Application Note

Substation Automation and Protection Division

Capacitor Bank Protection and Automatic Control Using the Type DPU2000R Intelligent Electronic Device

Introduction

The Distribution Protection Unit, DPU2000R, is designed to provide flexible protective and control elements. Along with these is the ability to create logical control schemes using the internal programmable logic functions. When combined, these two capabilities provide a vast number of possible configurations to suite a particular function not normally associated with a distribution relay. One such function that is possible with the DPU2000R is automatic capacitor bank control. This application note deals in detail with this function.

Application

First needed is the determination of how the capacitor bank control is to operate and which criteria will be used to determine an open and close situation. Capacitor bank controllers normally utilize voltage, VAr, Power Factor, or any combination of these system measurements to determine the capacitor bank commands. The example below will be based on using voltage. Controllers typically do not contain protection. The DPU2000R contains the protective elements necessary for capacitor bank phase and ground overcurrent protection along with the capability to logically control the bank. This allows for the purchase of a single piece of hardware to perform both duties, thus gaining a savings in overall cost.

Figure 1 outlines the Boolean logic associated with this application. The following text will reference this figure. In the following example the DPU2000R three phase undervoltage element, 27-3P, is used to determine a capacitor bank close condition. The overvoltage element, 59, is used to determine a capacitor bank open condition. The 51N* element is used to open the capacitor bank circuit breaker and a control lockout if a ground fault is seen. The asterisk (*) following the 51N function means that it is a sealed-in output and must be either manually reset or reset via remote communications. The bottom line is that this bit will call attention to an abnormal condition and it is up to the user to determine whether a reset of the condition is warranted.

The DPU2000R contains User Logical Input (ULI) and User Logical Output (ULO) functions. A ULI is an undefined logical input seen in the relay input map. A ULO is an undefined logical output seen in the relay output map. A ULI in the input map is soft connected to the corresponding ULO in the output map, I.E. ULI2 is connected to ULO2. This soft connection can be broken by a setting in the DPU2000R. A ULO can act like an S-R flip flop. They are set and reset via the DPU2000R MMI or by remote communications. When a ULO is used in this manner, it is usually necessary to break the soft connection between the ULI and ULO so that an input to the ULI does not affect the operation of the ULO. For example: An “Auto Enable” bit, User Logical Output 6 (ULO6) is used to enable or disable the overall operation of the capacitor bank control. It is set and reset via operator interface to the relay MMI. The operator interface is the only way desired to influence the control. If the soft connection between ULI6 and ULO6 is not broken, it is possible that a input map programming error could cause undesired operation of ULI6 and ULO6. A text string can be assigned to a ULO making it easier for an operator to understand the functionality that has been assigned to it. Other ULOs are used in this example for transfer of logic signals from the input map to output map. In this case the soft connection needs to remain. In summary, a ULO can be explained as a method of feeding an input signal to the output mapping.

The reverse is true for elements called “feedback terms”. These feedback terms (FBs) are a method of feeding a logical output signal back to the input map. They are also soft connected (I.E. FBO1—FBI1) as with the ULOs but this soft connection cannot be broken. When the ULO and FB terms are combined, it is possible to create programmable logic to perform any number of specific functions.

The three phase undervoltage element, 27-3P, and the three phase overvoltage element, 59, are used to determine capacitor bank state. Each has a maximum time delay of 60 seconds. The DPU-2000R also contains output timers. These timers have a maximum setting of 250 seconds (4 minutes) and there is one timer per output contact. When the under/overvoltage timers are combined with the output timers, a maximum time delay of 310 seconds (5.16 minutes) can be obtained. A 5 minute time delay is usually required for capacitor discharge upon a circuit breaker open. In this example, the over/undervoltage elements time delays are set to 60 seconds. The open and close output timers are set to 240 seconds for a total of 300 seconds (5 minutes).

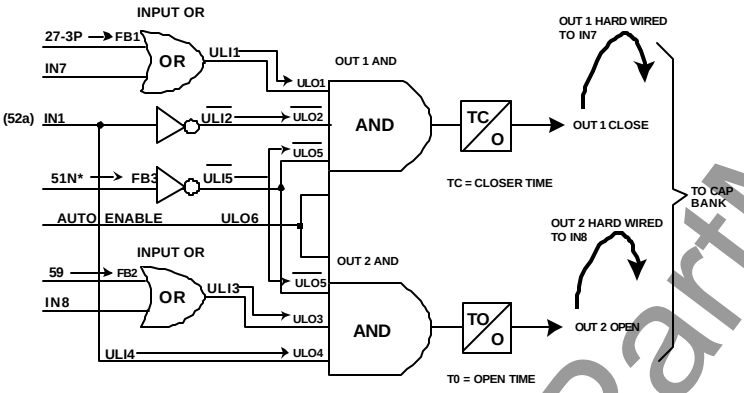

Figure 1 - Capacitor Bank Control Logic Control

Capacitor Bank Close Operation

The logic as shown in Figure 1 outlines the scheme operation. When the system voltage falls below the 27-3P threshold for 60 seconds, a logical 1 is output. This logical 1 from 27-3P is fed back to OR1 via feedback 1 (FB1). The output of OR1 is fed forward to AND1 via ULI1—ULO1. Other inputs to AND1 are the inverse of 52a fed forward via ULI2—ULO2, 51N* fed back through FB3, inverted, and fed forward via ULI5—ULO5. An “Auto Enable” bit ULO6 is also part of AND1. The following AND1 conditions must be true before a breaker close can be initiated via timer “TC”.

The 27-3P time-out has occurred

The circuit breaker is open indicated by the state of IN1 (52a)

The 51N* has not operated

The Auto Enable ULO6 is On

After the TC timer times out contact OUT1 will close. OUT1 is hardwired to input IN7 which in turn is input to OR1. This is necessary to hold the OUT1 contact closed or seal it in until the circuit breaker has completed its operation as indicated by the input IN1 (52a).

Capacitor Bank Open Operation

When the system voltage rises above the 59 threshold for 60 seconds, a logical 1 is output. This logical 1 from 59 is fed back to OR2 via feedback 2 (FB2). The output of OR2 is fed forward to AND2 via ULI3—

ULO3. Other inputs to AND2 are the 52a fed forward via ULI4—ULO4, 51N* fed back through FB3, inverted, and fed forward via ULI5—ULO5. An “Auto Enable” bit ULO6 is also part of AND2. The following AND2 conditions must be true before a breaker close can be initiated via timer “TO”.

The 59 time-out has occurred

The circuit breaker is closed indicated by the state of IN1 (52a)

The 51N* has not operated

The Auto Enable ULO6 is On

After the TO timer times out contact OUT2 will close. OUT2 is hardwired to input IN8 which in turn is input to OR2. This is necessary to hold the OUT2 contact closed or seal it in until the circuit breaker has completed its operation as indicated by the input IN1 (52a).

DPU2000R Programmable Logic Configuration

Once the Boolean logic drawing is complete, the DPU2000R input and output maps will require configuration. This can be done by adding the ULI—ULO (feed forward) and feedback mapping to the Boolean drawing. This has been done on Figure 1. After this, transfer the information to the input and output maps.

Figures 2, 3, and 4 show the input and output mapping required for this application. These are actual screen shots of the External Communications Program (ECP) that is required to perform this mapping. ECP is included with the DPU2000R.

Figure 2 shows the input map required for this application. On the top of the map screen are the physical inputs and feedback terms. To the left are the logical inputs and logical AND/OR selections. When a “C” is placed in the map, power is required for that logical input to assert. If an “O” is placed, the inverse is true, no power asserts the input. The “O” map can be used when an inverted signal is necessary. Next to each logical input is the selection of either AND or OR logic. Select each input logic as required. The feedback map is to the right of the physical inputs in the input map screen and should be connected to logical inputs. Remember that the feedback terms come from logical signals in the output map.

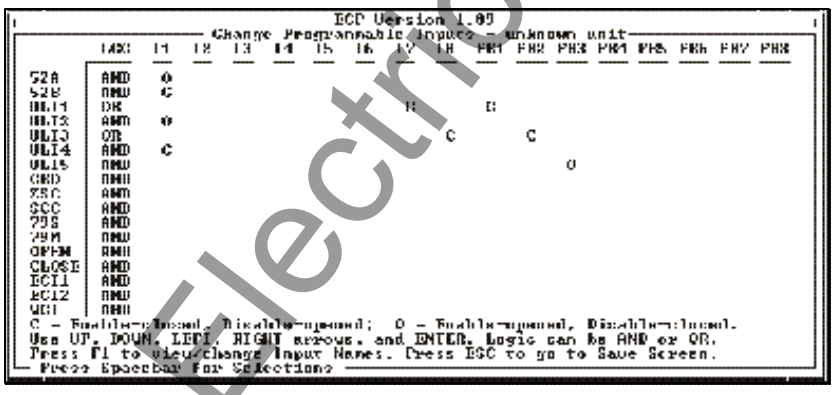

Figure 2 - Input Mapping

Figure 3 shows the output map required for this application. On the top of the map screen are the physical outputs, the timers associate with those outputs, and the logical AND/OR selection. To the left are the logical outputs. When an “X” is placed in the map, the logical output associated with the “X” will energize the output contact to which it is assigned. Press F2 to access the feedback map as shown in Figure 4. Place an “X” in the feedback column for the desired logical output to be fed back and utilized in

the input map. Remember that the ULO signals come from the input map unless the soft connection between them has been broken.

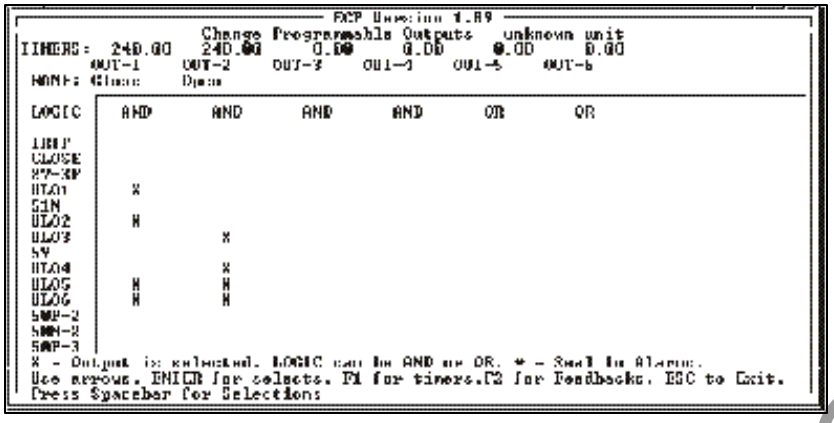

Figure 3 - Output Mapping

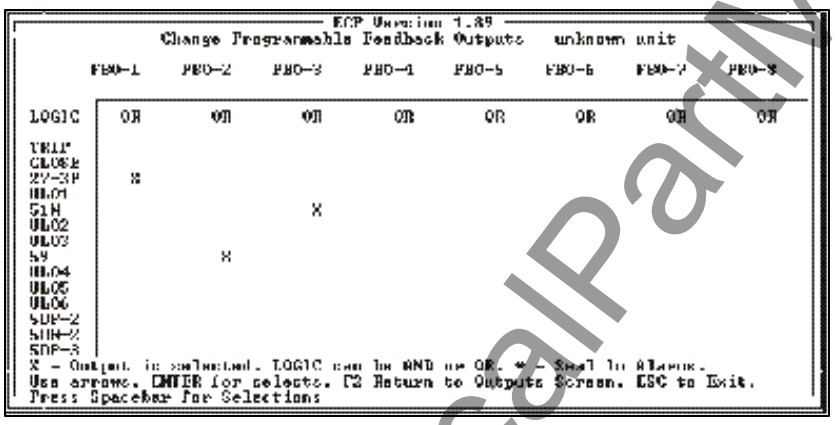

Figure 4 - Output Feedback Terms

Conclusion

This application is only one of a number that can be created using the DPU2000R protection and control elements along with the programmable logic capabilities. We at ABB Automation Inc. hope that this note will encourage you to investigate the possibilities. If there are any questions regarding this or any other application please contact ABB SAPD technical support at 1-800-634-6005.

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