



expertmeter™ PM180

PM180 Series
SUBSTATION AUTOMATION UNIT

Bay Controller Unit
BCU Application Note

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1 General

This application note describes functions, operation and configuring of the bay control unit integrated in the expertmeter™ PM180. For detailed information on operating the expertmeter™ PM180 and communication settings refer to the expertmeter™ PM180 Operation Manual.

The bay control unit provides fully automated control of substation switching devices. After switches are configured in the device, no additional logic is normally required for controller operation, except of interlocking logic.

Bay control solutions can be customized via control logic using a variety of expertmeter™ PM180 digital I/O and analog measurement capabilities for the circuit switch/breaker position indication, interlocking and control.

General bay controller features:

- Monitoring and control capabilities for as many as two circuit breakers and 14 circuit switches
- One-pole and tree-pole switch position monitoring using two or six contacts
- One control output for switch closing
- Two synchronous control outputs for switch opening for devices with one and two opening coils
- Select-close control output for secure switch closing operations
- Two select-open control outputs for secure switch opening operations
- Configurable command pulse duration
- Option for adaptive pulses controlled via setpoint control logic
- Supervision of command execution and reporting on operation termination
- Interlocking logic
- Secure timed-out interlocking bypass logic
- Switch position substitution option
- Indication of non-controllable breaker trips
- Counting of breaker and switch operations
- Logging close/open operations and switch position changes
- Local switch control via setpoint control logic
- Remote switch control and monitoring via Modbus and IEC 61850 protocols
- Inter-device IEC 61850 GOOSE communications for remote interlocking
- The bay control unit functionality is available with firmware versions 20.XX.07 and higher.

2 Bay Controller Operation

The bay control unit provides control of up to two circuit breakers and 14 circuit switches depending on the selected configuration.

The switching devices can be operated either remotely via communication ports, or locally via setpoint control equations. Remote control permissions can be restricted by enabling control commands for specific control ports or clients depending on the device control mode.

See Section 4.1 for information on configuring switching devices via PAS.

See Sections 3.1 and 3.2 for information on monitoring and control of switching devices via IEC 61850 and via Modbus communications.

2.1 Switch Position Monitoring

Position Indication

The bay controller can monitor signals from three-phase switches with general two-contact or per-phase six-contact position indication. Phase A contact inputs should be used in case of general switch position indication using two contacts.

Positions of switch poles can be indicated via the device digital inputs, control logic equations, controllable event flags, or via remote indication from other substation controllers using inter-device IEC 61850 GOOSE communications.

The position of each pair of the N.O. and N.C. contacts is allowed to be signaled by one of the contacts. In this case its complementary status is taken for the opposite contact.

In case of three-pole position monitoring with six contacts, the general position of a switch is evaluated in the following way:

1. In the event all poles have same position, it is taken as a general switch position.
2. In the event one of the poles is in the bad position (both contacts are closed), the general position is indicated as bad.
3. In other cases, the switch position is indicated as intermediate.

A position change is normally detected in a half cycle time.

Any switch position change is automatically logged to the device Event log with the time of change.

Position Substitution

A switch position can be manually substituted via communications in case that the actual position cannot be directly obtained by the controller, for example, when a switch is not accessible or not operational, while it blocks operation of controllable switches.

Switches with a substituted position are not allowed to be operated.

Indication of Breaker Trips

Uncontrollable breaker pole position changes from the closed to open state are indicated as breaker trips and are reported via the Modbus fault disconnect alarm registers and via the IEC 61850 switch controller data object AlmFlt.

The breaker trip indication is automatically reset in 5 seconds.

2.2 Interlocking Logic

Interlocking Control

Interlocking control logic blocks any switch control commands until predefined conditions are met. Interlocking logic is defined via setpoint control equations that must be evaluated to TRUE for the switch control commands to be executed.

If interlocking is not applicable to the switch, set the interlocking control setting to TRUE to allow unconditional command execution.

Interlocking Bypass Logic

The interlocking bypass option allows to temporary override interlocking logic. This is a one-shot action that is activated for a limited time and is controlled by an interlocking bypass timeout.

Interlocking bypass is enabled via a setpoint control equation, which normally monitors the status of an external "Interlocking OFF" switch, but can also track the status of a memorized event flag controlled via communications.

Interlocking bypass is active until the first control command is executed or until the bypass timeout expires.

The bypass control logic equation must be reset to FALSE in order to recharge this option before next use.

2.3 Controls

2.3.1 Control Parameters

See Section 4.1 for more information on configuring switching devices via PAS and for the full list of configurable options. The following gives explanations of control options and how they affect the switch operation.

Control Outputs

The bay controller provides control of up to 6 control outputs: one close command output, one or two open command outputs, one select-close output, and one or two select-open outputs.

Any of the 64 relay outputs available in the device or none of them can be selected as a switch control output.

Control outputs are not normally allowed to reuse same output relays. The only exception is made for the select-close and select-open outputs that may use the same relay for securing both closing and opening commands.

Control outputs are optional. When none of them is defined, the full switch functionality is still available, including position monitoring, interlocking and modeling control operations. Such a switch is seen as "virtual" that is not controllable, but which position indication may be used in interlocking equations of controllable switches.

When switch operation is enabled, the relay outputs are automatically put in unlatched mode with normal polarity, which will not be allowed to change. Relay outputs found under control of the bay controller are not available for direct control via communications or via control logic.

Command Duration

This parameter specifies the default duration of the output pulse for commands received via Modbus communications and from setpoint control equations.

In IEC 61850 Operate requests, the pulse duration can be set via the IEC 61850 CSWI switch controller node configuration by a non-zero CSWI\$CF\$pulsConfig\$onDur data attribute. When it is zero, the default command pulse duration is used instead.

The pulse duration is supervised by the immobility and command termination timeouts. In case that either of them expires while the pulse continues, the relay outputs are

deactivated and the operation is abnormally terminated. If the pulse is shorter than it will take for a switch to change its position, set the start moving timeout to more time than the expected duration of the pulse.

Pulse Duration Control Logic

A close/open command pulse is normally removed after the configured pulse duration expires. The bay controller allows a command pulse to be extended over the configured duration until a specific condition is met. The reason may be keeping the output pulse active until the new correct end position is reached, or until the line voltage is removed, or probably other binary or analog trigger reaches the expected value.

It is called an adaptive pulse and is handled by a setpoint logic equation that controls the pulse duration.

If a control equation is used, the output pulse will remain active until the logic equation is reset to FALSE. Operation of control logic is supervised by the immobility and command termination timeouts. In case that either of them expires while the pulse continues, the relay outputs are deactivated and the operation is abnormally terminated.

In all cases, the actual pulse duration is never less than the configured pulse duration. If you use the control logic, set the command pulse duration to a smallest reasonable value.

Start Moving Timeout

This parameter controls command execution supervision. It specifies the switch immobility timeout - the time that takes for a switch to start moving after command execution.

The parameter is optional. If you set it to zero, command execution is not supervised. In this case a control operation is immediately terminated after deactivating control outputs as the command pulse ends.

When the immobility timeout is used, command execution is supervised and a control operation is terminated and reported after the last of the two events happens: the command pulse ends and the switch position changes to either the intermediate, or a new end position. The immobility timer is reset and no more supervised as the switch position changes.

In case that the immobility timeout is used and the switch position does not change before the timeout expires, the active control outputs are deactivated and the operation is abnormally terminated by timeout.

Command Termination Timeout

This parameter defines the total operation supervision time since the command is taken for execution.

A control operation has to be terminated before the timeout expires. If the operation has not been completed before the command termination timer expires, the active control outputs are deactivated and the operation is abnormally terminated by timeout.

2.3.2 Control Command Execution

Control operations can be activated either via setpoint control equations, or via communications by commands sent via Modbus switch control registers or via the IEC 61850 CSWI switch controller nodes.

The IEC 61850 switch control interface supports direct control commands with enhanced security.

A control command is refused when one of the following conditions is encountered:

1. The communication client is not permitted to issue control commands because of unacceptable switching authority: either a client control port is disabled or blocked, or the device is in local control mode (actual for IEC 61850 clients only).
2. The switch is not controllable because of improper configuration.
3. A control command is already in execution.
4. The requested switch position has been reached.

5. The switch is in an invalid position.
6. Switch position is indicated by a substituted value.
7. Control commands for the switch are blocked by interlocking logic.
8. One of the control outputs is blocked by control logic.

When a remote control command is rejected, the cause is reported via a Modbus command termination status register, and via an IEC 61850 reporting service by the LastAppError variable in case of the IEC 61850 Operate request.

When a control command is accepted, the control operation is executed according to the following integrated logic:

1. If the control relay outputs are configured, they are all activated together and the pulse duration timer is started.
2. The command termination timer is started.
3. If the start moving timeout is defined, the switch immobility timer is started.
4. If the pulse duration timer expires while the pulse duration control logic is not used or is evaluated to FALSE, the control outputs are deactivated.
5. If the pulse duration control logic is defined and is evaluated to FALSE, while the pulse duration timer has just expired, the control outputs are deactivated.
6. If the control outputs are deactivated and the immobility timer is not running, the control operation is terminated.
7. If the immobility timer is running and the switch position changes to an intermediate state, or reaches the target position, the immobility timer is reset and, if the control outputs are not active, the control operation is terminated.
8. If the immobility timer expires, active control outputs are deactivated and the control operation is terminated by timeout.
9. If the command termination timer expires, active control outputs are deactivated and the control operation is terminated by timeout.

The operation activation and termination events are automatically logged with the timestamp to the device Event log.

Termination of a remote command with the cause is reported via a Modbus command termination status register, and via an IEC 61850 Operate response service. In case of abnormal termination of an IEC 61850 Operate request, the cause is also reported via an IEC 61850 reporting service by a LastAppError variable.

2.4 Operation Counters

The expertmeter™ PM180 provides operation counters that count the total number of switch operations. When a close-to-open position change is detected, the switch operation counter is incremented.

Switch operation counters can be reset via Modbus communications and via PAS from the Monitor/Reset dialog.

2.5 Using Control Logic

Monitoring Switch Operations

The expertmeter™ PM180 provides internal variables related to switch operation for use in interlocking logic and in switch control equations. The following table lists parameters that can be used for monitoring of the switch position and command execution in setpoint control equations.

Input Parameter	Range	Description
XCBRn_Pos, XSWIn_Pos	Intermediate, OFF, ON, Bad	Switch position indication
XCBRn_OpCls, XSWIn_OpCls	ON=operation in execution, OFF=operation terminated	Switch operation "Close" indication
XCBRn_OpOpn, XSWIn_OpOpn	ON=operation in execution, OFF=operation terminated	Switch operation "Open" indication
XCBRn_OpCnt, XSWIn_OpCnt	0-9999	Switch operation counter
ExtInd1...ExtInd128	OFF, ON	Single-point external indication
ExtInd1:2...ExtInd127:128	Intermediate, OFF, ON, Bad	Double-point external indication
ExtiVal1...ExtiVal32		External integer measured values
ExtfVal1...ExtfVal32		External floating-point measured values
REMOTE CONTROL	OFF, ON	Internal flag available for control via setpoint control logic. Defaulted to OFF.

All of the listed parameters are also available for monitoring via Modbus communications. See Section 3.2 for details.

Control Commands

The following table lists commands that are activated via setpoint control equations and may be used for local switch control and for control of the switching authority.

Control Action	Target	Description
CLOSE SWITCH	XCBR1-XCBR2, XSWI1-XSWI14	Activates breaker/switch close operation when a control equation evaluates to TRUE
OPEN SWITCH	XCBR1-XCBR2, XSWI1-XSWI14	Activates breaker/switch open operation when a control equation evaluates to TRUE
REMOTE CONTROL		Puts REMOTE CONTROL to ON while a control equation evaluates to TRUE. Tracks the output of control logic.
UNBLOCK CONTROL PORT	ALL, COM1, COM2, COM3, COM4, COM5, USB, Ethernet	Enables control operations via blocked control ports while a control equation evaluates to TRUE. Tracks the output of control logic.

2.6 Switching Permissions

Secure switching operations require that only one source is allowed to issue control commands at a time. Two mechanisms are provided in the device for restriction of the switching authority for users: a general permission based on the device local/remote control mode, and individual permissions based on the client connection ports and network addresses.

2.6.1 Local/Remote Control

The expertmeter™ PM180 has the internal REMOTE CONTROL flag (found within the STATIC EVENTS data group) that is handled via setpoint control logic. The control equation normally tracks the status of an external "Local/Remote" switch via a digital input and puts the device in remote mode with the REMOTE CONTROL action when the switch is in the "remote" position.

While the status of REMOTE CONTROL is OFF, control commands from IEC 61850 clients, commonly at station level, are denied. The Loc attribute in IEC 61850 logical nodes containing controls indicates the complementary status of the REMOTE CONTROL flag. Since REMOTE CONTROL is defaulted to FALSE, it must be set to ON via a control equation to allow control operations via IEC 61850.

Modbus communications is not directly affected by the status of the REMOTE CONTROL flag and may be used for local control via a local terminal station, which can be connected to the expertmeter™ PM180 via any available port, including serial ports, USB and Ethernet.

In cases when a local terminal station operates via IEC 61850, or remote Modbus communications is available for multiple users, or multiple clients may have access to the device via either protocol in REMOTE mode, per-client control permissions must be used.

2.6.2 Restricting Control Ports

Remote connection points via which direct control commands can be received are called direct control ports. For local ports, a connection point is identified by a physical port, while for Ethernet users a remote connection point is identified by the client IP address.

See Section 4.2 for more information on configuring direct control ports via PAS.

Control permissions may be permanently allowed or disabled, or be controllable via setpoint control logic for any of the ports.

To use controllable permissions, the control ports should be marked as "Blocked". The control permissions are given to a blocked port via setpoint control equations that normally monitor the status of the REMOTE CONTROL flag and unblock the port to which the switching authority is currently granted.

3 Bay Controller Communications

3.1 IEC 61850 Communications

See the expertmeter™ PM180 IEC 61850 reference guide for more information on implementing IEC 61850 communications in the expertmeter™ PM180. The reference guide also provides instructions on configuring IED names and setting up inter-device GOOSE communications.

3.1.1 Bay Control Nodes and Objects

The expertmeter™ PM180 provides the dedicated CTRL logical device linked to the bay control unit. The table below shows mapping of data nodes and data objects associated with supervision, monitoring and control of switching devices.

The following designation are used:

XCBRn, n=1-2: circuit breaker nodes XCBR1...XCBR2

XSWIn, n=1-14: circuit switch nodes XSWI1...XSWI14

CILOn, n=1-2: interlocking indication nodes for XCBR1...XCBR2, n=3-16: interlocking indication nodes for XSWI1...XSWI14

CSWIn, n=1-2: switch controller nodes for XCBR1...XCBR2, n=3-16: switch controller nodes for XSWI1...XSWI14

The breaker and switch names are normally preceded with prefixes (not shown in the table) that designate the type and location of the switch and can be configured for each apparatus via the expertmeter™ PM180 Switching Device Setup (see Section 4.1).

Data Object and Attribute	Range	Description	Mapping
Circuit breaker nodes			
XCBRn\$ST\$Loc\$stVal	OFF, ON	Local control behavior	Complement of REMOTE CONTROL
XCBRn\$ST\$Pos\$stVal	Intermediate, OFF, ON, bad	General position indication	XCBRn_Pos
XCBRn\$ST\$BlkOpn\$stVal	OFF=enabled, ON=blocked	Block opening indication	Complement of the interlocking logic output
XCBRn\$ST\$BlkCls\$stVal	OFF=enabled, ON=blocked	Block closing indication	Complement of the interlocking logic output
XCBRn\$ST\$OpCnt\$stVal	0-9999	Operation counter	XCBRn_OpCnt
XCBRn\$ST\$AlmFlt\$stVal	OFF, ON=alarm indication	Fault disconnect alarm	Fault disconnect alarm indication
Circuit switch nodes			
XSWIn\$ST\$Loc\$stVal	OFF, ON	Local control behavior	Complement of REMOTE CONTROL
XSWIn\$ST\$Pos\$stVal	Intermediate, OFF, ON, bad	General position indication	XSWIn_Pos
XSWIn\$ST\$BlkOpn\$stVal	OFF=enabled, ON=blocked	Block opening indication	Complement of the interlocking logic output
XSWIn\$ST\$BlkCls\$stVal	OFF=enabled, ON=blocked	Block closing indication	Complement of the interlocking logic output
XSWIn\$ST\$OpCnt\$stVal	0-9999	Operation counter	XSWIn_OpCnt
Switch interlocking indication nodes			
CILOn\$ST\$EnaOpn\$stVal	OFF=blocked, ON=enabled	Enable Open indication	Open interlocking logic output
CILOn\$ST\$EnaCls\$stVal	OFF=blocked, ON=enabled	Enable Close indication	Close interlocking logic output
CILOn\$SV\$EnaOpn\$subEna	OFF=disabled, ON=enabled	Substitution enable for EnaOpn	Interlocking bypass logic output
CILOn\$SV\$EnaOpn\$subVal	OFF=blocked, ON=enabled	Substitution value for EnaOpn	Interlocking bypass logic output

Data Object and Attribute	Range	Description	Mapping
CILOn\$SV\$EnaCls\$subEna	OFF=disabled, ON=enabled	Substitution enable for EnaCls	Interlocking bypass logic output
CILOn\$SV\$EnaCls\$subVal	OFF=blocked, ON=enabled	Substitution value for EnaCls	Interlocking bypass logic output
Switch controller nodes			
CSWIn\$CO\$Pos\$ctlVal	OFF=operation Open, ON=operation Close	General switch control command	XCBRn_OpOpn, XSWIn_OpOpn, XCBRn_OpCls, XSWIn_OpCls
CSWIn\$ST\$Loc\$stVal	OFF, ON	Local control behavior	Complement of REMOTE CONTROL
CSWIn\$ST\$Pos\$stVal	Intermediate, OFF, ON, bad	General position indication	XCBRn_Pos/XSWIn_Pos
CSWIn\$SV\$Pos\$subEna	OFF=disabled, ON=enabled	Substitution enable for Pos	Writeable
CSWIn\$SV\$Pos\$subVal	Intermediate, OFF, ON, bad	Substitution value for Pos	Writeable
CSWIn\$CF\$Pos\$pulseConfig	onDur=0-60000	Command pulse configuration	Replaces default pulse duration

3.1.2 Switch Control Model

The direct-with-enhanced-security control model is used for apparatus control operations. The command execution is supervised and is reported via the CommandTermination service as the operation completes. If the Start Moving Timeout is defined in the switching device setup, the switching operations are supervised for switch position change before reporting on operation termination.

In case of an unsuccessful command execution, the command termination report is extended by a LastApplError variable indicating the reason in the AddCause attribute. The supported AddCause values are listed in the following table.

Value	Description
1	Not-supported
2	Blocked-by-switching-hierarchy
4	Invalid-position
5	Position-reached
8	Blocked-by-Mode
9	Blocked-by-process
10	Blocked-by-interlocking
12	Command-already-in-execution
13	Blocked-by-health
16	Time-limit-over

3.2 Modbus Communications

See the expertmeter™ PM180 MODBUS reference guide for more information on operating the expertmeter™ PM180 via Modbus.

3.2.1 Bay Control Registers

The following table shows locations of Modbus registers associated with monitoring and control of switching devices and with inter-device GOOSE communications.

The following designations are used:

R – read only

W – write only

R/W – read and write

TRG – for use as a trigger in setpoint control equations

Address	Point ID	Description	Options/Range	Type	R/W
		Switch Position Indication			
29440-29471	0x8A00	Switch position (Pos)	00=intermediate, 01=OFF, 10=ON, 11=bad-state	UINT32	R
+0,1	0x8A00	XCBR1_Pos	00/01/10/11		TRG
+2,3	0x8A01	XCBR2_Pos	00/01/10/11		TRG
+4,5	0x8A02	XSWI1_Pos	00/01/10/11		TRG
			
+30,31	0x8A0F	XSWI14_Pos	00/01/10/11		TRG
		Operation-Open Indication			
29568-29569	0x8B00	Operation Open activation indication: Bit 0: XCBR1_OpOpn Bit 1: XCBR2_OpOpn Bit 2: XSWI1_OpOpn ... Bit 15: XSWI14_OpOpn	0x00000000 - 0x0000FFFF Bit value: 0=not active, 1=activated	UINT32	R
	0x8B00	XCBR1_OpOpn	0/1		TRG
	0x8B01	XCBR2_OpOpn	0/1		TRG
	0x8B02	XSWI1_OpOpn	0/1		TRG
			
	0x8B0F	XSWI14_OpOpn	0/1		TRG
		Operation-Close Indication			
29632-29633	0x8B80	Operation Close activation indication: Bit 0: XCBR1_OpCls Bit 1: XCBR2_OpCls Bit 2: XSWI1_OpCls ... Bit 15: XSWI14_OpCls	0x00000000 - 0x0000FFFF Bit value: 0=not active, 1=activated	UINT32	R
	0x8B80	XCBR1_OpCls	0/1		TRG
	0x8B81	XCBR2_OpCls	0/1		TRG
	0x8B82	XSWI1_OpCls	0/1		TRG
			
	0x8B8F	XSWI14_OpCls	0/1		TRG
29696-29727		Operation Counters (resettable)			
+0,1	0x8C00	XCBR1_OpCnt	0-9999	UINT32	R/W
+2,3	0x8C01	XCBR2_OpCnt	0-9999	UINT32	R/W
+4,5	0x8C02	XSWI1_OpCnt	0-9999	UINT32	R/W
			
+30,31	0x8C0F	XSWI14_OpCnt	0-9999	UINT32	R/W
		Switch Remote Control Registers			
44458-44459		Switch ON/Close command register: Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0=no effect, 1=ON	UINT32	W
44460-44461		Switch OFF/Open command register: Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0=no effect, 1=OFF	UINT32	W
44462-44463		Position substitution enable command register (subEna): Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0=no effect, 1=enable	UINT32	W
44464-44465		Position substitution disable command register (~subEna):	0x00000000 - 0x0000FFFF Bit value: 0=no effect,	UINT32	W

Address	Point ID	Description	Options/Range	Type	R/W
		Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	1=disable		
44466-44481		Position substitution value registers (subVal)	00=intermediate, 01=OFF, 10=ON, 11=bad-state		
+0		XCBR1 position substitution value		UINT16	W
+1		XCBR2 position substitution value		UINT16	W
+2		XSWI1 position substitution value		UINT16	W
...		...			
+15		XSWI14 position substitution value		UINT16	W
		Switch Status Registers			
44514-44515		Operation Open activation indication (alias): Bit 0: XCBR1_OpOpn Bit 1: XCBR2_OpOpn Bit 2: XSWI1_OpOpn ... Bit 15: XSWI14_OpOpn	0x00000000 - 0x0000FFFF Bit value: 0=not active, 1=activated	UINT32	R
44516-44517		Operation Close activation indication (alias): Bit 0: XCBR1_OpCls Bit 1: XCBR2_OpCls Bit 2: XSWI1_OpCls ... Bit 15: XSWI14_OpCls	0x00000000 - 0x0000FFFF Bit value: 0=not active, 1=activated	UINT32	R
44518-44519		Enable Opening status (EnaOpn): Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0= blocked, 1=enabled	UINT32	R
44520-44521		Enable Closing status (EnaCls): Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0= blocked, 1=enabled	UINT32	R
44522-44523		Position substitution enable status (subEna): Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0=actual position, 1=substituted position	UINT32	R
44524-44525		Fault disconnect alarm status (AlmFit): Bit 0: XCBR1 Bit 1: XCBR2 Bit 2: XSWI1 ... Bit 15: XSWI14	0x00000000 - 0x0000FFFF Bit value: 0=no alarm, 1=alarm	UINT32	R
44526-44541		Command termination status	0=Success, 1=Not-supported, 2=Blocked-by-switching-hierarchy, 4=Invalid-position, 5=Position-reached, 8=Blocked-by-Mode, 9=Blocked-by-process, 10=Blocked-by-interlocking, 12=Command-already-in-execution, 13=Blocked-by-health, 16=Time-limit-over	UINT16	R
+0		XCBR1 command termination status		UINT16	R

Address	Point ID	Description	Options/Range	Type	R/W
+1		XCBR2 command termination status		UINT16	R
+2		XSWI1 command termination status		UINT16	R
...		...			
+15		XSWI14 command termination status		UINT16	R
28160-28223		External Integer Measured Values			
+0,1	0x8000	ExtiVal1		INT32	R
+2,3	0x8001	ExtiVal2		INT32	R
		INT32	R
+62,63	0x801F	ExtiVal32		INT32	R
28288-28321		External Float Measured Values			
+0,1	0x8100	ExtfVal1		FLOAT32	R
+2,3	0x8101	ExtfVal2		FLOAT32	R
		FLOAT32	R
+62,63	0x801F	ExtfVal32		FLOAT32	R
		External Indication			
28416-28417	0x8200	ExtInd1:32 Bit 0: ExtInd1 ... Bit 32: ExtInd32	0x00000000-0xFFFFFFFF Bit value: 0=OFF, 1=ON	UINT32	R
28480-28481	0x8220	ExtInd33:64 Bit 0: ExtInd33 ... Bit 32: ExtInd64	0x00000000-0xFFFFFFFF Bit value: 0=OFF, 1=ON	UINT32	R
28544-28545	0x8240	ExtInd65:96 Bit 0: ExtInd65 ... Bit 32: ExtInd96	0x00000000-0xFFFFFFFF Bit value: 0=OFF, 1=ON	UINT32	R
28608-28609	0x8260	ExtInd97:128 Bit 0: ExtInd97 ... Bit 32: ExtInd128	0x00000000-0xFFFFFFFF Bit value: 0=OFF, 1=ON	UINT32	R
	0x8200	ExtInd1	0/1	UINT32	TRG
	0x8201	ExtInd2	0/1	UINT32	TRG
			
	0x827F	ExtInd128	0/1	UINT32	TRG

3.2.2 Switch Control Model

The direct-with-enhanced-security control model is used for apparatus control operations as described in Section 3.1.2 above. The command execution is supervised and is reported via the command termination status registers 44526-44541 as the control operation is terminated. The Operation-Open and Operation-Close indication registers can be monitored to follow the termination of the activated operation.

4 Configuring the Bay Controller

4.1 Configuring Switching Devices

To configure the switching devices for monitoring and control via the expertmeter™ PM180 bay control unit:

1. Select Bay Control Setup from the Meter Setup menu.

General		Control	
Switch Name	XCBR1	Close Control Output	R01
IEC 61850 Name Prefix	QA1	Open Control Output	R02
Switch Type	Breaker	Open-2 Control Output	----
Switch Enabled	Disabled	Select-Close Control Output	----
Position Indication		Select-Open Control Output	----
Phase A N.O. Contact Indication	DI1	Select-Open-2 Control Output	----
Phase A N.C. Contact Indication	DI2	Close Duration Control Logic Equation	----
Phase B N.O. Contact Indication	DI3	Open Duration Control Logic Equation	----
Phase B N.C. Contact Indication	DI4	Close Command Duration, ms	2000
Phase C N.O. Contact Indication	DI5	Open Command Duration, ms	2000
Phase C N.C. Contact Indication	DI6	Close Start Moving Timeout, ms	5000
Interlocking		Open Start Moving Timeout, ms	5000
Enable Close Logic Equation	SP9	Close Command Termination Timeout, ms	10000
Enable Open Logic Equation	SP9	Open Command Termination Timeout, ms	10000
Interlocking Bypass Logic Equation	----		
Interlocking Bypass Timeout, s	30		

2. Choose a switching device to configure in the Switch Name box and setup required switch attributes, position indication inputs and control outputs. See the table below for available options. See Section 2 for the explanations and configuration guidelines.
3. Select Enabled in the Switch Enabled box to activate switch monitoring.
4. Repeat the setup for other switches you wish to configure, and then send your setup to the device and save to the device database. Notice that switch name prefixes will not be available in PAS indications unless you saved the switch setup in the device database on your PC.

Parameter	Options	Default	Description
General			
Switch Name	XCBR1-XCBR2, XSWI1-XSWI14		Identification name of a switching device
IEC 61850 Name Prefix	1-5 ASCII characters		Name prefix to be displayed as a part of a switch name in IEC 61850 and in PAS.
Switch Type	Load break switch, Disconnecter, Earthing switch,		IEC 61850 switch type. Not changeable for breakers.

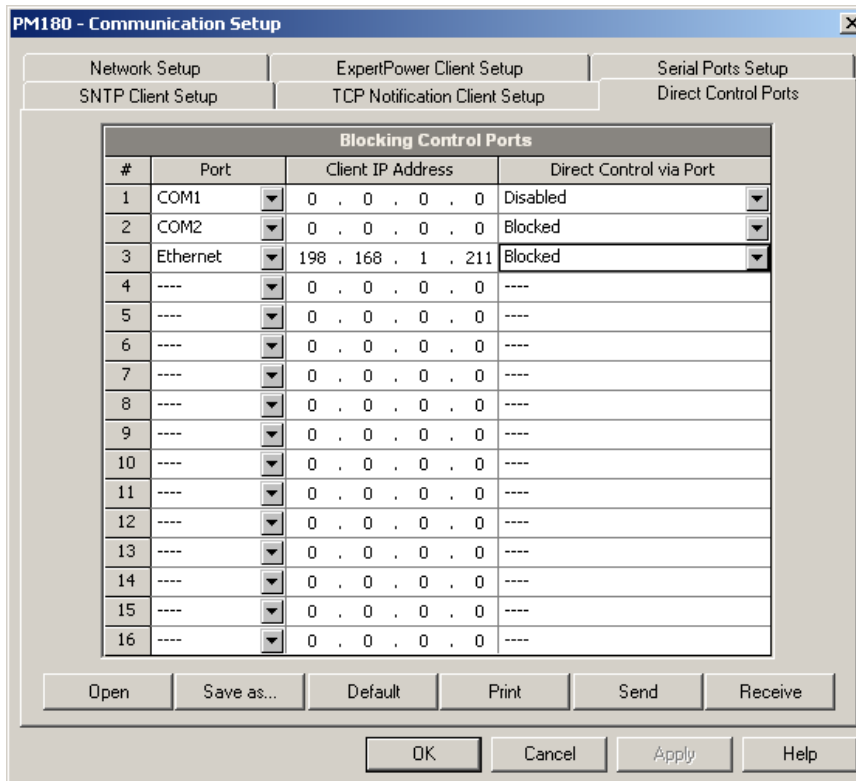
Parameter	Options	Default	Description
	High speed earthing switch, Breaker		
Switch Enabled	Disabled, Enabled	Disabled	Enables switch monitoring and control
Position Indication			
Phase A N.O. Contact Indication	None, DI1-DI48, SP1-SP64, FLAG1-FLAG64 ExtInd1-ExtInd128		Normally open contact input of phase A and for general switch position indication in case of two-contact position monitoring
Phase A N.C. Contact Indication	None, DI1-DI48, SP1-SP64, FLAG1-FLAG64 ExtInd1-ExtInd128		Normally closed contact input of phase A and for general switch position indication in case of two-contact position monitoring
Phase B N.O. Contact Indication	None, DI1-DI48, SP1-SP64, FLAG1-FLAG64 ExtInd1-ExtInd128		Normally open contact input of phase B
Phase B N.C. contact Indication	None, DI1-DI48, SP1-SP64, FLAG1-FLAG64 ExtInd1-ExtInd128		Normally closed contact input of phase B
Phase C N.O. Contact Indication	None, DI1-DI48, SP1-SP64, FLAG1-FLAG64 ExtInd1-ExtInd128		Normally open contact input of phase C
Phase C N.C. contact indication	None, DI1-DI48, SP1-SP64, FLAG1-FLAG64 ExtInd1-ExtInd128		Normally closed contact input of phase C
Interlocking			
Enable close logic equation	None, SP1-SP64, TRUE		Setpoint control equation enabling switch close commands. None = unconditionally blocked, TRUE = unconditionally enabled.
Enable open logic equation	None, SP1-SP64, TRUE		Setpoint control equation enabling switch open commands. None = unconditionally blocked, TRUE = unconditionally enabled.
Interlocking Bypass Logic Equation	None, SP1-SP64		Setpoint control equation overriding interlocking logic. Active within the bypass timeout interval. None = not used.
Interlocking Bypass Timeout, s	1-600 s	30	Interlocking bypass activity timeout
Control			
Close control output	None, RO1-RO24		Command output for switch close commands
Open control output	None, RO1-RO24		Command output for switch open commands
Open-2 control output	None, RO1-RO24		Second command output for switch open commands for devices with two opening coils
Select-Close control output	None, RO1-RO24		Pre-select control output for switch close commands
Select-Open control output	None, RO1-RO24		Pre-select control output for switch open commands
Select-Open-2 control output	None, RO1-RO24		Second pre-select control output for switch open commands for devices with two opening coils
Close Duration Control Logic Equation	None, SP1-SP64		Setpoint control equation controlling the close pulse duration for adaptive pulses
Open Duration Control Logic Equation	None, SP1-SP64		Setpoint control equation controlling the open pulse duration for adaptive pulses
Close Command Duration, ms	100-60000 ms	2000	Default close command pulse duration
Open Command Duration, ms	100-60000 ms	2000	Default open command pulse duration
Close Start Moving Timeout, ms	0-60000 ms	5000	Switch immobility timeout for close command execution supervision.

Parameter	Options	Default	Description
			0=not supervised
Open Start Moving Timeout, ms	0-60000 ms	5000	Switch immobility timeout for open command execution supervision. 0=not supervised
Close Command Termination Timeout, ms	1-120000 ms	10000	Total close operation supervision timeout
Open Command Termination Timeout, ms	1-120000 ms	10000	Total open operation supervision timeout

4.2 Configuring Control Ports

This setup allows configuring individual control permissions for user ports. To restrict control operations for users:

1. Select Communication Setup from the Meter Setup menu and then click on the Direct Control Ports tab.



2. Configure control permissions for user ports. The following table lists available options:

Direct Control Status	Description
Enabled	Control commands from the port are allowed
Disabled	Control commands from the port are denied
Blocked	Control commands from the port are denied until the port is unblocked via setpoint control logic

The following rules are applied:

- a) Control commands from serial ports and from the USB port not listed in the setup are allowed by default. Those for which direct control must be disabled or blocked should be listed in the setup.
- b) Control commands for Ethernet users are allowed for all clients by default if no Ethernet ports are listed in the setup. If one of the records points to an Ethernet

port, control commands are denied for all Ethernet clients except of listed in the setup. A record with a zero IP address applies to all Ethernet clients except of directly listed in the setup.

c) The order of listing of ports in the setup does not matter.

3. Send your setup to the device.