Book 6
Technical Specification and Requirements of Switch (SW)

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Technical Specification for Switch (SW)
In Microgrid Development Project at Mae Sariang District
Provincial Electricity Authority

1. Introduction

This technical specification presents the PEA's requirements concerning the remote control switch (RCS) and feeder device control unit (FDCU) for Mae-Sariang microgrid. Figure 1.1 shows a connection diagram of Mae-Sariang micro-grid, which the SW is denoted for the complete set of the RCS and FDCU. The SW functions are mainly designed in order to fulfill microgrid operation, a fault detection, an islanding operation and a fault location isolation and supply restoration (FLISR) operation and also a waveshape monitoring.

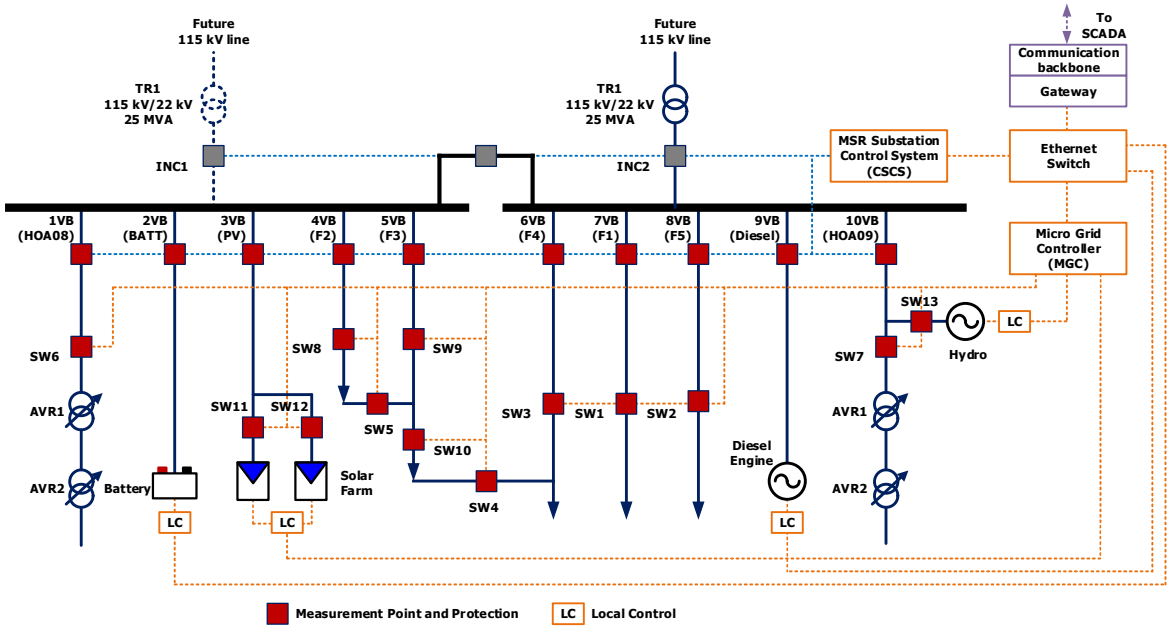

Figure 1.1Substation diagram of Mae-Sarieng microgrid

1.1 Scope of works

The contractor must supply the complete set of outdoor SW type for 22kV 50Hz distribution system. The operation time to open the switches at rated normal current shall not be more than 2 second and to close the switches at rated normal current shall not be more than 5 second. The SW shall have the functions to indicate the open/closed position of each interrupter, phase voltages and currents, reason for a phase trip, waveshave event and to monitor power quality. The communication module shall include an integrated Global Positioning System clock for event time-stamping.

The communication standard between SWs and microgrid controller (MGC) must be based on IEC61850 standard. The communication channels is a fiber optic cable. The fiber optic cable is utilized in a normal condition. If the MGC is failed, the PEA's SCADA system must be able to control all SWs.

The location of SWs is given in Figure1.2. The contractor will be received the exact location of SWs site installation including with x-y coordination GPS by PEA. The SWs shall be installed at point, which is provided by the PEA. The contactor must deliver 13 units of SW plus a spare part. The spare part of SW must not less than 20 % of delivered SWs.

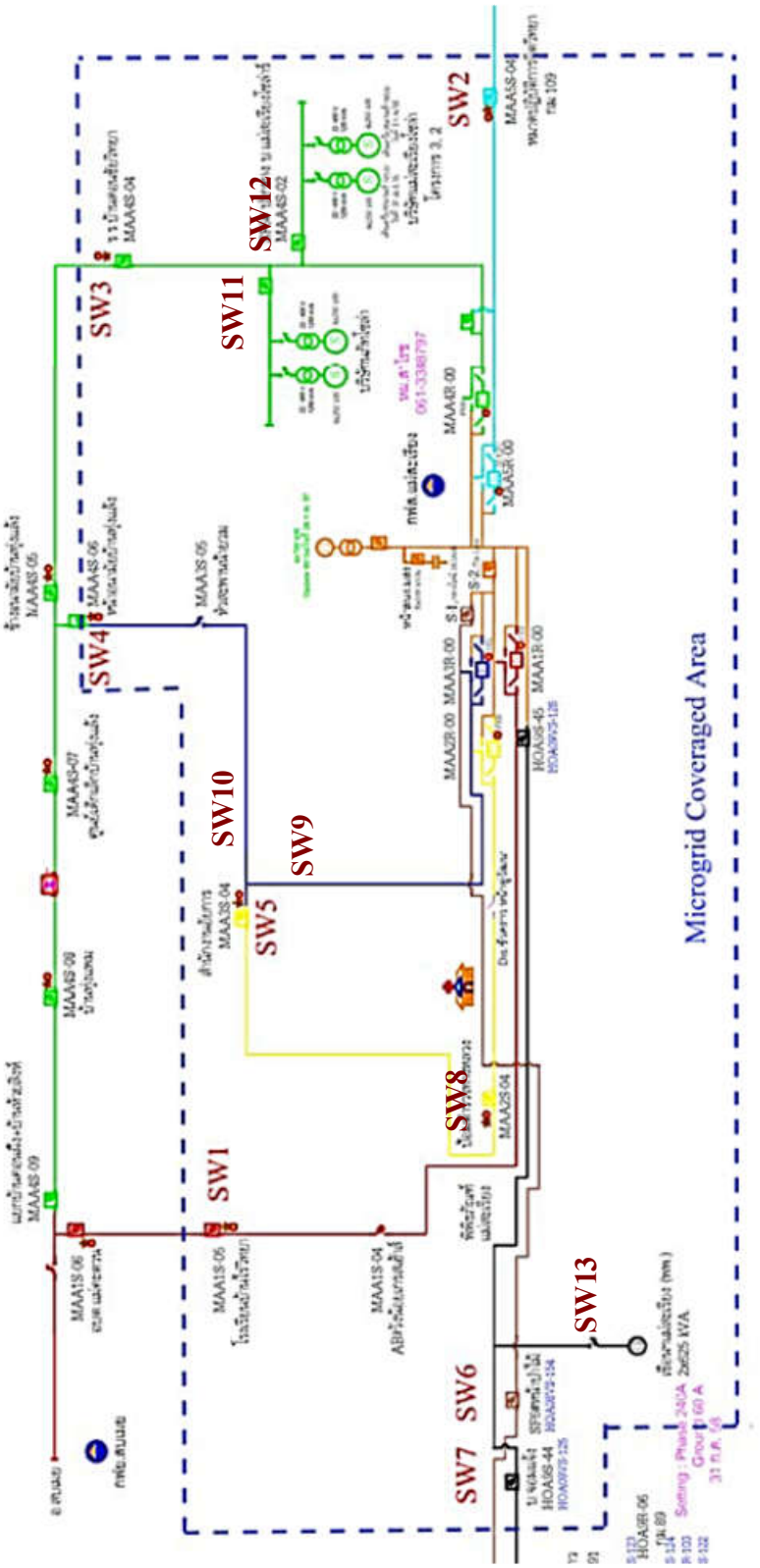

Figure 1.2 Location of SW in Mae-Sariang microgrid

2. Technical specification and requirements of Mae Sariang microgrid switch

The switch is a three phase system and will be installed at 22 kV 50 Hz overhead distribution system. This specification is a part of SW for Mae Sariang microgrid, which covers the technical specification of RCS and FDUC.

2.1 Common requirements

This clause describes the Authority's common requirements that apply to the SW equipment.

2.1.1 Standards

The SW and its accessories should be designed in accordance with one of the following standards:

1) International Electrotechnical Commission (IEC)
2) Institute of Electrical and Electronic Engineers (IEEE)
3) American National Standards Institute (ANSI)
4) National Equipment Manufacturers Association (NEMA).

For conditions not covered by the above referenced standards, other internationally recognized standards may also apply, if they are approved by the PEA. In all cases, the provisions of the latest current edition or revision of the applicable standards or codes in effect shall apply. If the referenced standard has been superseded, then the reference to the standard implies a reference to the superseded version of the standard.

In all cases, the provisions of the latest current edition or revision of the referenced standard or code shall apply. If the initially referenced standard or code has been superseded, any such reference shall imply a reference to the new standard or code.

In addition to the SW, it shall be manufactured and tested in accordance standard with the following issues:

1) Interrupting
2) Dielectric
3) Temperature Rise
4) Short Time
5) Fault Closing
6) Mechanical Endurance

2.1.2 Service condition

The SW shall be suitable for operation under the following conditions:

1) Ambient air temperature: up to $50^{O}C$
2) Relative humidity: up to 94%
3) Altitude: up to 1,000 m above mean sea level
4) Climatic condition : tropical climate

2.2 Functional requirements

The following issues are the major requirements for each SW.

2.2.1 Fault detection

The SW shall include a function to determine if phase-to-phase or phase-to ground faults on the both side of the SW. The fault detection function shall work properly for all possible configurations of the circuit on which the SW are installed. The feeder fault detection function shall be designed to prevent mis-operation due to magnetizing-inrush currents and other transient, no-fault conditions. Note that the fault detection is a part of FLISR operation.

2.2.2 Sequence of event

The SW shall include the sequence-of-events (SOE) reporting capability. It shall be possible to assign any status input point to SOE reporting in addition to normal status reporting. The SW shall detect changes in the state of SOE points, record the date and time of change with a resolution of plus or minus one millisecond (±1 ms) relative to the SW internal clock, inform the MGC that SOE data has been recorded, and report SOE data to the MGC upon request.

2.2.3 Waveshape monitoring

The SW shall include the waveshape monitoring function at the installation location. The waveshape of all switches has to be sent to MGC with the equal accurate event time-stamping. In additional, the software to examine of waveforms and events at the location of switch has to be provided, which the communication could be the secure Wi-Fi communication to a nearby laptop computer or hard connect direct to the SW.

2.2.4 Protection and control

The SW shall include a complete set of protection and control functions, including:

- Simultaneous independent directional phase, ground, negative-sequence, and sensitive-earth time-overcurrent, instantaneous-overcurrent, and definite-time elements
- Directional blocking of overcurrent elements
- Over/under voltage elements
- Over/under frequency elements

The protection and control elements shall enable sequence coordination, phase unbalance detection, and synchronization check functions, and include a cold-load pickup modifier.

2.2.5 Communication protocol

The communication standard between SW and MGC must be based on IEC61850 standard, which the communication channels is a fiber optic cable. If the MGC is failed, the PEA's SCADA system must be able to control all SW as SCADA normal operation.

2.3 The remote control switch (RCS)

The operation time of RCS shall be as follows:

- The time to open the switches at rated normal current shall not be more than 2 second.
- The time to close the switches shall not be more than 5 second.

The opening and closing times shall be measured as follows:

- Timing shall start when the switches open or close action is initiated at the local control panel of the switches, and
- Timing shall end when the switches position indicator changes state.

The number of operation shall be as follows:

- Mechanical operation should not less than 2000 times.
- Electrical operation at rated current should not less than 400 times.

The RCS shall be operated both manually without power supply by using a NEMA-head hook stick, and electrically by using operating mechanism and control unit. It shall be interlocked to permit operation only when the switches are open.

The RCS housing shall be molded from cycloaliphatic epoxy resin. All metallic housing components shall be stainless steel or corrosion resistant non-painted materials, and all components shall be mounted on a unitized stainless-steel base.

Note that, the RCS unit and its accessories shall be designed and constructed for mounting on the same pole, which has to be firstly approved by PEA.

2.3.1 Rating

The ratings and characteristics of SW are specified in Table 2.1.

Table 2.1 Ratings and characteristics of the RCS

Ratings and characteristics	unit	Requirement
Rated nominal system voltage	kV	22
Rated frequency	Hz	50
Rated normal current	A	Not less than 600
Rated symmetrical interrupting current	A	Not less than 600
Maximum voltage for power module	kV	24
Minimum voltage for power module	kV	20

2.3.2 Local operation

The SW shall be furnished with local swing type control panel for initiating control actions and viewing the status indicators of the SWs. As minimum, the local control panel shall include the following:

1. A color code indicator shall be provided, i.e. “Open” (green) and “Close” (red), with LED super bright pilot lamps or better. The indicator shall be readily visible from the ground.
2. An operation counter to indicate the number of switching cycles of the switches. The operation counter shall count the increment for electrical operations (remote control or local control) and mechanical operations (hook-stick).
3. Others according to manufacturer’s design.

2.3.3 Operation control interface

In general, the SW shall be support the mechanical operations (hook-stick). Furthermore, the SW shall be support the remote control and/or local control cabinet.

If the bidder proposes the remote control interface, the communication to RCS shall be the secure Wi-Fi communication to a nearby laptop computer. The unit shall not transmit a Wi-Fi signal until an encrypted wake-up message is sent by the securely recognized laptop. All wireless communications shall be adequately encrypted with user definable encryption keys and password protected for security purposes. The control software shall permit the selection of local (mechanical operations) or remote operation. When local operation has been selected, the control program shall command local electrical opening and closing of the interrupters. The laptop computer, software and its necessary accessories have to be provided. Remarks, the secure Wi-Fi communication and the communication distance to SW have to be approved by PEA.

If the bidder proposes the local control cabinet, it has to be mounted on the same pole of RCS. Each set of the RCS shall be equipped with a control cabinet that will houses all equipment according to manufacturer's design. Remarks, the wiring design inside control cabinet, the wiring design to its switch, and material of control cabinet have to be approved by PEA.

2.4 The feeder device control unit (FDCU)

2.4.1 Inputs

The FDCU shall:

1. Acquire analog inputs directly without transducers from each of three power system voltage and current terminals in the existing or Contactor-provided SW control cabinets.
2. Apply suitable filtering to eliminate the risk of signal aliasing.
3. Use voltage and current inputs for calculations that support MGC acquisition of the following data as a minimum:
   a. Line-to-line voltages.
   b. Phase current magnitudes and phase angles.
   c. Real and reactive powers (three-phase kW and kvar totals with sign).
   d. Power factor.
4. Accept AC voltage input signals with a normal input level of 110 V.
5. Employ analog to digital converters with minimum of 16-bit resolution for a bipolar input signal.
6. Accurately resolve AC voltage input signal levels from 0 to 150 V.
7. Accurately resolve AC current input signals with normal ranges of 0 to 5 A or 0 to 1 A.
8. Include the capability to report all analog values that have changed by more than their programmable dead bands from their last values successfully reported to the MGC.
9. Record maximum RMS fault current signals, over a period of at least one (1) second, up to 20 times normal (100 A) within a maximum error of 2.5% of Full Scale Deflection (FSD).
10. Not impose a total analog input burden of more than 0.5 VA for all current and voltage inputs.
11. Demonstrate an overall analog input error of no more than ±0.2% of 1.2 times normal FSD over the temperature range 0 to 70 ˚C
12. Demonstrate an analog input linearity better than ±0.05%.
13. Reject common mode AC (50 Hz) voltages up to 150 V

2.4.2 Status Inputs

As a minimum, the FDCU shall accept isolated wet and dry single contact two-state status inputs and two-state status inputs with memory, i.e., Momentary Change Detection (MCD) inputs. Input change of state shall be time-stamped to a precision of 1 millisecond.

Within this context:

1. All necessary wetting voltage, current limiting, input isolation, and bounce filtering shall be provided.
2. Contact de-bounce time periods shall be individually configurable.

3. The input circuits shall be optically isolated from the external signal.
4. Unless the FDCU can provide its own self-supplied wetting voltages, input contact wetting voltages shall be 24 Vdc as obtained from the dc power supply in the existing or Contactor- provided SW control cabinets.
5. Each wetting voltage circuit shall be protected with its own circuit breaker.

2.4.3 Control outputs

The FDCU shall support the following control output features:

1. A Select-CheckBack-Before-Operate (SCBO) procedure for all control operations. In this respect, the following concepts shall apply:
   a. On receipt of a control point select command, the FDCU shall check that no other point is selected, select the requested point, acknowledge the select command, and start a Command Receipt Timer.
   b. Control point selection shall be canceled if the subsequent operate command is not received within the Control Receipt Timer's programmable time-out period, which shall be adjustable from five (5) to thirty (30) seconds.
   c. On receipt of the operate command, if the control point has remained selected and no other point has become selected, the FDCU shall then initiate the requested control action.
   d. The SCBO procedure shall be canceled automatically on completion of the control action or if not completed within an adjustable time-out period of up to 60 seconds.
   e. Any further attempt at control shall require a new SCBO procedure.
2. SW opening and closing by sending commands to a complimentary pair of contact outputs such that:
   a. One command activates the contact used to open the switch.
   b. The other command activates the contact used to close the switch.
   c. Only one contact output in a complimentary pair can be activated at a time.
3. Momentary control where each output provides a contact closure pulse having an individually programmable duration from 1 to 60 seconds in increments of 1 second.

The following requirements shall also apply:

1. The voltage rating of the control output contacts shall be 24 Vdc.
2. All control power shall be obtained from the existing or Contractor supplied 24 Vdc power supply.
3. FDCU control outputs shall be able to drive loads of at least six (6) amps.
4. Output relays shall be designed for 106 (one million) mechanical operations.
5. The FDCU shall monitor all operations and local status information and give warnings or advisory messages when any wrong operational sequence is requested.
6. Abnormal conditions shall inhibit control operations.

2.4.4 Fail safe design

The FDCUs shall be designed to prevent false control actions being executed and erroneous data being transmitted. In this respect, they shall incorporate the following fail-safe design criteria in their control output logic:

1. No false output shall result from a single point of failure in any FDCU.
2. No false output shall result during FDCU power up or power down.
3. No false output shall result from inadvertently inserting a circuit card into a wrong slot within the FDCU.

2.4.5 I/O module

Each I/O module shall be capable of interfacing with analog inputs, digital inputs, control output points, and combinations of point types. I/O modules shall be replaceable without reprogramming, redefinition of configuration parameters, or rewiring. A control disable switch shall be provided within each I/O module. When the switch is in the control position, the MGC or test set shall have control of the digital control outputs. When the switch is in the disable position, the digital control outputs shall be disabled. The minimum requirement of I/O signals are given in Appendix. Note that, some extra I/O is only required, if the bidder proposes the local control cabinet.

2.4.6 Time and date module

The communication module of FDCU shall have an internal clock for data collection coordination and time tagging. The internal clock shall be synchronized using a Greenwich Mean Time (GMT) reference signal generated by the MGC in long format and properly accounting for relevant communication path delays. The resolution of the internal clock shall be 1 millisecond or better, and its real-time synchronization accuracy shall be within 10 milliseconds of the of the MGC time reference signal. Time drift of the internal clock shall drift by no more than 100 milliseconds per hour in the event that no time synchronization is received from the MGC.

No internal batteries shall be used to power the internal clock when the communication module of FDCU is disconnected from its 24 V DC power source. Therefore, whenever the communication module of SW unit is powered up, the internal clock must be re-synchronized using the MGC time and date reference signal. The need to re-synchronize, however, shall not prevent the communication module of SW from immediately registering inputs even before the time and date reference signal has been received from the MGC. Thus, any such registered inputs shall also be reported to the MGC.

2.4.7 Local control panel

The local control panel shall include:

1. An SW A/C power supply on/off switch.
2. Switches for opening and closing the SW. When the A/C power source is off, operation of the SW shall be possible by using the battery backup feature of the Contractor supplied dc power supply.
3. A Local/Remote switch. While this switch is in the “Local” position, control shall be permitted only from the local control panel (i.e., remote control shall be prohibited). Otherwise, while the switch is in its “Remote” position, control shall be permitted only from the MGC (i.e., local control shall be prohibited).
4. Separate green and red super bright LED pilot lamps not less than 6 mm in diameter for showing the open/close status of the SW respectively.

5. An operations counter to indicate the number of SW switching cycles. The counter shall increment for electrical operations (whether remote or local) and for mechanical hook-stick operations.
6. Red super bright LED lamps not less than 3 mm in diameter to show the following status indications as a minimum:
   a. Switch Mechanical Lock.
   b. Switch Mechanical Free.
   c. Low Battery Voltage.
   d. High Battery Voltage.
   e. Battery Failed Alarm.
   f. Battery Charger Overvoltage.
   g. Local or Remote Control.
7. Battery voltage test points

2.4.8 Interlocking

The FDCU shall include configurable interlock logic to prevent misoperation of the SW. In addition to preventing SW operation locally and/or remotely in accordance with the positions of the Local/Remote and Mechanical Lock/Free switches.

2.5 Power supply

1) The power supply shall be derived from an integral power module fed from one phase on one side of the interrupting system; or the power supply shall be derived from two integral power modules, each fed from a different phase on both sides of the fault interrupting system.
2) The integral power module(s) shall provide all control power for the interrupting system in standalone (non-communicating) applications.
3) AC line voltage must be available to the integral power module, which the integral power module shall supply 24 VDC.
4) The backup power supply shall be available and maintenance free. The backup power supply shall have sufficient capacity to sustain operation of the equipment including FDCU for not less than 12 hours after the AC power supply is failed, and shall be able to operate SW with not less than 2 open – close cycles.

2.6 Electric surge protection

1) All necessary measures shall be taken to ensure proper functions and component safety of the local control panel, the power supply, and all other SW components with respect to switching voltage transients and all regular atmospheric, electrical, and magnetic disturbances, whether induced or directly coupled.
2) In particular, the equipment shall be constructed and tested to meet the latest applicable standards of IEC 60255-5, or ANSI/IEEE C37.90.1 and ANSI/IEEE C37.1 and be capable of withstanding the tests described in these standards without damage, false control output, or loss of internally stored data and parameters.
3) The electric surge protection shall be separated from print circuit board (PCB).

4) The electric surge protection for power supply shall be Surge Protective Device (SPD) and shall be installed as follows:
   - Connected between Line and Neutral (L-N)
   - Connected between Neutral and Ground (N-G)

5) The SPD shall have rating as the follows:

- Standard	:	IEC 61643-11
- Arrester class	:	class II
- Nominal voltage, U_n	:	240 VAC
- Maximum continuous operating voltage, U_C (L-N)	:	320-350 VAC
- Maximum continuous operating voltage, Uc (N-G)	:	264 VAC
- Nominal discharge surge current, In (8/20 μs)	:	20 kA per phase
- Max discharge surge current, Imax (8/20 μs)	:	40 kA per phase
- Response time (L-N)	:	≤25 ns
- Response time (N-G)	:	≤100 ns
- Voltage protection level, Up (L-N)	:	≤1.5 kV
- Voltage protection level, Up (N-G)	:	≤1.5 kV
- Temperature range	:	-40^{O}C to 70^{O}C

2.7 Minimum nameplate information

1) Manufacturer's name/country
2) Type
3) Manufacturer's serial number
4) Year of manufacture
5) Rated voltage
6) Rated frequency
7) Rated normal current
8) Rated symmetrical interrupting current
9) Rated short-time withstand current, 1 sec
10) Rated short-circuit making current
11) Rated power frequency withstand voltage, 1 min
12) Rated impulse withstand voltage
13) Rated auxiliary voltage
14) Net weight

2.8 Test and test report

The bidder shall submit the test report to PEA. The required test report is the type test report. Further information according to test and test report is given in Book1–the project overview.

2.9 Marking

PEA's code number and contract number shall be painted in orange on all components. The code and contract number shall be easily visible from ground level. The code number and dimensions of each letter to be marked will be given by PEA after the final of bid consideration

2.10 Packing

Each set of the SW with installation instruction and its accessories with part list shall be seaworthy packed in an export crates or wooden cases; but each set of accessories with part list may be separately seaworthy packed in other wooden cases to avoid damage during transportation. Part belonging to different sets of the SW shall not be packed in the same package.

If the package is made of rubber wood (Yang-para of Heveabrasiliensis), the wooden parts shall be treated with wood preservative. A plastic foam will not be accepted.

Appendix – I/O List

The minimum requirement of I/O points for FDCU are listed as following.

Control Outputs											
Item	Point Name	State		Terminal	Point	DMS (DNP Mappling)					Remark
		1	2	Connection	Type	Obj	Var	Qii	Class	Address	
1	RCS Close/Trip Command	Close	Open		SBO	12	1	echo of		0	
					SBO			request			
2	RCS Test Command	Test	-		DOP	12	1	echo of		1	
					DOP			request			

Analog Points											
Item	Point Name	Unit	Scale		Terminal	Point	DMS (DNP Mappling)					Remark
			Actual Data	Raw Data	Connection	Type	Obj	Var	Qii	Class	Address	
1	Current Phase A	A	0-600	0-32767		AI	32	2	17,28	2	0	600/1 for 22kV, 400/1 for 33kV
2	Current Phase B	A	0-600	0-32767		AI	32	2	17,28	2	1	600/1 for 22kV, 400/1 for 33kV
3	Current Phase C	A	0-600	0-32767		AI	32	2	17,28	2	2	600/1 for 22kV, 400/1 for 33kV
4	Voltage Phasae A-B	kV	0-30	0-32767		AI	32	2	17,28	2	3	22000/110V
5	Voltage Phasae B-C	kV	0-30	0-32767		AI	32	2	17,28	2	4	22000/110V
6	Voltage Phasae C-A	kV	0-30	0-32767		AI	32	2	17,28	2	5	22000/110V
7	Active Power	MW	-31.167-+31.176	-32768-+32767		AI	32	2	17,28	2	6	Calculated by Software
8	Reactive Power	Mvar	-31.167-+31.176	-32768-+32767		AI	32	2	17,28	2	7	Calculated by Software
9	Power Factor	%	-31.167-+31.176	-32768-+32767		AI	32	2	17,28	2	8	Calculated by Software
10	Fault Current A	A	20,000			AI	32	2	17,28	2	9	
11	Fault Current B	A	20,000			AI	32	2	17,28	2	10	
12	Fault Current C	A	20,000			AI	32	2	17,28	2	11	

Status Points												
Item	Point Name	State			Terminal	Point	DMS (DNP Mappling)					Remark
		1	2	3	Connection	Type	Obj	Var	Qii	Class	Address	
1	1st Fault Detected Postitive	Normal	Alam			SOE	2	2	17,28	1	0	Calculated by Software
2	2nd Fault Detected Postitive	Normal	Alam			SOE	2	2	17,28	1	1	Calculated by Software
3	3rd Fault Detected Postitive	Normal	Alam			SOE	2	2	17,28	1	2	Calculated by Software
4	1st Fault Detected Negative	Normal	Alam			SOE	2	2	17,28	1	3	Calculated by Software
5	2nd Fault Detected Negative	Normal	Alam			SOE	2	2	17,28	1	4	Calculated by Software
6	3rd Fault Detected Negative	Normal	Alam			SOE	2	2	17,28	1	5	Calculated by Software
7	Control mode	Undefine	Remote	Local		DI	2	1	17,28	1	6	
8						DI	2	1	17,28	1	7	
9	Switch status	Undefine	Close	Open		SOE	2	2	17,28	1	8	
10						SOE	2	2	17,28	1	9	
11	Battery Low Voltage	Normal	Alam			DI	2	1	17,28	3	10	Battery Fail/Normal Group Alam
12	Battery High Voltage	Normal	Alam			DI	2	1	17,28	3	11	Battery Fail/Normal Group Alam
13	Battery Charger OverVoltage	Normal	Alam			DI	2	1	17,28	3	12	
14	Battery Charger Grounded	Normal	Alam			DI	2	1	17,28	3	13	Battery Fail/Normal Group Alam
15	Encloser Door Open	Normal	Alam			DI	2	1	17,28	1	14	
16	Control Inhibit Status	Normal	Alam			DI	2	1	17,28	3	15	
17	Mechanical Device Status	Undefine	Free	Lock		DI	2	1	17,28	3	16	
18						DI	2	1	17,28	3	17	
19	RTU Data Quality	Normal	Fault			DI	2	1	17,28	3	18	Generated by Software
20	RTU Testing Status	Normal	Fault			DI	2	1	17,28	1	19	

SBO = Output Command (select before operate), DOP = Output Command (direct operate)
AI = Analog Input (measurement)
DI = Regular Point (digital input without time tag), SOE = MDC point (digital input with time tag)
Note: The meaning of desciptor is before"/" is state "1" after"/" is state 0 for binary point; first line is state "0,1" second line is state "1,0" for ternary point.
Class1 = Unsolicited
CLass2,3 = Polling