Application Note

Substation Automation and Protection Division

TPU2000R Control Functionality Using DNP 3.0

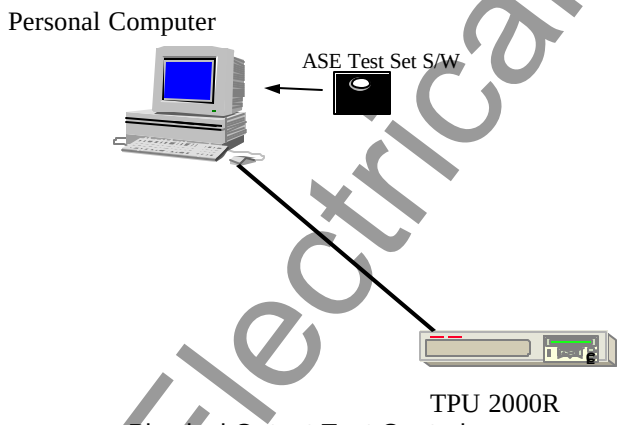
ABSTRACT: DNP 3.0 is a popular communication protocol in utility architectures. Although the protocol is consistent from level to level, manufacturers offer additional capability to perform various device functionality.

Sample Installation

A variety of DNP 3.0 protocol hosts allow for attachment to an ABB protective relay. The sample installation used for the purposes of this example is illustrated in Figure 1. The connection is point to point using an ASE Test Set as a host DNP device and the TPU 2000R is used as a receiving node. Communications on the TPU 2000R are configured via the front panel MMI or via ECP (External Communication Program Software, included with the relay). . Depending upon the communication card installed in the relay, DNP communication is available via the rear RS 232 port or the rear RS 485 port.

The TPU part numbers for relays supporting DNP communications are those with part numbers, 588RXXX2-6XXX1 or 588RXXX4-6XXX1 (X = Don't Care Digit). Depending upon the card inserted within the relay, DNP communication is possible on the RS 232 port or the RS 485 port. The configuration parameters for DNP are covered in the ABB DNP TPU 2000R-protocol manual.

Figure 1. Point to Point Topology



Each manufacturer of a protective relay offers differing data acquisition commands as well as control commands. A node may have a certain level of DNP implementation. The level determines the DNP commands, which are recognized by the receiving/sending nodes. However the manufacturer of the device determines the information obtained or control performed as a result of the command. The ABB TPU 2000R has a robust array of data available for control and acquisition. This note illustrates the control capabilities in enabling or disabling various TPU 2000R control features using DNP 3.0 commands.

The types of control possible via DNP is of the following types:

- Physical Output Test Control
- Trip Operate Control
- Reset Element Control
- ULO "Soft Point" Control
- Force Logical Input Elements
- Force Physical Input Status
- Force Physical Output Status

The TPU 2000R has 127 index points defined for control. The DNP 3.0 control object for control is Object 12. The status for the control points is mirrored for DNP 3.0 Object 10. The control points defined for the TPU 2000R version 3.0 or greater are defined in Table 1 of this document.

Table 1-TPU 2000R Defined Control Indexes for Object 10 and 12

INDEX	DESCRIPTION	INDEX	DESCRIPTION
PHYSICAL OUTPUT TEST CONTROL		**FORCE LOGICAL INPUT CONTROL** (cont'd)	
0	Trip Contact operate test	68	FLI 18 - status (ECI1)
1	Spare	69	FLI 18 - unforce (ECI1)
2	Output 1 Contact operate test	70	FLI 19 - status (ECI2)
3	Output 2 Contact operate test	71	FLI 19 - unforce (ECI2)
4	Output 3 Contact operate test	72	FLI 20 - status (WCI)
5	Output 4 Contact operate test	73	FLI 20 - unforce (WCI)
6	Output 5 Contact operate test	74	FLI 21 - status (TRIP)
7	Output 6 Contact operate test	75	FLI 21 - unforce (TRIP)
8	Output 7 Contact operate test	76	FLI 22 - status (SPR)
9	Spare	77	FLI 22 - unforce (SPR)
TRIP OPERATE CONTROL		78	FLI 23 - status (TCM)
10	Trip operate command	79	FLI 23 - unforce (TCM)
11	Spare	80	FLI 24 - status (ULI 1)
RESET ELEMENT CONTROL		81	FLI 24 - unforce (ULI 1)
12	Reset Alarms/Target LEDs	82	FLI 25 - status (ULI 2)
13	Reset Peak and Minimum Demand Currents	83	FLI 25 - unforce (ULI 2)
USER LOGICAL CONTROL COMMANDS		84	FLI 26 - status (ULI 3)
14	ULO1 Output Energize	85	FLI 26 - unforce (ULI 3)
15	ULO2 Output Energize	86	FLI 27 - status (ULI 4)
16	ULO3 Output Energize	87	FLI 27 - unforce (ULI 4)
17	ULO4 Output Energize	88	FLI 28 - status (ULI 5)
18	ULO5 Output Energize	89	FLI 28 - unforce (ULI 5)
19	ULO6 Output Energize	90	FLI 29 - status (ULI 6)
20	ULO7 Output Energize	91	FLI 29 - unforce (ULI 6)
21	ULO8 Output Energize	92	FLI 30 - status (ULI 7)
22	ULO9 Output Energize	93	FLI 30 - unforce (ULI 7)
23-31	RESERVED	94	FLI 31 - status (ULI 8)
FORCE LOGICAL INPUT CONTROL		95	FLI 31 - unforce (ULI 8)
32	Forced Logical Input 0 - status (87T)	FORCE PHYSICAL INPUT CONTROL	
33	Forced Logical Input 0 - unforce (87T)	96	Forced Phy. Input 1 - status (IN1)
34	FLI 1 - status (87H)	97	Forced Phy. Input 1 - unforce (IN1)
35	FLI 1 - unforce (87H)	98	FPI 2 - status (IN2)

36	FLI 2 - status (51P-1)	99	FPI 2 - unforce (IN2)
37	FLI 2 - unforce (51P-1)	100	FPI 3 - status (IN3)
38	FLI 3 - status (51P-2)	101	FPI 3 - unforce (IN3)
39	FLI 3 - unforce (51P-2)	102	FPI 4 - status (IN4)
40	FLI 4 - status (51N-1)	103	FPI 4 - unforce (IN4)
41	FLI 4 - unforce (51N-1)	104	FPI 5 - status (IN5)
42	FLI 5 - status (51G-2)	105	FPI 5 - unforce (IN5)
43	FLI 5 - unforce (51G-2)	106	FPI 6 - status (IN6)
44	FLI 6 - status (50P-1)	107	FPI 6 - unforce (IN6)
45	FLI 6 - unforce (50P-1)	108	FPI 7 - status (IN7)
46	FLI 7 - status (50P-2)	109	FPI 7 - unforce (IN7)
47	FLI 7 - unforce (50P-2)	110	FPI 8 - status (IN8)
48	FLI 8 - status (50N-1)	111	FPI 8 - unforce (IN8)
49	FLI 8 - unforce (50N-1)	112	FPI 9 - status (IN9)
50	FLI 9 - status (50G-2)	113	FPI 9 - unforce (IN9)
51	FLI 9 - unforce (50G-2)	**FORCE PHYSICAL OUTPUT CONTROL**	
52	FLI 10 - status (150P-1)	114	Forced Phy. Output 1 - status (OUT1)
53	FLI 10 - unforce (150P-1)	115	Forced Phy. Output 1 - unforce (OUT1)
54	FLI 11 - status (150P-2)	116	FPO 2 - status (OUT2)
55	FLI 11 - unforce (150P-2)	117	FPO 2 - unforce (OUT2)
56	FLI 12 - status (150N-1)	118	FPO 3 - status (OUT3)
57	FLI 12 - unforce (150N-1)	119	FPO 3 - unforce (OUT3)
58	FLI 13 - status (150G-2)	120	FPO 4 - status (OUT4)
59	FLI 13 - unforce (150G-2)	121	FPO 4 - unforce (OUT4)
60	FLI 14 - status (46-1)	122	FPO 5 - status (OUT5)
61	FLI 14 - unforce (46-1)	123	FPO 5 - unforce (OUT5)
62	FLI 15 - status (46-2)	124	FPO 6 - status (OUT6)
63	FLI 15 - unforce (46-2)	125	FPO 6 - unforce (OUT6)
64	FLI 16 - status (ALT1)	126	FPO 7 - status (OUT7)
65	FLI 16 - unforce (ALT1)	127	FPO 7 - unforce (OUT7)
66	FLI 17 - status (ALT2)	OBJECT 10 and 12 Version 3.4 index definitions.	
67	FLI 17 - unforce (ALT2)		

The indices listed in Table 1 above are used with the DNP object, variants and qualifiers listed as such:

Object 10 Variant 1 Qualifier 6x (Read Binary Output – Static Data– All Points)
Object 10 Variant 2 Qualifier 6x (Read Binary Output – Static Data W/Status – All Points)

Object 12 Variant 1 Qualifier 17x (Control Relay Output Block – Static Data 8 bit indices)
Object 12 Variant 1 Qualifier 28x (Control Relay Output Block – Static Data 16 bit indices)

ASE Test Set Parameterization

Connection to the relay may be accomplished via the test set's RS 232 port. If a direct connect is required, an RS 232 null modem cable must be connected between the TPU 2000R and the ASE Test Set. Various application notes are offered by ABB discussing the connection of a protective relay to RS 232 physical interfaces. Also the TPU 2000R's MODE 3 PARAMETER must be set to ENABLE, thus allowing DNP 3.0 communications via the RS 232 COM 3 port.

If the connection from the test set is to be accomplished via the RS 485 port, an appropriate RS232 to RS 485 converter must be placed between the ASE Test Set and the AUX Com Port resident on the TPU 2000R. Please consult the vendor's documentation in connecting the relay to the converter. ABB also offers application notes describing the connection between the relay and the RS485 converter.

ASE Test Set communication parameterization is as follows (USING THE DOS TEST SET):

Step 1 - Start the Test Set and construct a new file.
Step 2 - Enter the Standard list of all DNP exchanges (Make Default List)
Step 3 - Enter the "Settings Menu" and Select the Submenu "GENERAL I/O"
The Table shall be visible: Enter the following parameters –

BAUD	9600
CONTROL	CONSTANT
PORT	RS 232
PORT	A to RTU B to MASTER
Pre XMIT MARK	25
Post XMIT MARK	8
RCVR Squelch	0
Ignore Post Message Noise	ON X
Half Duplex Filtering	ON X

Step 4 - Depress the OK icon on the screen to accept the parameters.

The standard default list of parameters should be displayed.

TPU 2000R Parameterization

The selected parameters for this application note are as follows:

Unit Address	1
RP RS232 Baud	9600
RP RS 232 Frame	N 8 1
RP RS485 Baud	9600
RP RS 485 Frame	N 8 1
IRIG B	Disable (No Time Synch Via DNP Commands)
Parameter 1	40 (Inter-character Gap Timeout mS)
Parameter 2	30 (Data Link Layer Timeout in mS)
Parameter 3	0 (Data Link Layer Retries)
Parameter 4	200 (\Command Response Delay)
Parameter 5	254 (All Groups 0 – 7 Enabled)
Parameter 6	255 (All Groups 8- 15 Enabled)
Parameter 7	255 (All Groups 16- 24 Enabled)
Parameter 8	255 (All Groups 25 – 32 Enabled)
Parameter 9	0 (Reserved)
Parameter 10	0 (Reserved)
Mode Parameter 1	Disabled (Data Link Layer Confirm)
Mode Parameter 2	Disabled (Application Layer Confirm)
Mode Parameter 3	Enabled (DNP = RS 232) Disabled (DNP = RS485)
Mode Parameter 4	Disabled (RTS/CTS Handshake Confirms)
Mode Parameter 5	Disabled (Enable/Disable of Auto Reset)
Mode Parameter 6	Disabled (Reserved)
Mode Parameter 7	Disabled (Reserved)
Mode Parameter 8	Disabled (Reserved)

The ASE Test set offers (depending upon unit purchased), the ability to communicate via the personal computer's RS 232 port or via the RS 232 port on the supplied ISA or PCMCIA card. It would then require that the TPU 2000R Mode Parameter 3 be configured as "ENABLED".

DNP Control Explained

The explanation of DNP 3.0 control theory in relation to the ASE Test Set follows. The discussion is not to be host device centric but to be protocol centric. The commands discussed relate to the parameterization of the ASE Test Set.

The ASE DOS Test Set has a standard list of DNP 3.0 commands. DNP 3.0 is an object based protocol upon which different functions are defined. The DNP 3.0 protocol is defined by GE Harris and a protocol document Titled Distributed Network Protocol DNP 3.0 Basic 2 Document Set Part Number 994-0007 Revision 03 described the command set.

Control Functions and Objects Defined

DNP 3.0 defines two objects for discrete point data access/control. The defined Objects are:

Object 10 – Binary Output Status

Supporting Control Operation READ (Function 01)

Object 12- Binary Output Control.

Supporting Control Operations SELECT (Function 03)
OPERATE (Function 04)
DIRECT OPERATE (Function 05)
DIRECT OPERATE NO ACK (Function 06)

It should be noted that the standard ASE Object Command SBO Relay OUT uses functions 03 and 04 to complete the control functionality.

It should also be noted that the standard ASE Default List of DNP 3.0 commands uses 8 bit (single octet) range identifiers as a default. Thus Object 12 Variant 1 is intended to use a range qualifier of 17x when performing control functionality.

The use of Binary Output Control (Object 12) shall be explained within this application note. To perform the desired control functions with the ASE Test Set, the following information is required for initiation of communications to a TPU 2000R. ASE uses the description SBO Relay Out to denote control functionality.

Source	100	
Destination	1	
Object	12	
Variant	1	(Required for Object 12 Control)
Qualifier	17x (HEX) (Single Byte Range Argument)	
Range	1 (Single Control Type)	

Single Control Point Configuration

The ASE Test Set offers additional parameters that must be specified for control operation. Although multiple functions may be controlled via a DNP 3.0 command, this application note shall only deal with single point control. Depressing the Range button on the ASE Test Set and selecting the Single Point Control, a window shall be displayed requesting:

Index (Refer to Table 1 for the desired function)

Control Code Configuration

The second set of parameters which must be specified for control are particular to the control object 12. The specified control arguments required for in the Relay parameters field of the test set is:

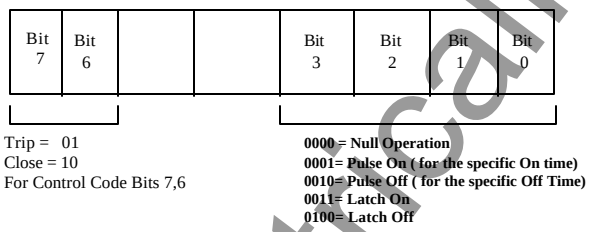
Control Code
Count (Number of Times Control operation is to be executed)
Length of Pulse ON (in mS) (Length of Pulse Control ON)
Length of Pulse OFF (in mS) (Length of Pulse Control OFF)
Status (TPU 2000R this argument is always = 0)

The Pulse Control OFF argument is useful when the count is greater than 1. The Pulse ON and Pulse OFF time creates a pulse train duration useful for execution of specific consecutive timed events.

The control codes are defined in DNP 3.0 as per the bit pattern as outlined in Figure 2. The following permutations are as such:

00 (hex)	NULL Control (Cancels the Control Operation Depending on the Control function)
01 (hex)	Momentary Pulse ON (Duration = Pulse ON Value Field)
02 (hex)	Momentary Pulse OFF (Duration = Pulse OFF Value Field)
03 (hex)	Latch ON (Set Control Value to ON until reset or Latch OFF)
04 (hex)	Latch OFF (Set Control Value to OFF until reset of Latch ON)
81 (hex)	Trip Designation with Momentary On (Paired Point Operation)
41 (hex)	Close Designation with Momentary Off (Paired Point Operation)

Each of the above control functions included in Table 1 shall be explained using single point control are reviewed in the following sections.



- The control code for Trip would be 41x (hex)
- The control code for Close would be 81x (hex)

Figure 2 - DNP Control Field Bit Designation

The following sections explain the control operations for each of the aforementioned grouping of points. The supported objects and variants for each of the TPU 2000R control types are listed in TPU 2000(R) Implementation of the DNP 3.0 User Guide Revision 3.0.

Paired Point Operation

Several indices are configured as paired points. Paired point operation, as per the DNP 3.0 definition operates with the TRIP (81x) and CLOSE (41x) commands. Paired Point implementation occurs with the following groups.

- Physical Output Test Control

- Trip Operate Control
- Reset Element Control
- User Logical Control

Several Groups of data have a PAIRED POINT operation implementation with respect to control codes TRIP 81x and CLOSE 41x. Each point in a PAIRED POINT IMPLEMENTATION group operates as such:

EVEN POINT NUMBER: If a TRIP Command is sent to this point the corresponding function is energized (for example, trip physical output[index 0], Output 1 [index 2], or ULO 1 [index 14] for example)

If a CLOSE command is sent to an even index, the next corresponding function [odd paired index] is energized (for example, spare [index 1], Output 2 [index 3] or ULO 2 [index 15]). The groups described as being paired points shall have the odd index- even index point pairing.

ODD POINT NUMBER: If a CLOSE Command (41x) is sent to an ODD index, the defined operation shall occur as the index is defined in Table 1. If a TRIP (81x) command is sent, the command shall be accepted but ignored.

The advantage of a PAIRED POINT implementation is that some legacy host devices perform trip and close on the same point index. The PAIRED POINT implementation allows ABB protective relays to provide superior automation control via DNP 3.0 with a wide variety of host implementations.

PAIRED POINT index implementation is not configurable from the operator or from the host device.

Physical Output Test Control (Index 0 Through 9)

Physical Output Control is provided for TPU 2000R test. ABB DNP 3.0 implementation allows for pulsing of the output contacts for test. The output may be pulsed on for a duration of 300 mS. Control Index points 0 through 9 allow for a single pulse of the selected point. The supported control operations are as follows for the aforementioned points. **PAIRED POINT operation is implemented.**

Even Numbered Control Points (0,2,4,6,8)

Control Code	01 (Momentary On) 03 (Latch On) 81 (Trip) 41 (Close) All other Control Codes are accepted. No action results.
Count	All counts other than 1 execute the command once.
Length of Pulse ON	A number 1 or greater pulses the output for 300 mS
Length of Pulse OFF	Field Value is ignored.
Status	Field Value is ignored.

Odd Numbered Control Points (1,3,5,7,9)

Control Code	01 (Momentary On) 03 (Latch On) 41 (Close) All other Control Codes are accepted. No action results.
Count	All counts other than 1 execute the command once.
Length of Pulse ON	A number 1 or greater pulses the output for 300 mS
Length of Pulse OFF	Field Value is ignored
Status	Field Value is Ignored

Trip Operate Control (Index 10 - 11)

The Trip Operate Control index operates only with the trip control argument. Since the TPU 2000R has only the ability to trip a breaker, (Closing is only possible via a manual operation via a mimic panel switch). **PAIRED POINT operation is implemented.** The following are accepted control codes for single point control:

Control Code	81x (Trip) 41x (Close) 03x (Latch ON) 04x (Latch OFF)
Count	Count of 1 is supported only all others execute once.
Length of Pulse ON	The entry in this field determines the pulse duration.
Length of Pulse OFF	Field Value is ignored
Status	Field Value is ignored

The TPU allows paired point operation for index points 11 and 12. As illustrated above, both a trip command (81 hex) or a close command (41 hex) produces a trip operation on this singular index.

Reset Element Control (Index 12 Through 13)

The TPU 2000R allows for resetting latched points via a DNP command (Supervisory Control). Targets, Alarms, and Demand values may also be reset. **PAIRED POINT operation is implemented.**

The control block for the RESET ELEMENT CONTROL functions are:

Even Numbered Control Points (12)

Control Code	01 (Momentary On) 03 (Latch On) 04 (Latch Off) 81 (Trip) 41 (Close) All other Control Codes are accepted. No action results.
Count	All counts other than 1 execute the command once.
Length of Pulse ON	A number 1 or greater pulses the output for 300 mS
Length of Pulse OFF	Field Value is ignored 0
Status	Field Value is ignored 0

Odd Numbered Control Points (13)

Control Code	01 (Momentary On) 03 (Latch On) 04 (Latch Off) 41 (Close) All other Control Codes are accepted. No action results.
Count	All counts other than 1 execute the command once.
Length of Pulse ON	A number 1 or greater for Code 01 is accepted otherwise the field is ignored.
Length of Pulse OFF	Field Value is ignored 0
Status	Field Value is ignored 0

ULO "Soft Point" Control (Index 14 through 22)

The TPU has a variety of ULI/ULO control capabilities within the unit. ABB offers various application notes covering applications in which ULO/ULI control is desirable. The ABBTPU 2000R Transformer Protection Unit 1MRA588372-MIB (IB 7.11.1.7-5) Manual (REV B) has a detailed explanation of such capabilities listed in Section 6.1. Soft Point Control may be linked to various TPU 2000R elements, Physical Output and timer capabilities. The TPU 2000R allows for the ULO (User Logical Output) elements to be controlled via DNP 3.0 **PAIRED POINT operation is implemented.**

Valid control parameterization accepted to perform these capabilities are as follows:

Even Numbered Control Points (14,16,18,20,22)

Control Code	01 (Momentary On) 03 (Latch On) 04 (Latch Off) 81 (Trip) 41 (Close) All other Control Codes are accepted. No action results.
Count	1 to 512
Length of Pulse ON	1 to 65,535
Length of Pulse OFF	If the count is 1 this field is ignored else the number in this field, 1 to 65,535 determines the OFF time duty cycle.
Status	Field Value is ignored 0

Odd Numbered Control Points (15,19,21,23)

Control Code	01 (Momentary On) 03 (Latch On) 04 (Latch Off) 41 (Close) All other Control Codes are accepted. No action results.
Count	1 to 512
Length of Pulse ON	1 to 65,535
Length of Pulse OFF	If the count is 1 this field is ignored else the number in this field, 1 to 65,535 determines the OFF time duty cycle.
Status	Field Value is ignored 0

Force Logical Input Configuration

The TPU 2000R has a default configuration of Force Logical Input bits. Forcing these bits on or off enables or disables the function associated with the function bits. The TPU ECP (External Configuration Program) allows reassignment of the default functions as listed in Table 1.

The TPU 2000 and TPU 2000R have the capability of automation configuration to a generic Logical Input bit. These bits are generic in nature and can be mapped via ECP (External Communication Program) or WIN ECP (WINdows External Communication Program). Mapping of the values occurs as such:

1. *From ECP or WIN ECP select the menu item "FLI Index and User Name" selection.*
2. *A list of default mappings are shown as in Figure 3 (ECP Screen) In this case the user is viewing the screen in ECP as shown in the CHANGE SETTINGS Screen.*
3. *The default list corresponds to the Logical Input mapping of Logical Inputs (hereto referred as LI) as illustrated in Table 2.*

4. *If one would wish to change the relay protective function element mapped to the specific LI, depress the "ENTER" key. The display in Figure 4 shall be displayed.*
5. *The user would then scroll down the list and highlight the element desired to be mapped to the specific LI within the edited list.*
6. *Depress the "ENTER" key to map the selected element into the table.*

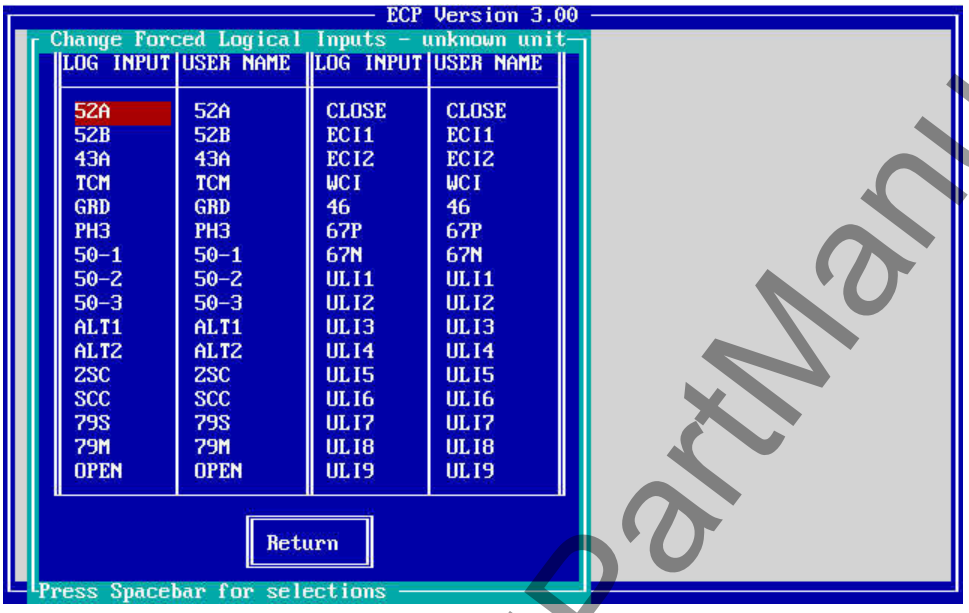


Figure 3 – ECP Default Logical Input List

Table 2 - ECP Default Correlation to Forced Logical Input Bit Map

FLI Number	Description	User Name	FLI Number	Description	User Name
FLI 01	Relay Status	52 a	FLI 17	Initiate Close Output	CLOSE
FLI 02	Relay Status	52 b	FLI 18	Event Capture Initiate	ECI 1
FLI 03	Reclosing Enable	43 a	FLI 19	Event Capture Initiate	ECI 2
FLI 04	Trip Coil Monitor	TCM	FLI 20	Waveform Capture Initate	WCI
FLI 05	Ground Protection Overcurrent51N/50N-1/50N-2 Enable	GRD	FLI 21	Negative Sequence Time Overcurrent Enable	46

FLI 06	Phase Protection Overcurrent51 P/50P-1/50 P-2 Enable	PH3	FLI 22	Positive Sequential Directional Control Time Overcurrent Enable	67 P
FLI 07	Phase & Ground Instantaneous Level 1 Enable	50-1	FLI 23	Negative Sequence Directional Control Ground Overcurrent Enable	67 N
FLI 08	Phase & Ground Instantaneous Level 2 Enable	50-2	FLI 24	User Logical Input 1	ULI 1
FLI 09	Phase & Ground Instantaneous Level 3 Enable	50-3	FLI 25	User Logical Input 2	ULI 2
FLI 10	Alternate Relay Setting 1	ALT 1	FLI 26	User Logical Input 3	ULI 3
FLI 11	Alternate Relay Setting 2	ALT 2	FLI 27	User Logical Input 4	ULI 4
FLI 12	Zone Sequence Control	ZSC	FLI 28	User Logical Input 5	ULI 5
FLI 13	Spring Charging Contact	SCC	FLI 29	User Logical Input 6	ULI 6
FLI 14	Single Shot Reclosing Enable	79 S	FLI 30	User Logical Input 7	ULI 7
FLI 15	Multi Shot Reclosing Enable	79 M	FLI 31	User Logical Input 8	ULI 8
FLI 16	Initiate Trip Output	OPEN	FLI 32	User Logical Input 9	ULI 9

The usefulness of this feature cannot be understated. Each one of these functions can be forced via a network control. Programming need not be done to allow for function control via a network. If the relaying feature “RECLOSING” were to be enabled, the bit FLI 03 could be forced to an “ON” condition via the network control. If a desired control function were to be controlled via the network, then ECP mapping would have to be configured as per FIGURE 4.

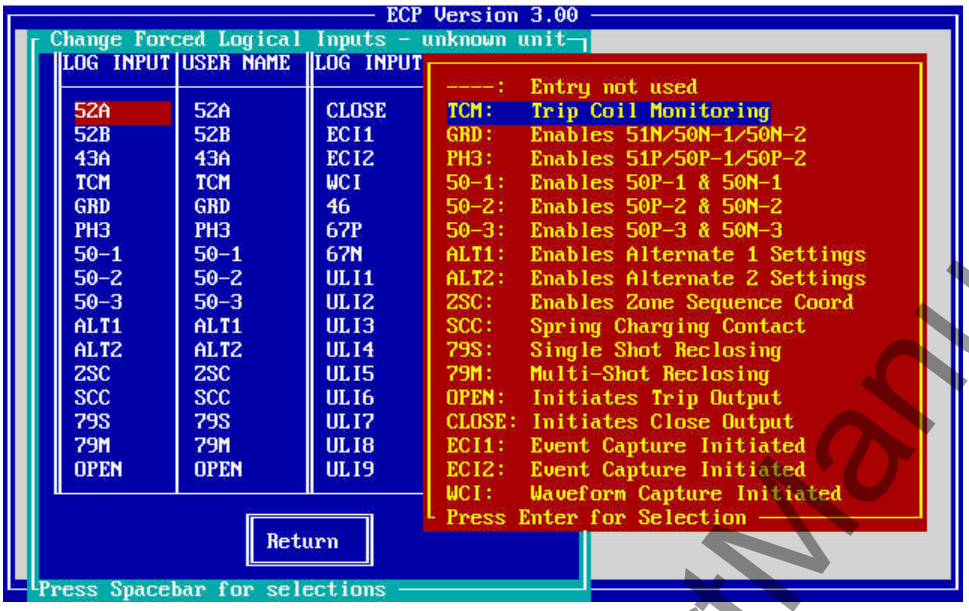


Figure 4 – ECP Forced Logical Input Mapping Screen

Point Forcing Control Functionality (Index 32 Through 127)

The TPU 2000R allows forcing of the following control points:

- Logical Inputs
- Physical Inputs
- Physical Outputs

Traditionally, network or supervisory operation of control points was determined to be a special operation. As a safeguard to unintended operator control initiation ABB's implementation of forcing functionality has specifically required certain steps to be performed within the DNP 3.0 protocol for a supervisory operation to occur.

Additionally, when the operator has executed a force function, a visual indication is initiated on the faceplate of the relay. When no element is forced, the NORMAL LED at the front of the relay is illuminated in a solid green color. When any element is forced within the relay, the NORMAL LED flashes at a rate of one second energized and one second extinguished. The NORMAL LED shall continue to flash until no elements are forced within the TPU 2000R.

Supervisory Forcing control points are implemented in a odd-even arrangement. As per TABLE 1, even points are designated as STATUS whereas odd points are designated as UNFORCE. The descriptions of their functionality is as follows:

Control Code	03 (Latch On) 04 (Latch Off) All other Control Codes are accepted. No action results.
Count	All counts other than 1 execute the command once.
Length of Pulse ON	1
Length of Pulse OFF	Field Value is ignored 0

Status	Field Value is ignored 0

A write of the control code 03x “LATCH ON” forces the point to a state of 1. A write of the control code 04x “LATCH OFF” forces the point to a state of 0. A force of the point allows control by the operator or supervisory host. If the point is forced, any logic capabilities configured in the TPU 2000R are overridden by the supervisory control established via DNP 3.0. The forced index control shall be forced until the point is “UNFORCED”.

To “UNFORCE” a control point, the following control code parameterization is required.

Control Code	01 (Momentary On) 02 (Momentary Off) 03 (Latch On) 04 (Latch Off) 81x (Trip) 82x (Trip Off) 41x (Close) 42x (Close Off).
Count	All counts other than 1 execute the command once.
Length of Pulse ON	1
Length of Pulse OFF	Field Value is ignored unless 02 or 82 code is used. 1
Status	Field Value is ignored 0

When the code is “UNFORCED” control is restored to the configured logic in the TPU 2000R.

Conclusion

Configuration of DNP 3.0 functionality varies from host device to host device. Configuration of a system is eased somewhat when the configuration of the relay is tested prior to the integration of a host device. Use of a test set as that from ASE, simplifies the commissioning of automation systems. The protective relay network can be tested by sending the raw DNP 3.0 commands to each node on the network. When network commissioning has completed, the host can be connected to the TPU 2000R network and host parameterization can be tested.

Control operation testing is important since the DNP 3.0 host capabilities can be commissioned as well as those capabilities relating to supervisory functionality and physical output control.

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