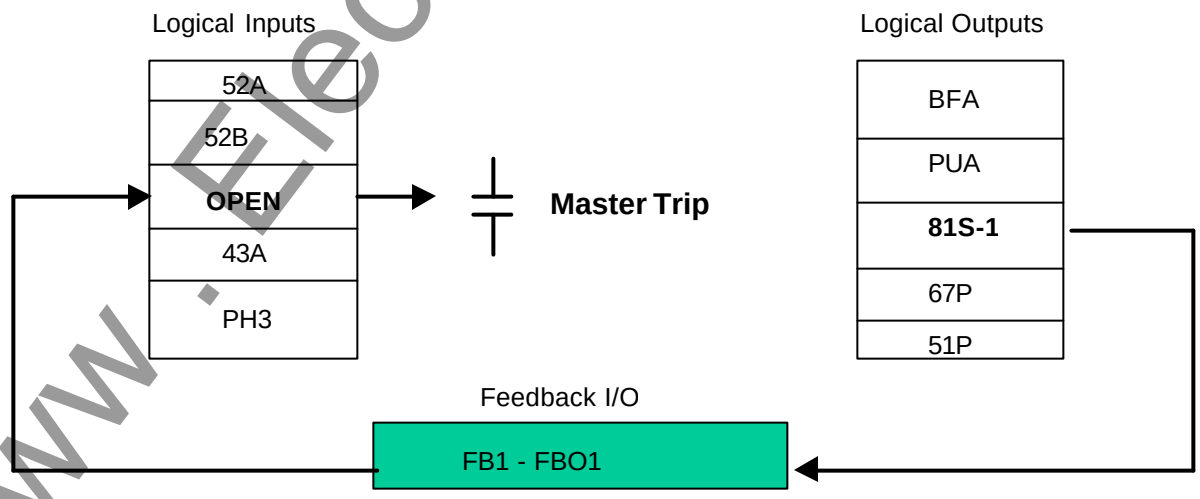
Example 7: Under frequency load shed tripping using a Feedback Logic Scheme

A common application for a feedback logic scheme is under frequency load shed tripping. Example 3 above shows how to trip for under frequency using a physical output. The disadvantage of this approach is that it requires a dedicated output for the 81S-1. The goal of this example is to trip the breaker through the Master Trip Output, thereby saving an output for other uses. The problem is that the 81S (under frequency shed) Logical Output does not directly control the Master Trip Output. Feedback Logical I/O can easily overcome this difficulty.

Logical Output used: **81S-1**. This is the Frequency Load Shed Module 1. It is asserted when the system frequency drops below the 81S-1, and the 81S-1 time delay has expired.

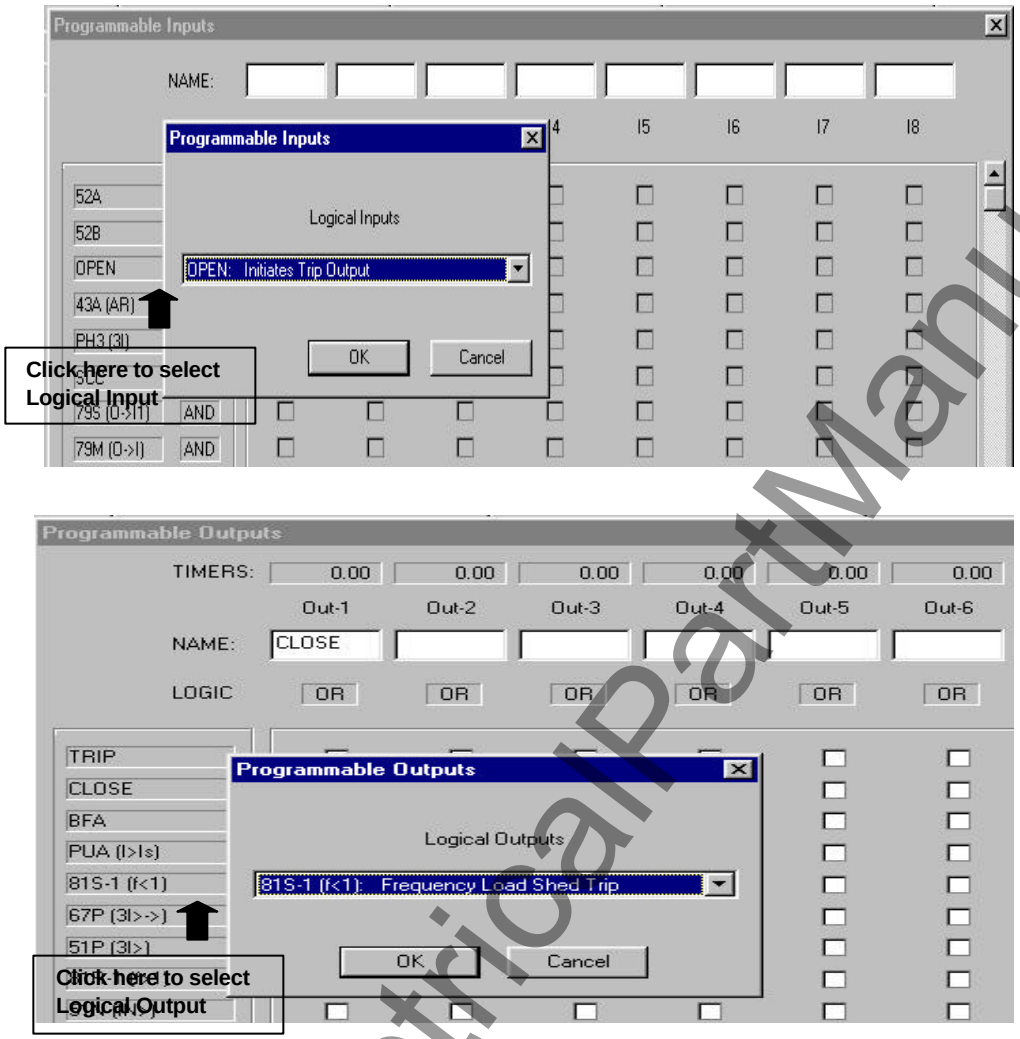
Logical Input used: **OPEN**. When asserted, this logical operates the Master Trip Output.

The following block Diagram illustrates the solution:

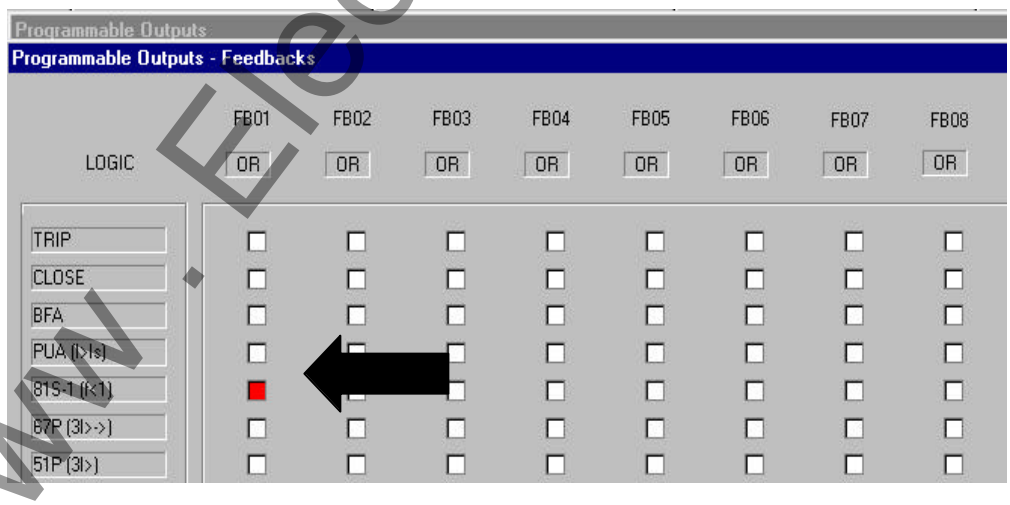


I/O Mapping:

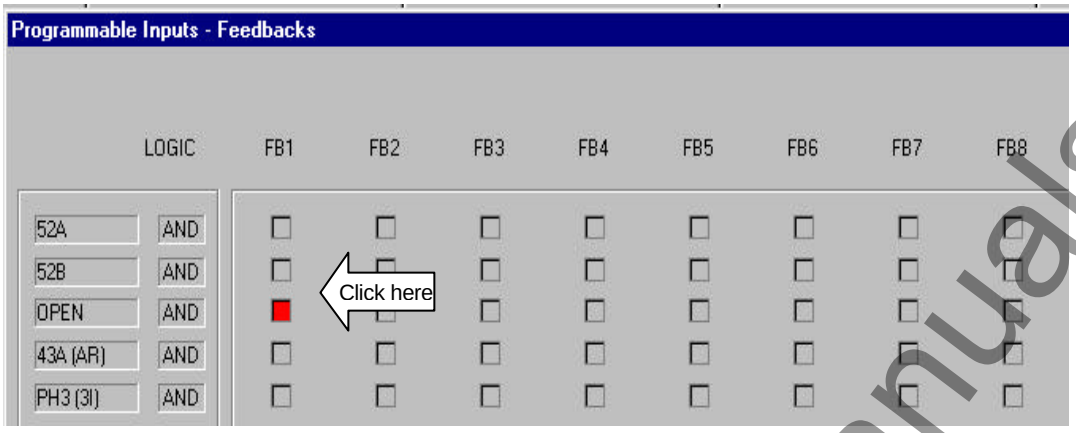
Step1: Place the 81S-1 and OPEN Logicals in their respective Maps.



Step 2: Programming the Feedback Output Map.



Step 3: Programming the Feedback Input Map.

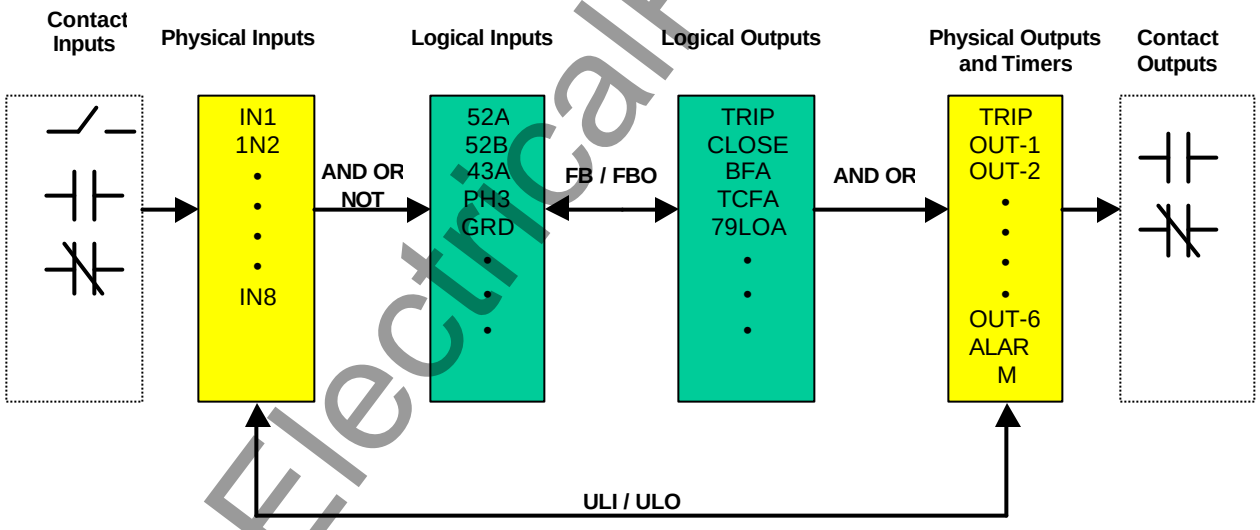


The logic scheme is now complete. The objective of tripping through the Master Trip Output has been met. The Boolean expression is: **Master Trip = 81S-1**

Conclusion

The figure below illustrates the building blocks that make up the I/O structure for the DPU2000R. This arrangement creates an easy-to-use toolkit to compose complex control schemes for substation applications.

DPU2000R I/O Structure



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