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## Appendix A:

Technical Specifications  
Feeder Device Control Unit



## 1. Common Requirements

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

### 1.1 General

The following general requirements shall be met:

- 1) The FDCU equipment shall be designed, fabricated, assembled, finished, and documented with workmanship of the highest production quality and shall conform to all applicable quality control standards of the original manufacturer and/or Contractor.
- 2) All materials shall be new, unused, and of the best industrial grade.
- 3) The equipment shall incorporate all recent improvements in both design and materials and, in this respect, shall be assembled using current production components from reliable component manufacturers. Manufacturer standard designs shall be used as much as possible.
- 4) To facilitate expansion and maintenance, modularity shall be employed in the design of the equipment.
- 5) Major components shall carry permanent labels providing a cross-reference to the Contractor's corresponding documentation.
- 6) Materials promoting the growth of fungus or susceptibility to corrosion and heat degradation shall not be used. Steps shall be taken to provide rodent proof installations.
- 7) The equipment shall support internal clock time retention in the event of a power supply failure. In this respect, the use of an on-board battery is not acceptable (also refer to Clause 2.3.4). The mechanism for internal clock retention shall not require periodic maintenance.



- 8) All features of the proposed equipment, as described in the Contractor's proposal and associated reference materials, shall be fully supported by the equipment delivered.

### 1.2 Standards

With respect to installation procedures and associated accessories (such as power cables, ground cables, surge arrestors, etc.), the standards of the Engineering Institute of Thailand shall apply. Otherwise, the FDCU equipment shall be designed in accordance with applicable International Electrotechnical Commission (IEC) standards and comply, as may be necessary, to standards published by other organizations, such as the Institute of Electrical and Electronic Engineers (IEEE), American National Standards Institute (ANSI), National Equipment Manufacturers Association (NEMA), and Electronic Industries Alliance (EIA).

For conditions not covered by the referenced standards, other internationally recognized standards identified by the Contractor and approved by the Authority shall apply.

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.

Within the context above, the Authority is particularly concerned with the end-to-end security of all data communications between the TDMS and FDCUs. Consequently, the Contractor's proposal shall have identified any cyber security related standards (such as IEEE 1686, IEEE 1815, IEEE 802.1X, IEC 62351, NERC CIP, or equivalent) with which the FDCUs comply along with any specific security measures that meet these standards and, on this basis, may be implemented in coordination with the security features of the TDMS and WRL communications system with which the FDCUs shall interface.

### 1.3 Service Conditions

The FDCU equipment shall be suitable for continuous outdoor operation in Thailand's tropical monsoon climate, which includes exposure to severe frequently occurring thunderstorms. It shall also be suitable for conditions where it will be exposed to heavy industrial pollution, salt-spray, and high levels of airborne dust. These exposure requirements



shall apply to all accessories that may be vulnerable to such weather and environmental conditions as well. Thus, the Contractor's proposal shall have clearly clarified how the FDCU equipment and its accessories comply with such requirements. Otherwise, as may be necessary, conformal coating (Class 2 in accordance with IEC 60870-2-2 or Class 3K7 in accordance with IEC 60721) shall apply to all components that are prone to misoperation and/or damage from such exposure.

In addition, the equipment shall have been type tested for continuous operation under specific conditions as follows:

- 1) **Temperature:** 0°C to 70°C (IEC 60068-2-1, 2, 3, and 14, or equivalent)
- 2) **Temperature Gradient:** Up to 30°C (IEC 60068-2-1, 2, 3, and 14, or equivalent)
- 3) **Relative Humidity:** Up to 95% at 40°C (IEC 60068-2-30 and 38, or equivalent)
- 4) **Cyclic Damp Heat:** 40°C to 25°C at 95% Relative Humidity (IEC 60068-2-30 and 38, or equivalent)
- 5) **Absolute Humidity:** Up to 29g/m<sup>3</sup> (IEC 60068-2-30 and 38, or equivalent)
- 6) **Vibration (sinusoidal):** 2g acceleration, 9 to 350Hz (IEC 60068-2-6, or equivalent)
- 7) **Shock:** 15g, 11ms test (IEC 60068-2-27, or equivalent)
- 8) **Tilted Pole:** Up to 10 degrees from vertical in any direction
- 9) **Altitude:** Up to 1,000 meters.

The required type tests shall have been carried out by suitably accredited test laboratories that are independent of the manufacturer and Contractor. Certified copies of all type test certificates and test results shall have been included as part of the Contractor's proposal.<sup>1</sup>

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<sup>1</sup> *In general, all type test requirements, as referenced here and elsewhere in the Technical Specifications, apply to Contractor standard products. In case customization or prototyping is necessary during project implementation, supplementary type testing shall apply.*

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#### 1.4 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.

#### 1.5 Maintainability

The Authority prefers FDCU equipment designs that do not require periodic preventive maintenance and inspection. If periodic maintenance is required, it shall be possible to perform all such work in the field without dismounting the equipment and without requiring that the associated power system circuit be de-energized.

Within this context, the FDCU hardware shall:

- 1) Be designed to minimize or eliminate the need for periodic maintenance.
- 2) Be assembled from modules to facilitate troubleshooting on a module basis.
- 3) Be configured to simplify the removal and replacement of modules or component parts with minimum effort.
- 4) Include module interfaces that minimize opportunities for damage due to removal and replacement of modules and plugging and unplugging cables within the control cabinet.
- 5) Include graphic placard warnings of hazardous and potentially damaging actions.

The FDCU software, including firmware and firmware parameters where applicable, shall:

- 1) Include a mechanism to locally display the operating software and firmware versions.





- 2) Be remotely downloadable and upgradeable in an encrypted form to assure a secure and complete download (refer to Clause 2.3.3).
- 3) Be downloaded into parallel memory for error check and decryption before being loaded into operating memory.
- 4) Be stored locally as a previous version before new software and firmware is executed and, on this basis, be available for restoration.
- 5) Employ watchdog timers to detect FDCU failure and generate a restart.
- 6) Be supported by operation and maintenance information in the FDCU user manual.

## 1.6 Corrosion Protection

### 1.6.1 Galvanizing

Except for stainless steel, and unless otherwise approved, all structural steel and all exterior and interior steel surfaces, e.g., enclosure panels, clamps, and associated nuts and bolts, as may be vulnerable to damage from weather and other environmental conditions, shall be hot-dipped galvanized or electrolytic galvanized, as appropriate in particular cases, and in accordance with ASTM Specification A123/A123M-15, "Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products", or equivalent.

### 1.6.2 Powder Coating Paint

All mild steel surfaces that are not galvanized shall be treated to protect against corrosion using the following procedure as a minimum:

- 1) The surface shall be cleaned to bare material by mechanical or chemical means.
- 2) One or more phosphatizing or priming coats of paint shall be applied to the bare surface using a zinc-based or lead-based primer.
- 3) Polyester spray powder finish paint shall be applied over the primer coat to a thickness of 50-75 micrometers (0.002-0.003 inches). The finish-coat color shall be grey (RAL 7032).



### 1.7 Marking

The Authority's code number shall be painted in orange on the FDCU components to be assembled at site as well as on their export crates. The code number on the Contractor's pole-mounted control cabinet shall be easily viewable from ground level. The Authority will provide the code number at the time required by the Contractor.

### 1.8 Immunity to Electrical Stress and Disturbance

The electrical and electronic components of the FDCUs shall satisfy the requirements for insulation, isolation, and immunity from electromagnetic interference, radiated disturbance, and electrostatic discharge by complying with relevant international standards. In this respect, the standards with which the FDCUs comply shall be identified by the Contractor for Authority approval and shall have been verified by type tests carried out by suitably accredited test laboratories that are independent of the Contractor and/or manufacturer of the FDCU components. Certified copies of all relevant test certificates and test results shall have been included as part of the Contractor's proposal.

#### 1.8.1 Minimum Insulation of Equipment

The following classes of exposure to electrical interference shall be used in interpreting the insulation requirements of all components and wiring as installed:

- 1) ***Exposed Equipment*** - Exposed equipment terminals may be interconnected without special protection of the insulation. Equipment terminals shall be considered exposed if they are galvanically connected to current or potential transformer secondary circuits.
- 2) ***Controlled Exposure Equipment*** - Controlled exposure equipment terminals may be interconnected when relevant conditions are satisfied. Equipment terminals shall be considered controlled exposure terminals when the following criteria are met:
  - a) The rated voltage of the associated circuit does not exceed 32 Vac or 48 Vdc.



- b) Direct galvanic connections to exposed equipment terminals are made using a suitable barrier device that has the isolation ratings required for exposed equipment.

Exposed equipment terminals shall be intrinsically designed to meet the insulation requirements. The provision of externally mounted “add-on” circuitry, including devices such as auxiliary relays, isolating transformers, and electronic or gas suppressors, solely for compliance with the insulation requirements shall not be permitted.

Within the context above, the FDCUs shall meet or exceed the minimum insulation requirements listed in Exhibit 1-1.

**Exhibit 1-1: Minimum Insulation Requirements**

Requirements	Test Standard	Specified Details	
		Exposed Equipment	Controlled Exposure Equipment
Rated Insulation Voltage	IEC 60255-5 Table I	500 V	60 V
Dielectric Test Voltage	IEC 60255-5 Table I Series B (Clause 6)	2.0 kV rms	1.0 kV rms
Insulation Resistance Test	IEC 60255-5 (Clause 7)	Required	Required
Impulse Voltage Test	IEC 60255-5 (Clause 8)	5 kV 1.2/50 $\mu$ s 0.5 J	5 kV 1.2/50 $\mu$ s 0.5 J

**1.8.2 Immunity from EMI, Radiated Disturbance, and Electrostatic Discharge**

The FDCUs shall be designed for safe operation in harsh environments subject to high voltages. Their data communication ports shall be designed to withstand disturbance testing without permanent corruption of data and subsequent delay of data transfer. Within this context, they shall conform to the immunity, susceptibility, and interference requirements shown in Exhibit 1-2.



**1.9 Construction**

The FDCU equipment shall be sufficiently sturdy to withstand handling during shipment, installation, and start-up without damage. The configuration for shipment shall adequately protect the equipment from scraping, banging, or any other damage. The Contractor shall assume responsibility for correction of all such damage prior to final acceptance of the equipment.

**1.10 Interconnecting Cables, Wiring, and Terminal Blocks**

The Contractor shall provide all interconnecting cables, wires, connectors, terminations, and terminal blocks required by the FDCU equipment.

**Exhibit 1-2: Immunity, Susceptibility, and Interference Requirements**

Requirements	Test Standard	Class or Level	Specified Details
High Voltage Impulse	IEC 60060-1	-	5 kV, 0.5 J
Electrical Disturbances (1 MHz Burst)	IEC 60255-22-1	Class 3	2.5 kV CM
	IEC 60255-22-1	Class 3	1.0 kV DM
Electrostatic Discharge Immunity	IEC 61000-4-2	Level 3	8 kV air
	IEC 61000-4-2	Level 4	8 kV direct
Radiated Immunity	IEC 61000-4-3	Level 3	80 MHz-1 GHz
Fast Transient/Burst Immunity	IEC 61000-4-4	Level 4	4 kV
	IEC 60255-22-4	Class 4	4 kV
	ANSI/IEEE C37.90.1	-	4-5 kV
Surge Immunity	IEC 61000-4-5	Level 4	2 kV/4 kV
Conducted Immunity	IEC 61000-4-6	Level 3	10 V
Harmonics Emissions	IEC 61000-4-7	-	Required for ac powered systems
Power Frequency Magnetic Field Immunity	IEC 61000-4-8	Level 4	30 A/m
Pulse Magnetic Field Immunity	IEC 61000-4-9	Level 5	1000 A/m
Damped Oscillatory Magnetic Field Immunity	IEC 61000-4-10	Level 4	30 A/m
Oscillatory Transient Immunity	IEC 61000-4-12	Level 4	Ring Wave
	IEC 61000-4-12	Level 3	Damped Oscillatory 2.5 kV



### 1.10.1 Metallic Cables and Wiring

All metallic cables and wiring shall:

- 1) Use copper conductors with flame retardant insulation.
- 2) Be neatly laced and clamped.
- 3) Employ permanent labels for identification.
- 4) Use individually color-coded conductors in case of multi-conductor cables.

### 1.10.2 External Connection Points

The control cabinet connection points for external cables and wires shall be:

- 1) Permanently labeled.
- 2) Easily accessible for connection and disconnection.
- 3) Sealed to prevent incursion of moisture, dust, and insects.

### 1.10.3 Terminal Blocks

The following requirements shall apply to the control cabinet terminal blocks:

- 1) They shall be used for connecting dc power cables to the FDCU and UHF radio (Cellular Router) and for terminating all I/O signals between the RCS and FDCU.
- 2) They shall be of heavy-duty 600 Vdc molded-block (bare-wire compression) type with molded insulating barriers between terminals.
- 3) No more than two cable wires shall be connected to any terminal.
- 4) Each terminal block and individual terminal shall have white, removable, self-extinguishing fireproof marking strips for circuit identification.
- 5) Termination blocks with by-pass bridges shall be provided for all ac inputs from CTs.
- 6) Adequate space as well as terminal blocks shall be provided for routing all associated cabling within the control cabinet.



## 2. FDCU Functional Requirements

This clause describes FDCU functional requirements from the perspective of remote monitoring and control of the Authority's remote controlled switches. Required FDCU configuration, maintenance, and diagnostic features are also described.

### 2.1 TDMS Interface

Each FDCU shall support two-way communications with Front-End Processors (FEPs) located at two Authority data centers. These FEPs and other servers will comprise the central computer platforms for DDIP's new Transmission and Distribution Management System (TDMS). The TDMS computer platforms will host the SCADA and EMS/DMS applications that will support remote power system operations from multiple Authority control centers and, in this respect, the computer platforms and control centers will provide backup for each other. The FDCUs shall communicate with the FEPs at both data centers using the latest secure authentication version of the DNP 3.0 protocol over IP. For additional details concerning the TDMS, refer to Part A of the Technical Specifications.

Within this context, each FDCU shall use the co-located Cellular Router supplied and installed by contractor, such that the data can be received by both data centers simultaneously. It shall be possible for the data to be sent under the following DNP 3.0 defined modes of operation:

- 1) During a Class 0, 1, 2, and/or 3 poll by the TDMS. This shall include:
  - a) Integrity and report by exception polling.
  - b) Sending selected status or analog points on demand.
- 2) During an unsolicited (spontaneous) Class 1, 2, and/or 3 FDCU response to a power system event. This shall include sending an analog or status point value in the event:
  - a) An analog value exceeds an individually configurable dead band around its previously reported value.
  - b) An analog value exceeds an individually configurable Threshold.
  - c) A status point changes state.



The FDCU shall include the capability to receive and implement DNP 3.0 control commands as sent from any SCADA server that is a part of the two TDMS data center platforms. The capability to configure the FDCU remotely using a secured and/or encrypted TCP/IP protocol like “https” shall also be supported.

## **2.2 Input/Output Points**

The FDCU shall include facilities for handling all required analog input, status input, and control output points. The requirements for each type of I/O point are described in the following sub-clauses. Also, refer to Appendix C (IO list) where an example of the I/O points currently handled by existing FRTUs at some of the project RCS sites are identified. The FDCU shall handle similar points. However, all points to be handled will be confirmed during project implementation, i.e., during the initial design phase. Within this context, the Contractor’s proposal shall have referenced the standards to which the FDCU complies such as IEC 61557-12, IEC 61000-4-30 Class S, or equivalent.

### **2.2.1 Analog 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 RCS control cabinets.
- 2) Apply suitable filtering to eliminate the risk of signal aliasing.
- 3) Use voltage and current inputs for calculations that support TDMS 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 TDMS.
- 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  $\pm 0.2\%$  of 1.2 times normal FSD over the temperature range 0 to 70 °C.
- 12) Demonstrate an analog input linearity better than  $\pm 0.05\%$ .
- 13) Reject common mode ac (50 Hz) voltages up to 150 V.

### 2.2.2 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 RCS control cabinets.
- 5) Each wetting voltage circuit shall be protected with its own circuit breaker.

### 2.2.3 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) RCS 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  $10^6$  (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, e.g., low gas-pressure lockout of an RCS.

#### **2.2.4 Feeder Fault Current Detection**

The FDCU shall be able to detect and report the passage of momentary as well as sustained feeder fault currents. Within this context, sensitive earth fault as well as all other fault type detection shall be supported. It shall also be able to detect and report loss of power system voltage and a return-to-normal feeder energized state. In this respect, the following functional requirements shall be met:

- 1) Fault passage detection shall be based on checking if a current set point value has been exceeded. If such a condition is detected and continues for a specified time



duration, the detection logic shall result in a Fault Event being registered and reported to the TDMS.

- 2) Fault passage detection shall include reporting features for the different types of fault that can occur. In this respect, for example, the fault detection features associated with such relays as follows shall be incorporated, where equivalent IEC 60617 codes as well as the referenced ANSI codes may apply:
  - a) Overcurrent (ANSI 50/51, 50G/51G)
  - b) Sensitive earth fault (ANSI 50SEF)
  - c) Directional relay (ANSI 67)
  - d) Broken conductor (ANSI 46BC or ANSI 47BC)
  - e) Negative sequence voltage (ANSI 47)
- 3) Detection of a return-to-normal state shall be based on recognizing that the voltage level has been above a configurable set point for a specified time, in which case a Fault Cleared Event shall be registered, reported to the TDMS, and used to reset the FDCU so it is ready to detect any subsequent fault.
- 4) The FDCU shall support TDMS downloading and uploading of the set points and time periods that correspond to Fault Events and Fault Clearance Events using the DNP 3.0 protocol.
- 5) The FDCU's feeder fault detection function shall:
  - a) Work properly for all possible configurations of the power system circuit where the FDCU is installed.
  - b) Prevent miss-operation due to magnetizing inrush currents and other transient no-fault conditions.
  - c) Report the fault current level with time stamp to the TDMS and reset the fault current register to zero.



- d) Report Fault Event, Fault Direction, and Fault Clearance Event details as time-stamped Sequence of Events (SOEs).
- e) Save the last 128 Fault Events along with their corresponding Fault Direction and associated Fault Clearance Event details and, on demand, report them to the TDMS.
- f) Support a configurable format for local fault record reporting including the Comma Separated Variable (CSV) format for use in a spreadsheet and the COMTRADE (IEEE C37.111-1999) format for use with a commercial COMTRADE viewer.

### **2.3 FDCU Architecture**

The FDCU shall incorporate a programming capability within an architecture that supports convenient installation, maintenance, and expansion features. The architecture shall include a central processing module, I/O module, control module, communications module, and time and date module. Associated equipment such as dc power supply and local control panel are described elsewhere in the Technical Specifications.

#### **2.3.1 Central Processing Module**

The Central Processing Module (CPM) shall:

- 1) Support a high-level language processing capability per the open IEC-61131-3 standard for programmable logic controllers.
- 2) Support management of the FDCU database from a local test set including the DAC Simulator.
- 3) Support download and upload of FDCU parameters and configuration data.
- 4) Implement the DNP 3.0 Secure Authentication protocol interface with the TDMS.
- 5) Control data acquisition from the RCS and the sending of control commands to the RCS using an I/O module.



- 6) In accepting commands from the TDMS:
  - a) Perform address recognition.
  - b) Assemble response messages in accordance with the received command messages.
  - c) Transmit these messages to the TDMS.
- 7) Provide interfaces for a time standard and test set.
- 8) Manage communications between all other functional modules of the FDCU.
- 9) Determine the integrity of the FDCU.
- 10) Provide diagnostic information in the message structure that the TDMS shall monitor.
- 11) Set a flag if the FDCU performs a restart for any reason including power failure.
- 12) Include a watch-dog timer that is reset regularly by FDCU software. If the software fails to reset the watch-dog timer (e.g., because of a software error causing the software to “loop” or “hang”), then the timer shall expire causing the CPM to reset and restart.

### 2.3.2 I/O Module

I/O module requirements include the following capabilities and features:

- 1) Capability to accept analog and status inputs and send control outputs. This shall include fault current measurements.
- 2) Capability of being replaced without reprogramming, redefinition of configuration parameters, or rewiring.
- 3) A Control Switch (CS) that, if not in its normal control position, inhibits RCS control from the TDMS or test set.



- 4) A status input contact so that the TDMS or test set can monitor if the position of the CS is in its normal control position.
- 5) Capability to report the position of the Local/Remote (L/R) switch supplied with the RCS. For the CS to be effective, the L/R switch must be in “Remote.” Otherwise, with the L/R switch in “Local”, remote control from the TDMS or test set shall be disabled irrespective of the CS position.

### 2.3.3 Communications Module

The FDCU shall be provided with a communications module including necessary and sufficient numbers and types of port that can be used to support:

- 1) Remote data communications with external systems and devices over an Ethernet/IP network using the latest secure DNP 3.0 communications protocol. This shall include data communications with multiple masters, as in the TDMS systems at the Authority’s two data centers, and the DAC Simulator.
- 2) Local and remote configuration with a static IP address.
- 3) The fully implemented message security features of the DNP 3.0 protocol running over TCP/IP. This capability shall be demonstrated successfully as part of factory acceptance testing.
- 4) Communications that is not degraded by simultaneous activity in other parts of the FDCU.
- 5) Temporary connection of laptops (such as the DAC Simulator or Contractor supplied test set) for local installation, maintenance, diagnostic, and test purposes for all configurations and data access functions associated with the FDCU.
- 6) SCP/SSH with respect to downloading, for example, FDCU configuration parameters and firmware updates.
- 7) Features such as HTTPS for web server functionality (refer to Clause 2.3.5).
- 8) Blocking or disabling of ports to prevent unauthorized access.



- 9) MAC and IP filtering so that Ethernet traffic is limited to a configurable “whitelist” of network device MAC and IP addresses.
- 10) Access control using a secure log-in procedure. As a minimum, this shall include user authentication based on a unique username and password.
- 11) System logging (syslog) at a device or system level. Syslog alerts shall include remote user access activity including successful and unsuccessful login attempts.
- 12) Manual configuration of a routing table with different metrics so that networks may be reached using locally entered alternative paths (IP redundant paths for example).

In addition to the above requirements, the FDCU communications module shall support IEC 61850 as well as the DNP 3.0 data communications protocol. In this respect, there shall be no need for any change in hardware or firmware. In addition, the Authority prefers that the FDCU can be configured for IEC 61850 or DNP 3.0 remotely as well as locally. Relevant details shall have been provided in the Contractor’s proposal. Support for IEC 61850 shall be verified during factory acceptance testing.

#### **2.3.4 Time and Date Module**

The FDCU’s time and date module shall:

- 1) Include an internal time-of-day clock for data collection coordination. The time resolution of the internal clock shall be one (1) ms or better and, without synchronization, the time shall drift by no more than 5 ms per hour.
- 2) Use the existing or Contractor-provided RCS control cabinet’s 24 Vdc power supply as the only source of power for the internal clock, i.e., no other source such as an internal (on-board) battery shall be used.
- 3) Synchronize the internal clock whenever the FDCU is powered up. This shall not prevent the FDCU from immediately registering inputs even before the time and date reference signal has been received. Any such inputs shall be reported to the TDMS



with the appropriate time and date, i.e., use of an arbitrary default time and date is not acceptable.

- 4) Be able to receive a DNP 3.0 compliant time and date message that contains a Greenwich Mean Time (GMT) reference signal, generated by the TDMS in long format and in such a way as to properly account for communication path delays.
- 5) Be able to synchronize the internal clock to the GMT time and date received from the TDMS.
- 6) Be able to synchronize to an optional Global Positioning System (GPS) receiver as described in the Contractor's proposal. The GPS antenna shall be of low profile type for secure and moisture-resistant mounting on top of the FDCU enclosure. The receiver shall be used to synchronize the internal clock to the correct GMT time and date within a time resolution of at least 1 millisecond.

The time and date facility shall be accomplished by all necessary devices, equipment, and software provided and installed by the Contractor. This shall include full cooperation with the TDMS contractor to ensure correct functionality from an overall system perspective.

### **2.3.5 Web Server Module**

The FDCU shall include a web server module. The module's facilities shall be accessible through a secure HTTPS connection both locally and remotely by means of not only the FDCU test set, but also a standard laptop PC, tablet, or smartphone. Access shall be password protected and allow for different permissions based on defined user roles. Passwords and roles shall be defined during project implementation. As a minimum, the facilities of the web server module shall include:

- 1) Maintenance features that include the capability to upgrade and configure FDCU firmware.
- 2) The capability to set FDCU communication parameters such as DNP3 Source Address, Destination Address, Timeouts, Retries, Frame Size, etc.





- 3) The capability to set FDCU clock time, time synchronization, and fault detection features.
- 4) Display and clearance of historical logs and the capability to export logs in CSV format.
- 5) MMI features such as mimic and graphic displays supporting for example RCS monitoring and control, visualization of site location details, and presentation of voltage and current measurements.
- 6) An FDCU field testing feature that allows a locally entered data point (simulating for example a power system voltage measurement) to be sent to the TDMS via DNP 3.0 along with an appropriate data quality code.

## **2.4 Software/Firmware**

The term “software” is used in these Technical Specifications to mean software or software implemented through firmware. All software shall be implemented per the Contractor’s established design and coding standards. Complete and comprehensive documentation shall be provided for all software.

### **2.4.1 Operating System**

The FDCU operating system shall:

- 1) Be a real-time non-proprietary operating system.
- 2) Manage and support all FDCU applications.
- 3) Support editing and customization by the Authority as needed to maintain FDCU operation.
- 4) Provide automatic restarts of the FDCU on power restoration, memory parity errors, hardware failures, and manual request.
- 5) Initialize the FDCU on power-up and begin execution of the FDCU functions without intervention by the TDMS.
- 6) Report all restarts to the TDMS.



#### 2.4.2 Operating Software

The FDCU operating software shall be:

- 1) Prepared in a high-level language such as the IEC61131 programming suite.
- 2) Documented in detail.
- 3) Free of additional licensing charges or license agreements.
- 4) Supported by protocol, configuration, and application data contained in easily programmable non-volatile memory such as Flash EPROM.
- 5) Independent of any data communications protocol that would impose restrictions on the flexibility or functionality of the FDCU. In this respect, protocol changes shall be capable of being accomplished by locally and remotely implemented software/firmware changes only.

#### 2.4.3 Diagnostic Software

FDCU diagnostic software shall:

- 1) Continuously monitor operation of the FDCU.
- 2) Report FDCU hardware errors to the TDMS.
- 3) Check for memory, processor, and input/output errors and failures.
- 4) Be sufficiently detailed to detect malfunctions to the level of the smallest replaceable component.
- 5) Facilitate isolation and correction of all failures.
- 6) Include features promoting rapid fault isolation and component replacement.
- 7) Include integrated on-line diagnostic functions in all functional module nodes.
- 8) Report diagnostic results to the CPM for store and forward to the TDMS.



## 2.5 Interlocking

The FDCU shall include configurable interlock logic to prevent misoperation of the RCS. In addition to preventing RCS operation locally and/or remotely in accordance with the positions of the Local/Remote and Mechanical Lock/Free switches, the RCS control command shall be prohibited in the case of a low SF<sub>6</sub> gas alarm. The interlock information shall be sent to the TDMS via the DNP 3.0 protocol.

## 2.6 FRTU Plate's Dimension

The Contractor shall mount the FRTU and the associated Cellular Router in pole-mounted enclosures supplied by others. These enclosures allow for combined FRTU and Cellular Router physical dimensions of no more than 430 mm (height) x 600 mm (width) x 150 mm (depth) that refer to appendix G.



### 3. Documentation

It is the intent of the Authority to become self-sufficient in all aspects of the FDCU equipment. To assure that the Authority can become self-sufficient in a timely and orderly manner, it is necessary that the Contractor provide high quality documentation (including drawings), which the Authority shall be permitted to copy for internal use

In addition to typical project documentation defined in the following sub-clause, the documentation as a minimum shall:

- 1) Include manuals, drawings, and data covering functional design, configuration, testing, installation and startup, operation, and maintenance details for all FDCUs and associated equipment.
- 2) Reflect the actual equipment and its hardware and software configurations as supplied. This shall include the functionality, performance, and operation of the FDCUs in their final operationally acceptable form.
- 3) Be in English and, in case of operating and maintenance manuals, in Thai and English.

#### 3.1 Definitions

For the purposes of this project, the following definitions shall be used:

- 1) **Documents or Documentation** – Textural and graphical information describing the FDCUs, whether embodied in hardcopy form or electronic form such as common word processor files. Documents may also be referred to as manuals, guides, books, drawings, transmittals, and specifications. Documents are further divided into standard, OEM, and custom documents.
- 2) **Standard Documents** – Documents produced by the Contractor and used prior to the award of this contract that are applicable to all users of the equipment and software, including the Authority. It is expected that the Contractor will use a formal revision control scheme to maintain its standard documents. Documents not maintained under such a scheme shall be considered custom documents.



- 3) **OEM Documents** – OEM (original equipment manufacturer) documents are standard documents produced by subcontractors. Documents produced by subcontractors for customized elements of the FDCUs shall be deemed custom documents.
- 4) **Custom Documents** – All documents not categorized as standard or OEM documents, including the Contractor’s standard documents that are modified to meet the Authority’s specific requirements.
- 5) **Project Documents** – Project documents are those documents produced for the purpose of managing and implementing the project, but which do not directly describe the FDCU equipment. Examples of project documents include transmittal cover pages, correspondence between the Authority, Contractor, and other parties, electronic mail messages, records of telephone conversations, meeting minutes, action item lists, test plans and procedures, training materials, change orders, and transmittal and document lists.

### 3.2 Document Format

Documents shall be delivered in two phases:

- 1) Documents submitted for Authority review and approval.
- 2) Final documents.

Format requirements are as follows:

- 1) Both hardcopies and softcopies shall be provided.
- 2) Softcopy approval documents shall be delivered by posting and notification via the Project Tracking System, in searchable and editable format using the Microsoft (MS) Office 2010 suite of applications (Word, Excel, Project, Visio, etc.).
- 3) Final documents shall be delivered as hardcopy and on CD-ROM in the form of searchable PDF files (including hyperlinks) as well as searchable and editable files such as MS Word, Excel, Project, and Visio.



- 4) In general, all documents shall be formatted for A4 size paper. Drawings, where appropriate, shall be formatted for A3.
- 5) Drawings and diagrams may be supplied embedded in the document files or may be supplied as separate editable Visio or AutoCAD files.
- 6) Each document shall include:
  - a) A Title Block showing the Contractor document number, title, and revision record. The document number shall be a unique number assigned in accordance with the Contractor's standard practice. The revision record shall include the date of change, a brief description of the change, an indication that the change has been reviewed and approved in accordance with the Contractor's quality assurance procedure, and the version or release of the hardware or software to which the document applies.
  - b) A space on the Title Block into which the Authority may enter a document number assigned from the Authority's document management system.
  - c) A Table of Contents. If a document is divided into several physical volumes, each volume shall contain the complete table of contents of the whole document.
  - d) A cross-reference table, listing all topics of significance covered by the document, and giving the page or section references of all pages or sections with discussions of the topic.

Documents that describe generic or typical FDCU equipment shall not be accepted unless the specific material applicable to the project is easily distinguishable from the material not applicable to the project. Custom documents shall not contain any material that is not project specific.

### **3.3 Document Review and Approval**

All Contractor and OEM standard documents shall be subject to review by the Authority. Custom documents shall be subject to Authority approval as well as review. In this respect:



- 1) The acceptance or approval of any documents by the Authority shall not relieve the Contractor of the responsibility to meet all requirements of the contract including responsibility for correction of the documents.
- 2) The Contractor shall have no claim for additional costs or extensions of time on account of delays due to document revisions that may be necessary to ensure compliance with the contract.
- 3) All deliverable documentation shall be revised by the Contractor as may be necessary to reflect the FDCU equipment as delivered.
- 4) Any modifications resulting from factory and site acceptance tests shall be incorporated.
- 5) All submitted documents that change because of subsequent engineering changes, contract changes, or errors or omissions shall be resubmitted for review or approval as appropriate.

### **3.3.1 Document Review**

The Authority will review Contractor documents within ten (10) working days following notification of their submittal via the Project Tracking System. The review shall determine if:

- 1) The documents are legible and have been produced in accordance with the documentation standards of the Contractor or subcontractors.
- 2) All referenced hardware and software is in full conformance with the contract.
- 3) The documents clearly and accurately describe the features and options of the hardware and software that pertain to the FDCU equipment.

The Authority will review the editable documents by inserting comments indicating the need for correction or clarification. They shall then be posted on the Project Tracking System. This will include notifications of posting being sent to the Contractor. If not so notified within the review period, the Contractor shall request the Authority to confirm that the document has been accepted as submitted.



The Contractor shall respond to Authority comments within ten (10) working days of their receipt. If the comments address OEM documents, the Contractor shall act as an advocate of the Authority to initiate and facilitate resolution of the comments with the OEM.

### 3.3.2 Document Approval

All custom and project documents shall be subject to a formal approval process. This includes training materials as well as test plans and test procedures. The review for approval performed by the Authority will be like the document review process, but will more closely examine the functionality and design aspects of the hardware or software. Clarity and completeness of the presentation of the material within the documents will be a key element of the review for approval.

The approval process shall include Authority posting and notification of the reviewed document for approval on the Project Tracking System along with a transmittal to indicate which of the following categories apply:

- 1) **Approved** – The Contractor may proceed with the work covered by the document. No further approval action is required.
- 2) **Approved with Comments** – The Contractor may proceed with the work covered by the document and comments.
- 3) **Not Approved** – The Contractor may proceed with the work covered by the document and comments only at the Contractor's own risk. No schedule or cost relief will be granted for any work undertaken prior to approval of the appropriate documents.

The comments may be discussed to clarify the Authority's intent. Otherwise:

- 1) The Contractor shall revise and resubmit the documents, in accordance with the comments, within five (5) working days. This time may be adjusted by agreement.
- 2) All changes to reflect approval comments shall be clearly highlighted and the revision record shall be updated to reflect the changes. The Authority prefers use of the applicable document change-tracking feature.





- 3) The review and comment process shall be repeated until the document is accepted. After the document is accepted, the Contractor shall deliver the required number of final copies free of highlighting due to the tracking of changes.

### **3.4 Hardware Documentation**

As a minimum, the following documentation shall be provided for all Contractor-supplied hardware pursuant to this contract:

- 1) List of deliverable hardware.
- 2) Configuration diagrams.
- 3) Site installation drawings and procedures.
- 4) Equipment manuals.
- 5) Hardware maintenance manuals.

The equipment and hardware maintenance manuals to be supplied shall be commensurate with the hardware maintenance philosophy to be employed by the Authority, which is to maintain all hardware after acceptance using its own staff as much as possible.

#### **3.4.1 List of Deliverable Hardware**

The list of deliverable hardware shall itemize each hardware component along with associated accessories such as cables and connectors. It shall also include equipment configuration information of sufficient detail that the Authority can procure identical hardware items from their manufacturer.

Where possible, the Contractor shall employ commercially available, off-the-shelf hardware components. This applies to standard cables and connectors, as well as OEM equipment that can be sourced through the Contractor or directly from the supplier as spares are needed.

The “List of Deliverable Hardware” shall identify the source of each hardware component as delivered. It shall also indicate at least one alternative source for each component.



### 3.4.2 Configuration Diagrams

The configuration diagrams shall depict, in detail, the specific FDCU equipment modules and the logical and physical interconnection of these modules operating as an integrated system. The configuration diagrams shall also show how the field installed FDCU equipment interconnects with other equipment whether supplied or not supplied by the Contractor. This shall include connections related to:

- 1) The data input points as derived from the RCS ac voltage and current sensors.
- 2) The RCS control output points.
- 3) The site's potential transformer.
- 4) The Cellular Router.
- 5) The local control panel and dc power supply.

Each interconnecting cable to be provided by the Contractor shall be identified along with its terminations. All equipment and cabling shall be identified using the same terminology as the list of deliverable hardware so that the correspondence between this list and the configuration diagrams can be readily determined.

### 3.4.3 Site Installation Drawings and Procedures

The site installation drawings shall depict the physical arrangement of the FDCU components. References to the appropriate equipment manuals are acceptable. The drawings and associated installation procedures shall include:

- 1) Equipment physical drawings showing dimensions, cabinet internal arrangements, and the size and weight of each enclosure.
- 2) Unpacking, moving, handling, and other installation details.
- 3) The location of external connections including types and sizes of connectors.
- 4) Input power, grounding, and surge protection details.



- 5) Environmental requirements (if any).

#### 3.4.4 Equipment Manuals

Equipment manuals shall contain the following:

- 1) A description of equipment function.
- 2) Installation, setup, and operating instructions.
- 3) A block diagram showing the logical and physical interconnections among the major modules and components.
- 4) Expansion and upgrade capabilities and instructions.
- 5) Preventive maintenance instructions.
- 6) Detailed functional, logical, electrical, and mechanical characteristics of all interfaces to the equipment including protocol descriptions.
- 7) Troubleshooting and repair guides, including descriptions and instructions for the diagnostics furnished.

#### 3.4.5 Hardware Maintenance Manuals

The hardware maintenance manuals shall describe the preventive and corrective maintenance procedures required to maintain the FDCU equipment in good operating condition. The information in the manuals shall include:

- 1) ***Operating details*** – This information shall include:
  - a) A detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.
  - b) Descriptions of external data transfers with other equipment, including data patterns, security check-codes, and transfer sequences.
  - c) Detailed logic diagrams shall also be provided as necessary for troubleshooting analysis and field repair actions.



- 2) ***Preventive maintenance instructions*** – These instructions shall include:
  - a) All applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the equipment.
  - b) Instructions on how to load and use any test and diagnostic program and any special or standard test equipment.
  
- 3) ***Corrective maintenance instructions*** – These instructions shall include:
  - a) Procedures for locating malfunctions down to the field-replaceable module level.
  - b) Adequate details for quickly and efficiently locating the source of an equipment malfunction.
  - c) Explanations for the adjustment or replacement of all items, including printed circuit cards.
  - d) Schematic diagrams of electrical, mechanical, and electronic circuits, parts-location illustrations, photographs, cable routing diagrams, and sectional views giving details of mechanical assemblies as necessary to replace faulty equipment.
  - e) Information on tolerances, clearances, wear limits, and maximum bolt-down torque for mechanical items requiring field repair.
  - f) Information on the loading and use of special off-line diagnostic programs, tools, and test equipment, as well as any cautions or warnings that must be observed to protect personnel and equipment.
  
- 4) ***Parts information*** – This information shall include:
  - a) Identification of each replaceable or field-repairable module at a level of detail sufficient for procuring any repairable or replaceable part.



- b) Cross-references between Contractor and OEM part numbers.

### **3.5 Software Documentation**

The following documents shall be provided for all software (and/or firmware where applicable):

- 1) List of Deliverable Software.
- 2) Database definition documents.
- 3) Software functional description documents.
- 4) Installation images and source code.
- 5) Detailed design documents.
- 6) Software maintenance manuals.

#### **3.5.1 List of Deliverable Software**

The list of deliverable software shall itemize each software item and include version and any applicable license information. The distribution media for each software item shall be identified. The list shall also indicate for each item whether source code is supplied.

#### **3.5.2 Database Definition**

The database definition shall identify the characteristics of the FDCU database. It shall include, but shall not be limited, to the following:

- 1) The name or identification of the database.
- 2) A description of the intended use of the database.
- 3) A description of the organization of the database (the database schema or model).
- 4) A description of each field of each data item.
- 5) Instructions for generating and populating the database.



- 6) Details of programming interfaces including Application Programming Interfaces (APIs). This shall encompass access methods, address schemes, and read, write, and modify actions.
- 7) Initialization description (how, or by what software, data is initialized and to what values).
- 8) Details of maintenance actions.

The Authority encourages the use of "self-documenting" database technology, where the database definition is developed and stored with the data. The resulting documentation shall be printable.

### 3.5.3 Software Functional Descriptions

The functions of each FDCU software module shall be described from the standpoint of a user. Such software functional descriptions are also referred to as user guides. In this respect, the FDCU's functional operation shall be clearly described so that it can be understood without understanding the detailed operation of each software module.

The software functional descriptions shall include the following minimum content:

- 1) **Functional description** – A narrative description of the software including algorithms where applicable.
- 2) **Performance requirements** – The execution periodicity, processing capacity, and tuning and execution parameters that control or limit the capabilities of the software.
- 3) **Resource requirement** – The expected minimum requirements for main memory, auxiliary memory, processor capacity, and other resources required by the software.
- 4) **User interface** – A description of the interface used to control the software, including all user inputs and the corresponding software response to these inputs.
- 5) **Software interface requirements** – A description of the logical interfaces with other software.



- 6) **Data requirements** – A description of all data and databases accessed by the software, including execution parameters.
- 7) **Error messages** – A concise description of all error messages and possible corrective actions.
- 8) **Diagnostic messages** – The messages the software generates as a record of its internal operations.
- 9) **Maintenance and expansion procedures** – A description of the steps required to maintain and/or expand the software (as in modifying the software or adding new functionality).

#### 3.5.4 Installation Images and Source Code

The software shall be delivered in three forms:

- 1) As fully operational software already installed in the FDCUs.
- 2) As distribution images, suitable for installation.
- 3) As source code including libraries, compilers, and linkers for building the software.

The distribution images shall include all operating system, platform software, application software, and the code management library of modifications incorporated into the delivered software. All standard software shall be supplied on the original installation media used by the Contractor to build the system. The Authority prefers CD-ROM as this media. All customized software shall be supplied as part of the code management library or other distribution image against which the code changes are to be applied.

It shall be possible for the Authority to completely generate, build, install, and configure FDCU software from the distribution images and software utilities provided by the Contractor. To this end, "make files" or other compilation, generation, and installation tools, scripts, and directives shall be delivered.



For the purposes of this requirement, "software" shall specifically include the FDCU database, i.e., sufficient definition and content images shall be supplied such that the database can be created and installed in the FDCUs.

### **3.5.5 Detailed Design Documents**

The detailed design documents are intended as a second level of detail to the software functional descriptions. In general, a detailed design document shall relate to a single software functional description.

For customized software, the Contractor shall first deliver a software functional description for approval by the Authority. After approval, the Contractor shall produce a detailed design document for approval. Production of the software shall then proceed after approval of the detailed design document.

The detailed software design documentation shall include, but shall not be limited to, the precise design information needed for planning, analysis, and implementation of the software. It shall show the divisions of the software design entities, a dependency description specifying the dependent entities, their coupling, and required resources, an interface description providing details of external and internal interfaces, and a detailed design description containing the internal details of each design entity.

The detailed software design documentation shall provide a detailed description of how the software will support the functions described in the software functional description. Detailed software design documentation shall include a diagram of the software indicating major modules and an overview of the operation of each module. It shall describe data structures and flow and a diagram or description of the way the modules interface with other modules.

### **3.5.6 Software Maintenance Manual**

A software maintenance manual shall be provided for each FDCU. It shall describe all user procedures necessary to build, maintain, and configure the FDCU software. It shall also include detailed information on troubleshooting, describing the meaning of all software-generated error or informational messages, the recommended response to these messages, and the procedures





required to restore normal operation following failure of the FDCU, such as directions to restore software as well as to restore configuration and operating data.

### 3.6 Interface Requirements Document

The Interface Requirements Document shall describe the hardware and software interfaces between the FDCU equipment and:

- 1) Cellular Router.
- 2) RCS (its I/O points).
- 3) RCS site's PT.
- 4) TDMS.

Within this context, the Interface Requirements Document shall describe how the Contractor-supplied FDCU meets the Authority's overall functional requirements for interfacing the TDMS with a SCADA-ready RCS. The Contractor shall coordinate development of the Interface Requirements Document in close collaboration with the Authority and TDMS supplier.

As a minimum, the Interface Requirements Document shall include the following information:

- 1) Description of the hardware interface.
- 2) Description of the communication protocols, including the lower level network protocols, the upper level session, presentation, and application protocols, and the options and parameters selected.
- 3) Description of the database access methods and capabilities, including specific user interface facilities, commands, and any access authorization requirements.
- 4) Description of relevant database structures and contents.
- 5) Data exchange requirements including timing, priority, volume, and any security requirements.
- 6) A specific list of data to be exchanged during FDCU factory and site testing.



- 7) Description of the performance requirements.
- 8) Exception processing, e.g., error processing.
- 9) Failover/backup processing where applicable.
- 10) Alarm conditions.
- 11) Any archiving requirements.

### **3.7 Operating Manuals**

The Contractor shall submit, for review and approval, operating manuals providing FDCU operating instructions. It shall be provided in Thai and English.

Each manual shall be organized for quick access to each detailed description of the user procedures that are required to interact with the FDCU functions. This shall include the procedures, as required both remotely from the TDMS and DAC Simulator and locally from a Windows laptop computer (using the FDCU's USB port for example), to configure the FDCU, upload and down load the configuration, test and save the configuration, and restore the configuration should it become corrupted.

Each manual shall present in a clear and concise manner all information that a user needs to know to understand and operate the FDCU. It shall make abundant use of diagrams and/or photographs to help illustrate procedure utilization.

### **3.8 As-Built Documents and Drawings**

The Contractor shall submit as-built documents including applicable drawings for review and approval. All deliverable documents and drawings shall be revised by the Contractor to reflect the as-built FDCU equipment. Any errors in or modifications from factory and/or site acceptance testing shall be incorporated. Within this same context, all previously submitted documents that are changed because of engineering changes, contract changes, errors, or omissions shall be resubmitted for review and approval.



#### **4. Quality Assurance Program**

To ensure the Contractor provides well-engineered and contractually compliant sets of FDCU equipment, a Quality Assurance (QA) program approved by the Authority shall be followed. The QA methods such as those covering equipment design, development, and manufacturing, type testing, inspection and test procedures, and documentation standards shall have been described in detail in the Contractor's proposal.

The Contractor shall adhere to the QA program for the preparation of all contract deliverables, including documentation, hardware, firmware, and software. The program shall provide for early detection of actual or potential deficiencies or variances, timely and effective corrections, and a method of traceability of all such variances. As part of the program, formal testing such as factory and site acceptance testing shall be performed.

##### **4.1 Variance Recording and Resolution**

The Contractor shall establish a process to record, track, and resolve variances. This process shall be initiated at a time to be determined by the Contractor and shall continue through the completion of the warranty period. Both the Contractor and the Authority may initiate variances at any time.

###### **4.1.1 Variances**

Variances shall be used to record deficiencies with respect to the FDCU equipment. All deficiencies and subsequent corrections shall be fully documented. Authority and Contractor meetings shall be held to review the variances. The deficiencies may include:

- 1) Software Deficiencies (including software patches).
- 2) Documentation Deficiencies.
- 3) Functional Deficiencies.
- 4) Performance Deficiencies.
- 5) Procedural Deficiencies (e.g., deviations from contractually required QA procedures).



- 6) Test Deficiencies (e.g., equipment cannot complete a test procedure due to a problem with the test).

The variance process shall:

- 1) Produce reports of all variance in spreadsheet format.
- 2) Include the capability to produce subsets of these reports based on user-specified searches controlled via the selection of different variance parameters either singly or in combination.
- 3) Make variance reports available to the Authority always.
- 4) Distribute a weekly Variance Summary Report that, for each variance, provides a brief description of the variance as well as its variance report number, category, priority, and status information. Whether active or resolved, this report shall accumulate every variance identified throughout execution of the project.

#### 4.1.2 Variance Records

The record of each variance shall include the following information:

- 1) Time and date of the initial discovery of the variance.
- 2) Variance number, a unique sequential number assigned when the variance enters the tracking system.
- 3) Identity of person submitting the variance and the names of any witnesses such as other Authority or Contractor representatives.
- 4) Identity of the equipment component, such as hardware or software item, against which the variance is being written.
- 5) Test plan and test procedure identities along with the identity of the step in the procedure where the variance was detected.
- 6) Brief description of the variance suitable for use in keyword searches.



- 7) Detailed description of the variance.
- 8) Variance category:
  - a) **Open** - Recorded but not scheduled for further action.
  - b) **Assigned** - Scheduled for further action.
  - c) **Pending** - Variance has been resolved, but not tested.
  - d) **Closed** - Authority has accepted the resolution.
  - e) **Disputed** – In contrast to Authority opinion, Contractor believes reported problem or proposed solution is acceptable.
  - f) **Deferred** - Variance will be corrected at a later project phase.
- 9) Date of variance assignment to each category.
- 10) Variance priority:
  - a) **Critical** – To be used only if the equipment is in commercial use, this priority identifies a problem that prevents the use of an equipment feature that is essential to the Authority's operation of the power system.
  - b) **High** – Denotes the failure of the equipment to perform a required feature in a manner that significantly reduces the utility of the equipment or which delays further testing of the equipment.
  - c) **Normal** – Denotes the failure of the equipment to perform a required feature in a manner that reduces the utility of the equipment, but does not otherwise delay any further testing of the equipment.
  - d) **Low** – Denotes the failure of the equipment to perform a required feature in a manner that reduces the utility of the equipment only slightly and, as such, does not delay any testing. Variances that record transient failures, i.e., failures that cannot be readily reproduced, shall be initially assigned to this priority.



Subsequent occurrences of the transient failure shall result in raising the priority of the variance.

- 11) Description of the resolution, including identification of all hardware, software, and documents modified or otherwise changed and the names of the Contractor or Authority staff involved with the resolution.
- 12) Record of all testing performed.
- 13) Identity of Authority staff accepting the variance resolution and its date of acceptance.

#### 4.1.3 Schedule for Variance Correction

Schedules for variance correction shall be agreed upon. In this respect, the following guidelines shall apply:

- 1) A schedule for the correction of critical and high priority variances shall be set within one (1) working day of their discovery. The schedule for correction of all other variances shall be set within three (3) working days of their addition.
- 2) The Contractor shall assign resources for the correction of critical variances with the intent of correcting the variance within two (2) working days of their opening.
- 3) The Authority and Contractor shall establish a mutually agreeable date for the correction of high priority variances. In this respect:
  - a) If the equipment is in productive use, the variances shall be scheduled for correction within one (1) calendar week of their discovery.
  - b) Prior to the commencement of productive use, the variances shall be scheduled for correction within two (2) calendar weeks of their discovery (possibly longer provided the overall project schedule will not be jeopardized).
- 4) The Authority and Contractor shall establish a mutually agreeable date for the correction of normal priority variances. In this respect:



- a) If the equipment is in productive use, the variances shall be scheduled for correction within two (2) weeks of their discovery.
  - b) Prior to the commencement of productive use, the variances shall be scheduled for correction within three (3) calendar weeks of their discovery (possibly longer provided the overall project schedule will not be jeopardized).
- 5) Low priority variances may be scheduled for correction at any time, but shall not exceed one (1) calendar month as of their discovery.

#### **4.1.4 Variance Resolution**

The Contractor shall support all testing deemed necessary by the Authority to correct and resolve variances. A variance shall be deemed resolved only upon written acceptance of the correction by the Authority. Upon resolution, the Contractor shall update the variance record to reflect the corrective action taken.

#### **4.2 Inspection and Test Requirements**

Inspections and tests shall be performed to ensure compliance of the FDCU equipment with the Authority's specifications. Responsibility for conducting the inspections and tests shall rest with the Contractor. The Authority will participate in the inspections and will witness the testing as described in the following sub-clauses.

##### **4.2.1 Test Plans and Test Procedures**

The Contractor shall provide test plans and detailed procedures for all required testing. These plans and procedures, to be reviewed and approved by the Authority, shall ensure that each test is comprehensive and verifies proper performance of the FDCU equipment. In this respect:

- 1) The test plans shall describe the overall test process, including the responsibilities of the test personnel, how the test results will be documented, and the test equipment and/or instrumentation supported by relevant harness and assembly drawings.



- 2) The test procedures shall describe the individual tests segments and the steps comprising each segment, particularly the methods and processes to be followed and the criteria for test pass or fail.

#### 4.2.2 Test Reports

The Contractor shall maintain complete records of all test results. The records shall be keyed to the test procedures.

Upon completion of each test, the Contractor shall submit a test report summarizing the tests performed and the results of the tests. The test report shall include the following information:

- 1) **Test Log** - A chronological record of all events related to execution of the tests.
- 2) **Test Incident Report** – A detailed description of any event during the testing process that required investigation.
- 3) **Test Summary Report** – A presentation of results pertaining to the designated test activities and a summary of all relevant recommendations and conclusions based on these results.
- 4) **Variance Report** – A summary of the problems detected during testing and the corresponding resolutions.
- 5) **Official Certification** – A formal declaration that the required testing was performed and, if applicable, was completed successfully.

*Signatures* – As designated representatives of the Contractor and/or Authority, the signatures of witnesses for each completed test, whether successful or not successful, along with relevant dates. Witness names and contact information shall also be provided.

#### 4.2.3 Inspections

In conducting inspections, Authority representatives shall:

- 1) Have access to any Contractor or other facility where the equipment is being produced or tested. Such access will be used to verify by inspection that the equipment is being or has been fabricated and tested in accordance with the Technical Specifications.





- 2) Visit Authority sites where the equipment has been delivered and is being or has been installed and tested to ensure the installation and testing is proceeding or has been completed in the manner intended.
- 3) Attempt to coordinate inspections with visits to witness equipment testing.

The Contractor shall support the Authority inspections by:

- 1) Providing all documentation that is necessary to complete the Authority inspections.
- 2) Facilitating Authority inspection of Contractor's quality assurance standards, procedures, and records.
- 3) Facilitate Authority checks on inventory, general appearance, cabling, drawing conformance, and labeling.
- 4) Taking all necessary steps to address and resolve any concerns that the Authority representatives may raise because of these activities in a timely fashion.
- 5) Facilitate further inspections and tests until the Authority representatives are fully satisfied that the inspections and tests have been completed successfully.

#### 4.2.4 Type Tests

The FDCU shall have passed type tests in accordance with IEC 60255-3, IEC 60255-5, IEC 60255-6, IEC 61000-4-2, and IEC 61000-4-3 to demonstrate that it complies with the ratings stated in these standards. In this respect:

- 1) Certified copies of all relevant test certificates and test results shall have been included as part of the Contractor's proposal.
- 2) All type tests shall have been carried out by suitably accredited test laboratories that are independent of the Contractor, FDCU equipment manufacturer, and parts OEMs.
- 3) At the Authority's discretion, certain type test certificates may be submitted during project implementation, in which case submission must be completed within three (3) months following contract signing.



As a minimum, the following type tests shall have been conducted:

- 1) Dielectric tests.
- 2) Impulse voltage withstand tests.
- 3) High frequency disturbance tests.
- 4) Thermal requirement tests.
- 5) Mechanical requirement tests.
- 6) Limiting dynamic value tests.
- 7) Contact performance tests.
- 8) Electromagnetic radiation susceptibility tests.
- 9) Electrostatic discharge susceptibility tests

#### **4.2.5 Factory Acceptance Testing**

Responsibility for conducting FAT shall rest with the Contractor using Authority-approved test procedures prepared and submitted by the Contractor. This testing shall consist of two separate phases described as follows.

##### **4.2.5.1 Full Functional Test**

A Full Functional Test (FFT) shall take place on a prototype FDCU. The test shall take place at the supplier's manufacturing facilities and shall be witnessed by Authority representatives. All expenses, such as airfares, ground transportation, hotel accommodation, and meals shall be borne by the Contractor. Such details including FFT location and how many days will be required to complete each FFT shall have been included in the Contractor's proposal.

The prototype FDCU shall be configured using the components and materials that are required to attain the Authority's specified functional performance requirements. In this respect, the FFT shall verify that the prototype can meet such basic requirements as follows:



- 1) Fail safe design.
- 2) Transducer acquisition of ac analogs, such as voltages and currents, within specified signal levels and with required accuracy and sampling rates.
- 3) Correct calculation of ac analogs such as kW, kVar, and power factor.
- 4) Detection of fault current amplitude and direction.
- 5) Acquisition of dc analogs corresponding to all specified types and signal levels.
- 6) Rejection of specified common mode voltage and normal mode noise levels.
- 7) Availability of at least one ac voltage reference signal of specified accuracy.
- 8) Ability to report analogs by exception using a programmable dead band on an individual point-by-point basis.
- 9) Ability to support de-bounce time periods individually configurable for each status input point.
- 10) Ability to accommodate the Authority's specified status input types.
- 11) Status input wetting at 24 Vdc.
- 12) Ability to issue all relevant control output types, e.g., on/off commands.
- 13) Ability to select the timeouts associated with control output commands.
- 14) Control outputs capable of driving loads of at least 6A at the primary control voltage, following a Select-Checkback-Before-Operate (SCBO) procedure, and properly accounting for applicable interlocking features.
- 15) Reporting of SOE records with specified capacity and time tag resolution.
- 16) Reporting of analog limit excursions with specified time tag resolution.
- 17) Equipped and capable of operating with each of the specified number of configurable communication ports.



- 18) Ability to communicate with external systems using the DNP 3.0 (Secure Authentication) over serial and IP protocols at the specified data rates.
- 19) Ability to support download and upload of FDI (FDCU) parameter and configuration data.
- 20) Availability and function of specified watch dog timer.
- 21) Availability and function of specified local and remote, control disable, and auto/manual switches.
- 22) Time and date facilities meeting specified time resolution and drift criteria and capable of being synchronized using time and date reference signals remotely from the TDMS as well as locally from an OEM GPS clock.
- 23) Batteries and battery chargers capable of meeting all specified capabilities and features including those associated with voltage limits, alarms, and discharge/recharge times.
- 24) Availability of specified diagnostic capabilities including the maintenance and test facilities associated with the FDCU's web server module.
- 25) Availability of specified programmable logic capabilities of IEC 61131 type.

At the end of each FFT, the Contractor shall submit a corresponding test report for Authority review and approval.

#### **4.2.5.2 Factory Routine Test**

The Contractor shall perform a Factory Routine Test (FRT) on every set of FDCU equipment when fully assembled, in readiness for transportation to site, regardless if the Authority chooses to witness this testing or not. The FRTs shall not take place until the Authority is satisfied that the FFT has been completed successfully.

To demonstrate that all component parts and functions of the FDCU equipment are in good working order and properly configured for field installation and subsequent integration with the TDMS, the FRT shall include the following tests as a minimum:

- 1) Visual tests to confirm that construction and physical sizing requirements have been met.



- 2) Verification that the interface software and firmware support FDCU sizing and expansion requirements.
- 3) Rigorous testing of each input and output function. This shall include the fault current detection functions as well as operation and performance of the time and date facilities. Suitable I/O panels and other equipment shall be provided to simulate appropriate test signals.
- 4) Verification of the capabilities and features of the Contractor's test sets for FDCU maintenance and testing including access and proper operation with respect to the FDCU's web server module.
- 6) Verification of the ability to download and upload parameters and configuration data.
- 7) Testing for secure operation, including verification that:
  - a) Communication errors are detected.
  - b) SCBO procedures are properly performed for control outputs.
  - c) No erroneous control operation occurs and no incorrect data is generated when power is turned on or off or when operating on low battery voltage.

The FRTs shall be conducted at a factory in Thailand where the Contractor has determined to assemble and configure each set of FDCU equipment. The FRT process shall be conducted as follows:

- 1) FRT testing by the Contractor shall be undertaken in batches with each batch not to exceed more than 5% of the total sets of FDCU equipment to be delivered. The Authority may choose to attend or audit this testing, but such attendance shall not be considered mandatory.
- 2) Once the FRT has been completed successfully for the entire batch, the Contractor shall submit duly signed test reports and declare the batch to be ready for inspection.



- 3) Authority representatives shall check the test reports for completeness and arbitrarily identify which FDCU equipment comprising the batch will be subject to Authority witnessed routine testing as well as inspection.
- 4) The subsequent procedure shall be based on the following concepts:
  - a) A randomly selected 10% of each batch shall be tested in the presence of the Authority's representatives. If all selected equipment passes the witnessed FRT successfully, including the Authority's inspection, the Authority will declare the entire batch as acceptable and ready for transportation to site.
  - b) If any of the selected equipment fails, however, the Authority will select another 20% of the same batch for witnessed testing, and the outcome of this additional testing shall be resolved in either of the following two ways:
    - i. If all additional FRTs are successful, and if all variances associated with the initial samples have been resolved to the Authority's complete satisfaction, then the entire batch shall be declared as acceptable and ready for transportation to site.
    - ii. If any of the additional FRTs fails, the Authority shall declare the entire batch as unacceptable. Consequently, the Contractor shall make all necessary corrections and notify the Authority when the entire batch is ready for retesting.
  - a) At Authority discretion, the Contractor shall be allowed to make corrections for minor variances associated with the witnessed FRTs without requiring further factory inspection and testing. Otherwise, all retesting shall take place in the presence of the Authority. Furthermore, within this same context, the Authority shall have the right to request the retesting of any hardware or software that may be affected by the Contractor's corrections.
  - b) The Contractor shall submit test reports for all witnessed FRTs. These reports shall be duly signed by both Authority and Contractor representatives prior to accepting any batch for transportation to site.



#### 4.2.6 Site Acceptance Testing

Every set of FDCU equipment shall be tested at site. SAT shall be conducted by the Contractor using Contractor-prepared test plans and procedures approved by the Authority. In addition, the Authority reserves the right to request the Contractor to perform tests that are not covered by the approved SAT procedures, e.g., tests covered by the FFT or FRT procedures.

Within this context, the following requirements shall apply:

- 1) Unit testing by the Contractor at the time of installation shall be conducted to ensure all components can be powered up and are in good working order.
- 2) Site Acceptance Testing (SAT) shall be undertaken by the Contractor to demonstrate to the Authority that the FDCU equipment is fit for purpose and fully operational.
- 3) SAT shall be carried out by using the functional capabilities of the FDCU to monitor and control the site's associated RCS. This may require:
  - a) RCS isolation in full coordination with the Authority's dispatchers.
  - b) The monitoring of actual analog and status inputs but checking for control output signals at points that are temporarily isolated from the power system.
- 4) SAT shall also include a full demonstration of the FDCUs from the perspective of interoperating with the TDMS. This shall include point-by-point checks to make sure that the FDCU database is properly mapped to the corresponding TDMS database.

The Authority will witness all site acceptance tests. The Authority will also inspect the FDCU equipment installations and the corresponding Contractor maintenance records to identify all equipment that may have been modified, repaired, or replaced between the completion of FAT and the start of SAT.

Following completion of the site acceptance tests, the Contractor shall:

- 1) Prepare and submit reports whether a test is successful or not successful.



- 2) Ensure the reports are duly signed by Authority and Contractor representatives participating in the tests.
- 3) If any test or associated site inspection is not completed successfully:
  - a) Submit a variance report.
  - b) Take all necessary corrective actions.
  - c) Inform the Authority of a schedule for retesting and/or re-inspection.
  - d) Bear the cost of providing ground transportation and any normal expenses incurred for the Authority to participate in the retesting and/or re-inspection activities.

No FDCU installation shall be accepted as complete until the Authority is satisfied that all variances associated with an individual site have been corrected and that the FDCU equipment is SCADA ready, i.e., can be considered fully available for integration with the TDMS.

#### **4.2.7 End-to-End Tests**

The TDMS contractor will be responsible for overall commissioning of the TDMS under typical field conditions, including the need to verify that it can interoperate successfully with the Contractor's installed FDCUs. Verification will be based on end-to-end tests concerned with:

- 1) Checking for correct database mapping between the TDMS and the FDCUs.
- 2) Making sure that the TDMS and FDCUs, working together as an integrated system, can meet the Authority's overall functional performance requirements.

In effect, the end-to-end tests shall serve as a means of commissioning the FDCU equipment as well as the TDMS. The Contractor, therefore, shall:

- 1) Support commissioning by having adequate Contractor personnel on hand to witness the end-to-end tests.





- 2) Resolve any FDCU variances that may be raised. Variances specifically identified as FDCU problems shall be taken care of as quickly as possible to avoid delays in commissioning of the FDCU and the beginning of their warranty period.

Prior to starting the warranty period, the Contractor shall:

- 1) Submit a report clearly identifying the results of all end-to-end testing from the perspective of the FDCU equipment.
- 2) Submit a Variance Summary Report including end-to-end testing variances and their current category.
- 3) Submit a plan for resolving all variances not yet categorized as “Closed.”



## 5. Training

In providing the FDCU related training requirements for Authority personnel, the Contractor shall:

- 1) Prepare them to:
  - a) Assume full responsibility for coordinating and supervising the Contractor's field work.
  - b) Configure, install, and maintain the FDCU equipment.
  - c) Assume full responsibility for repair by replacing FDCU printed circuit boards, modules, and assemblies.
- 2) Conduct courses in a classroom and laboratory format. This shall include hands-on implementation of the lessons learned during the classroom training program in a hardware and communication capable setting.
- 3) Conduct training in Thai using FDCUs, maintenance tools, test systems, and training materials delivered by the Contractor.
- 4) Support the Authority in making video recordings of all training classes. The Authority will use these recordings solely for internal instruction purposes and will not release them to third parties.

### 5.1 Training Documents

The Contractor shall prepare a training plan in cooperation with the Authority. The training materials shall be subject to Authority review and approval.

#### 5.1.1 Training Plan and Schedule

The Contractor's training plan shall:

- 1) Coordinate with the schedule for implementation of the FDCU equipment.
- 2) Include material on acceptance, installation, testing, and commissioning of the FDCU equipment.



- 3) Organize the training in a logical sequence of sessions. In this respect:
  - a) Training on basic concepts shall be given before the training of more specific FDCU details.
  - b) Classroom and laboratory sessions shall alternate in the schedule. Each laboratory session shall provide hands-on training for the immediately preceding classroom session.
- 4) Provide a list of course prerequisites for each session.
- 5) List each course by name, summary of course description, and the proposed dates for the course.
- 6) Coordinate the training schedule to begin training before the first batch of FDCU equipment has been made ready for testing.
- 7) Reference the course description documents described below.

The schedules for all formal training courses shall be included in the project's detailed implementation schedule, which the Contractor shall submit for Authority approval.

### **5.1.2 Course Descriptions**

Course descriptions shall be included with the training plan to provide the following information for each course included in the training plan:

- 1) The course name (and number if applicable).
- 2) A brief description of the course classroom and laboratory material.
- 3) A description of the intended audience for the course.
- 4) A description of the relationship of the course to others in the training plan.
- 5) The duration in hours of the course and laboratory sessions.
- 6) A breakdown of the course schedule to include the classroom, laboratory, and hands-on periods.



- 7) A list of the training materials, laboratory space, and equipment to be supplied.
- 8) A list of reference material to be used in the course.
- 9) A list of any prerequisite training or experience expected of the attendees.

### **5.1.3 Course Materials**

The Contractor shall:

- 1) Provide all necessary training materials.
  - a) Training materials such as class notes, overhead slides, and handouts shall be provided in English and Thai.
  - b) Each trainee shall receive individual copies of these materials along with any reference materials such as Contractor or OEM technical manuals submitted as part of the FDCU equipment documents.
- 2) Provide three (3) additional sets of hard-copy training materials for Authority archives. Soft copies shall also be distributed as directed by the Authority.
- 3) Grant ownership of all class materials, including those sent before the training classes are held, to the Authority. In this respect, the Authority reserves the right to copy the materials for in-house training use only.
- 4) Submit all relevant course materials for Authority approval at least one (1) month prior to each course.
- 5) Transmit approved course materials to the attendees at least two (2) weeks before the course is due to start.

### **5.2 Instructor Qualifications**

Instructors shall be approved by the Authority. Therefore, within this context, it is required that:

- 1) The resumes of instructors be submitted at least one (1) month prior to their assigned courses.



- 2) Course instructors have demonstrated technical competence in the subject matter as well as previous instructing experience.
- 3) If the course instructor is not proficient in the Thai language, the Contractor shall provide an interpreter, with relevant technical background, to help the instructor deliver his presentation as efficiently and effectively as possible.

The Authority prefers instructors who specialize in course presentation as opposed to hardware or software developers who only occasionally present courses. However, for course elements produced specifically for this contract, the Contractor may use the developer as the instructor. The developer shall use appropriate training staff as resources when developing the training course and materials.

Where practical, subcontractors shall deliver training on their products directly. However, the Contractor shall remain responsible for selecting these courses, coordinating their delivery, and ensuring that all training objectives are met.

### **5.3 Training Curriculum**

The training curriculum is intended to describe the contents of the training when viewed as a whole. The subjects covered by the Contractor's individual courses may differ as long as the overall objectives are satisfied.

#### **5.3.1 FDCU Equipment Courses**

These courses shall focus on the need for Authority personnel to fully understand the theoretical and practical details that relate to the functional design, configuration, installation, startup, testing, and maintenance of the FDCU equipment. They shall include:

- 1) An introduction to the FDCU equipment from the perspective of how it will support the TDMS.
- 2) Theory of operation of the equipment from both a hardware and software perspective. This shall include the procedures to define, build, edit, and expand the FDCU database and install and configure all relevant software.



- 3) Block diagrams and data flows describing the interrelationships between all components of the FDCU equipment.
- 4) All diagnostic capabilities, including error messages and other indications, supported by the FDCU.
- 5) Use of test systems and all associated test equipment.
- 6) Troubleshooting to the replaceable part level. This shall include printed circuit board, module, and assembly replacement procedures.
- 7) Configuration, installation, startup, adjustment, and expansion of the FDCU and the Contractor's FDCU test system.
- 8) Testing of FDCU communications with the TDMS, DAC Simulator, and Contractor's test system.
- 9) Orientation and coordination of the FDCU equipment and test system documentation such as manuals, configuration and assembly drawings, schematic diagrams, and parts list.
- 10) Diagnostics and verification of the proper operation of the FDCU test systems.
- 11) Theory of operation of the test systems and, to the extent practical, troubleshooting and repair of the test systems.
- 12) Safety procedures related to installing and maintaining the FDCU equipment.
- 13) Any modifications made to the FDCU equipment.

# Appendix B:

RMIS 102-2559 (3G Router)

Specification





# PROVINCIAL ELECTRICITY AUTHORITY

## TECHNICAL SPECIFICATION DIVISION

Specification No.: RMIS-102/2559: CELLULAR EQUIPMENT FOR FIELD DEVICES INTERFACE

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**C3 Schedule of detailed requirement**

Invitation to Bid No.: 66IACEB190

Item	PEA Material No.	Quantity	Description
1	-	1 lot	<p><b>1.1 .....set(s) 3G Modem</b>, suitable for connecting with field devices such as Remote Controlled Switches (RCS), reclosers, etc. for SCADA communication via cellular network, with:</p> <p>Cellular technology : GSM, GPRS, EDGE, UMTS and HSPA, or more</p> <p>Frequency bands : 850, 900, 1,800 and 2,100 MHz, or more</p> <p>Maximum output power : according to Thailand's telecommunication standards and regulations and approval certificate from NBTC shall be submitted</p> <p>Protocol support : UDP, TCP, IP, and PPP, or more</p> <p>Functions and securities : - automatic connection - transparent (for TCP client/server and UDP protocol for serial interface) - keep alive - built-in watchdog or equivalent function - or more</p> <p>SIM card interface : 1 x SIM card holders, or more</p> <p>Communication interface: - RS-232, with: - number of ports : not less than 1 port - baud rate : 1,200 bps – 115,200 bps, or better - data format : 8 bits, 1 stop bit, None/Odd/Even parity</p> <p>External antenna interface : SMA female, or other interface connectors provided with adaptor</p> <p>Mounting : wall mounted or standard DIN rail mounted</p> <p>Signal strength and status indicators : LED indicators</p> <p>Operating temperature : up to 70<sup>o</sup>C</p> <p>Operating relative humidity : up to 90% non-condensing</p> <p>Nominal power supply voltage : 12 V DC and 24 V DC, or better</p> <p>Complete with:</p> <ol style="list-style-type: none"> <li>1. One (1) set of communication cable, not less than 1 meter length, with connector for connecting the Modem to the field device via RS-232 port.</li> <li>2. One (1) set of communication cable, not less than 1 meter length, with connector (SMA male to SMA female) for connecting the Modem via external antenna interface to surge arrester.</li> </ol>
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PROVINCIAL ELECTRICITY AUTHORITY

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### C3 Schedule of detailed requirement

Invitation to Bid No.: 66IACEB190

Item	PEA Material No.	Quantity	Description
	I		<p>3. Power supply cord  4. Mounting kit  5. Software for modem configuration with Graphic User Interface (GUI) and instruction manual  6. Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.</p> <p><b>1.2 .....set(s) Surge arrester</b>, gas discharge type, suitable for protection the 3G Modem form an external surge by series connection, with:  Working frequency range : DC to 3 GHz, or better  DC breakdown voltage : not less than 90 V DC  Voltage protection level : not more than 700 V  Maximum discharge current : not less than 10 kA  Voltage Standing Wave Ratio (VSWR) : not more than 1.5:1  Insertion loss : not more than 0.9 dB  Interface : SMA male (Modem/Router side) to SMA female (Antenna side) or other interface connectors provided with adaptor  Operating temperature : up to 70°C  Operating relative humidity : up to 90% non-condensing  Complete with:  1. Instruction manual  2. Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.</p> <p><b>1.3 .....set(s) Antenna</b>, omni directional and outdoor application, suitable for using with 3G Modem, with:  Polarization type : vertical  Gain : not less than 3 dBi  Frequency : 850, 900, 1,800 and 2,100 MHz, or more  Voltage Standing Wave Ratio (VSWR) : not more than 2.0:1  Material : waterproof fiberglass</p>



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**C3 Schedule of detailed requirement**

Invitation to Bid No.: 66IACEB190

Item	PEA Material No.	Quantity	Description
2	-	1 lot	<p>Complete with:</p> <ol style="list-style-type: none"> <li>1. Antenna mounting, suitable for installation the antenna on the top of the existing field device’s control cabinet or beside of the concrete pole.</li> <li>2. One (1) set of communication cable, not less than 1 meter length, with connector for connecting the antenna to surge arrester. The antenna interface of the arrester is SMA female.</li> <li>3. Instruction manual</li> <li>4. Other accessories according to manufacturer’s design and auxiliary equipments necessary to complete.</li> </ol> <p><b>2.1 .....set(s) 3G Router</b>, industrial grade, suitable for connecting with field devices such as Remote Controlled Switches (RCS), reclosers, etc. for SCADA communication via cellular network, with:</p> <p>Electromagnetic compatibility (EMC) standards compliance : - IEC/EN 61000-4-3 level 3, or better  - IEC/EN 61000-4-4 level 3, or better  - IEC/EN 61000-4-5 level 3, or better  - IEC/EN 61000-4-6 level 3, or better  - IEC/EN 61000-4-12 level 3, or better</p> <p>Cellular technology : GSM, GPRS, EDGE, UMTS and HSPA, or more</p> <p>Frequency bands : 850, 900, 1,800 and 2,100 MHz, or more</p> <p>Maximum output power : according to Thailand’s telecommunication standards and regulations and approval certificate from NBTC shall be submitted</p> <p>Protocol support : UDP, TCP, IP, PPP and Telnet, or more</p> <p>Functions, features and securities : - automatic connection  - transparent (for TCP client/server and UDP protocol for serial interface)  - keep alive  - Network Address Translation (NAT), port forwarding, intrusion protection, filtering and Access Control List (ACL) or equivalent function  - or more</p> <p>SIM card interface : 1 x SIM card holders, or more</p>



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### C3 Schedule of detailed requirement

Invitation to Bid No.: 66IACEB190

Item	PEA Material No.	Quantity	Description
	I		<p>Communication interface:</p> <ul style="list-style-type: none"> <li>- Ethernet port (RJ-45), with:               <ul style="list-style-type: none"> <li>- number of ports : not less than 1 port</li> <li>- baud rate : 10/100 Mbps, or better</li> <li>- protection : not less than 1.5 kV Electro Static Discharge (ESD) protection</li> </ul> </li> <li>- RS-232, with:               <ul style="list-style-type: none"> <li>- number of ports : not less than 1 port</li> <li>- baud rate : 1,200 bps – 115,200 bps, or better</li> <li>- data format : 8 bits, 1 stop bit, None/Odd/Even parity</li> <li>- protection : not less than 6 kV Electro Static Discharge (ESD) protection</li> </ul> </li> </ul> <p>External antenna interface : SMA female, or other interface connectors provided with adaptor</p> <p>Mounting : wall mounted or standard DIN rail mounted</p> <p>Signal strength and status indicators : LED indicators</p> <p>Degree of protection : IP 20, or better</p> <p>Operating temperature : up to 70<sup>o</sup>C</p> <p>Operating relative humidity : up to 90% non-condensing</p> <p>Nominal power supply voltage : 12 V DC and 24 V DC, or better</p> <p>Complete with:</p> <ol style="list-style-type: none"> <li>1. One (1) set of communication cable, not less than 1 meter length, with connectors for connecting the Router to the field device via Ethernet port.</li> <li>2. One (1) set of communication cable, not less than 1 meter length, with connectors for connecting the Router to the field device via RS-232 port.</li> <li>3. One (1) set of communication cable, not less than 1 meter length, with connector (SMA male to SMA female) for connecting the Router via external antenna interface to surge arrester.</li> <li>4. Power supply cord</li> <li>5. Mounting kit</li> <li>6. Software for router and Telnet configuration with Graphic User Interface (GUI) and instruction manual</li> <li>7. Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.</li> </ol>



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**C3 Schedule of detailed requirement**

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Item	PEA Material No.	Quantity	Description
	I		<p><b>2.2 .....set(s) Surge arrester</b>, gas discharge type, suitable for protection the 3G Router form a external surge by series connection, with:</p> <p>Working frequency range : DC to 3 GHz, or better            DC breakdown voltage : not less than 90 V DC            Voltage protection level : not more than 700 V            Maximum discharge current : not less than 10 kA            Voltage Standing Wave Ratio : not more than 1.5:1 (VSWR)            Insertion loss : not more than 0.9 dB            Interface : SMA male (Modem/Router side) to SMA female (Antenna side) or other interface connectors provided with adaptor            Operating temperature : up to 70<sup>0</sup>C            Operating relative humidity : up to 90% non-condensing</p> <p>Complete with:</p> <ol style="list-style-type: none"> <li>1. Instruction manual</li> <li>2. Other accessories according to manufacturer’s design and auxiliary equipments necessary to complete.</li> </ol> <p><b>2.3 .....set(s) Antenna</b>, omni directional and outdoor application, suitable for using with 3G Router, with:</p> <p>Polarization type : vertical            Gain : not less than 3 dBi            Frequency : 850, 900, 1,800 and 2,100 MHz, or more            Voltage Standing Wave Ratio : not more than 2.0:1 (VSWR)            Material : waterproof fiberglass</p> <p>Complete with:</p> <ol style="list-style-type: none"> <li>1. Antenna mounting, suitable for installation the antenna on the top of the existing field device’s control cabinet or beside of the concrete pole.</li> <li>2. One (1) set of communication cable, not less than 1 meter length, with connector for connecting the antenna to surge arrester. The antenna interface of the arrester is SMA female.</li> <li>3. Instruction manual</li> <li>4. Other accessories according to manufacturer’s design and auxiliary equipments necessary to complete.</li> </ol>



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### C3 Schedule of detailed requirement

Invitation to Bid No.: 66IACEB190

Item	PEA Material No.	Quantity	Description
	I		<p><b>Notes:</b></p> <ol style="list-style-type: none"><li>1. Each Item shall be packed in suitable package.</li><li>2. The Bidders have to quote the unit costs.</li><li>3. The Bidders shall be sole distributor or authorized representative and have a permanent office in Thailand; otherwise shall not be accepted.</li><li>4. The Bidders have to submit the sufficient references describing the previous experience of the suppliers (e.g. list of supply of equipment and/or materials having the same or similar design as proposed, field experience, the registration of TISI, the copies of license, and/or the inspection to supplier's factory by PEA's inspectors, etc.) to the satisfaction of PEA.</li><li>5. In case the samples are requested by PEA, the Bidders have to supply at least one (1) sample of the proposed Item(s) within fifteen (15) calendar days. The bidders who cannot supply the samples shall be rejected. PEA reserves the right to test the sample(s) according to PEA's testing procedure. In case of the failing test results, the Bidders will be rejected. The sample(s) will be returned after the test and consideration.</li><li>6. The Contractor has to guarantee the quality of the 3G Modem/ 3G Router, surge arrester and antenna for <b>Three (3) years</b> from date of issuance of the notice of acceptance. During the guarantee period, the Contractor shall replace the defective Modem/Router, arrester and antenna for free of charge or shall pay an amount equal to the exact purchasing value for the defective quantity of them.</li></ol>



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
1	-		<p><b>1.1 3G Modem</b>, suitable for connecting with field devices such as Remote Controlled Switches (RCS), reclosers, etc. for SCADA communication via cellular network, with:</p> <p>Cellular technology : .....</p> <p>Frequency bands : .....</p> <p>Maximum output power : .....</p> <p>.....</p> <p>Protocol support : .....</p> <p>Functions and securities : .....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>SIM card interface : .....</p> <p>Communication interface:</p> <p>- RS-232, with:</p> <p>- number of ports : .....</p> <p>- baud rate : .....</p> <p>- data format : .....</p>	set(s)		
<b>I</b>						



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
I			External antenna interface : ..... Mounting : ..... Signal strength and status indicators : ..... Operating temperature : ..... °C Operating relative humidity : ..... Nominal power supply voltage : ..... Complete with: 1. .... 2. .... 3. .... 4. .... 5. .... 6. .... <b>1.2 Surge arrester</b> , gas discharge type, suitable for protection the 3G Modem form a external surge by series connection, with: Working frequency range : ..... DC breakdown voltage : .....V DC	set(s)		



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
	<b>I</b>		Voltage protection level : .....V Maximum discharge current : .....kA Voltage Standing Wave Ratio : ..... (VSWR) Insertion loss : .....dB Interface : ..... Operating temperature : .....°C Operating relative humidity : ..... Complete with: 1. .... 2. ....  <b>1.3 Antenna</b> , omni directional and outdoor application, suitable for using with 3G Modem, with: Polarization type : ..... Gain : .....dBi Frequency : ..... Voltage Standing Wave Ratio : ..... (VSWR)	set(s)		





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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
2	-		Material : ..... Complete with: 1..... 2..... 3..... 4.....	set(s)	Total of Item 1	
			<b>2.1 3G Router</b> , industrial grade, suitable for connecting with field devices such as Remote Controlled Switches (RCS), reclosers, etc. for SCADA communication via cellular network, with: Electromagnetic compatibility : ..... (EMC) standards compliance ..... ..... ..... Cellular technology : ..... Frequency bands : ..... Maximum output power : ..... .....			

**I**



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
			Protocol support : ..... Functions and securities : ..... ..... ..... ..... SIM card interface : ..... Communication interface: - Ethernet port (RJ-45), with: - number of ports : ..... - baud rate : ..... - protection : ..... - RS-232, with: - number of ports : ..... - baud rate : ..... - data format : ..... - protection : ..... External antenna interface : ..... Mounting : .....			
<b>I</b>						



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
<b>I</b>			Signal strength and status indicators : ..... Degree of protection : ..... Operating temperature : .....°C Operating relative humidity : ..... Nominal power supply voltage : ..... Complete with: 1. .... 2. .... 3..... 4. .... 5. .... 6. .... 7. ....  <b>2.2 Surge arrester</b> , gas discharge type, suitable for protection the 3G Router form a external surge by series connection, with: Working frequency range : ..... DC breakdown voltage : .....V DC	set(s)		



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
I			Voltage protection level : .....V Maximum discharge current : .....kA Voltage Standing Wave Ratio : ..... (VSWR) Insertion loss : .....dB Interface : ..... Operating temperature : .....°C Operating relative humidity : ..... Complete with: 1. .... 2. ....  <b>2.3 Antenna</b> , omni directional and outdoor application, suitable for using with 3G Router, with: Polarization type : ..... Gain : .....dBi Frequency : ..... Voltage Standing Wave Ratio : ..... (VSWR)	set(s)		



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**C4 Price schedule**

Invitation to Bid No.: 66IACEB190

**Manufacturer :**

**Country of origin :**

**Trade-mark :**

Item	PEA Material No.	Catalogue No.	Description	Quantity	Unit Cost (See details & conditions attached)	Total Cost (See details & conditions attached)
			Material : ..... Complete with: 1..... 2..... 3..... 4.....			
			<b>Total of Item 2</b>			

**I**

# Appendix C:

I/O Point List



Control Outputs												
Item	Point Name (up to 50 chars)	State		Terminal	Point	DMS (DNP Mapping)					Remark	
		1	2	Connection	Type	Obj	Var	Qii	Class	Address		
1	RCS Close/Trip Command	Close	Open		SBO	12	1	echo of request			0	
					SBO							
2	RCS Test Command	Test	-		DOP	12	1	echo of request			1	
					DOP							

Analog Points												
Item	Point Name (up to 50 chars)	Unit	Scale		Terminal	Point	DMS (DNP Mapping)					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	600/1A for 22kV;400/1A for 33kV
2	Current Phase B	A	0-600	0-32767		AI	32	2	17,28	2	1	600/1A for 22kV;400/1A for 33kV
3	Current Phase C	A	0-600	0-32767		AI	32	2	17,28	2	2	600/1A for 22kV;400/1A for 33kV
4	Voltage Phase A-B	kV	0-30	0-32767		AI	32	2	17,28	2	3	22000/110V
5	Voltage Phase B-C	kV	0-30	0-32767		AI	32	2	17,28	2	4	22000/110V
6	Voltage Phase C-A	kV	0-30	0-32767		AI	32	2	17,28	2	5	22000/110V
7	Active Power	MW	-31.176+31.176	-32768-32767		AI	32	2	17,28	2	6	Calculated by Software
8	Reactive Power	MVAR	-31.176+31.177	-32768-32767		AI	32	2	17,28	2	7	Calculated by Software
9	Power Factor	%	-31.176+31.176	-32768-32767		AI	32	2	17,28	2	8	Calculated by Software
10	Fault Current A	amps	20,000			AI	32	2	17,28	2	9	
11	Fault Current B	amps	20,000			AI	32	2	17,28	2	10	
12	Fault Current C	amps	20,000			AI	32	2	17,28	2	11	

**Status Points:**

Item	Point Name (up to 50 chars)	State			Terminal Connection	Point Type	DMS (DNP Mapping)					Remark
		0	1	2			Obj	Var	Qii	Class	Address	
1	1st Fault Detected Postitive	Normal	Alarm			SOE	2	2	17,28	1	0	Calculated by Software
2	2nd Fault Detected Postitive	Normal	Alarm			SOE	2	2	17,28	1	1	Calculated by Software
3	3rd Fault Detected Postitive	Normal	Alarm			SOE	2	2	17,28	1	2	Calculated by Software
4	1st Fault Detected Negative	Normal	Alarm			SOE	2	2	17,28	1	3	Calculated by Software
5	2nd Fault Detected Negative	Normal	Alarm			SOE	2	2	17,28	1	4	Calculated by Software
6	3rd Fault Detected Negative	Normal	Alarm			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	Alarm			DI	2	1	17,28	3	10	Battery Fail/Normal Group Alarm
12*	Battery High Voltage	Normal	Alarm			DI	2	1	17,28	3	11	Battery Fail/Normal Group Alarm
13	Battery Charger OverVoltage	Normal	Alarm			DI	2	1	17,28	3	12	
14*	Battery Charger Grounded	Normal	Alarm			DI	2	1	17,28	3	13	Battery Fail/Normal Group Alarm
15	SF6 Gas Low Pressure	Normal	Alarm			DI	2	1	17,28	3	14	
16	Encloser Door Open	Normal	Alarm			DI	2	1	17,28	1	15	
17	Control Inhibit Status	Normal	Inhibit			DI	2	1	17,28	3	16	
18	Mechanical Device status	Undefine	Free	Lock		DI	2	1	17,28	3	17	
19						DI	2	1	17,28	3	18	
20	SF6 Low-Gas Lockout	Normal	Lockout			DI	2	1	17,28	3	19	
21	RTU Data Quality	Normal	Alarm			DI	2	1	17,28	3	20	Generated by Software
22	RTU Testing status	Normal	Test			DI	2	1	17,28	1	21	
23	Phase Fault Current A	Normal	Fault			DI	2	1	17,28	1	22	
24	Phase Fault Current B	Normal	Fault			DI	2	1	17,28	1	23	
25	Phase Fault Current C	Normal	Fault			DI	2	1	17,28	1	24	
26	Earth Fault Condition	Normal	Fault			DI	2	1	17,28	1	25	
27	Broken Conductor	Normal	Fault			DI	2	1	17,28	1	26	



SBO = Output Command (Select before operate) , DOP = Output Command (Direct operate)

AI = Analog input (Measurement)

DI = Regular point (Digital input without time tag) , SOE = MCD point (Digital input with time tag)

Note : The Meaning of Descriptor 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.

Class 1 = Unsolicited

Class 2, 3 = Polling

# Appendix D:

FDCU Demo Test





Company : \_\_\_\_\_

BID No. : \_\_\_\_\_

Manufacture : \_\_\_\_\_

Test date : \_\_\_\_\_

Test Item	Requirement	Result	Note
1	Feeder Fault Current Detection		
2	Overcurrent Fault		
3	Sensitive earth fault (ANSI 50SEF)		
4	Directional relay (ANSI 67)		
5	Broken conductor function		
6	Return-to-normal state		
7	FDCU's feeder fault detection function		
8	Analog Inputs		
9	Status Inputs		
10	Control Outputs		
11	Multi-fragment		

Remark

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Contents

Test items	Page
1. Feeder Fault Current Detection	4
2. Overcurrent Fault	6
3. Sensitive earth fault (ANSI 50SEF)	8
4. Directional relay (ANSI 67)	10
5. Broken conductor function	12
6 Return-to-normal state	14
7. FDCU's feeder fault detection function	18
8. Analog Inputs	20
9. Status Inputs	22
10. Control Outputs	24
11 Multi-fragment	27

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Test Item 1

Clause Reference 3.2.4

### Requirement

#### Feeder Fault Current Detection

Fault passage detection shall be based on checking if a current set point value has been exceeded. If such a condition is detected and continues for a specified time duration, the detection logic shall result in a Fault Event being registered and reported to the TDMS\*.

Remark: TDMS\*= Protocol Simulator

### Test Process :

- 1) Inject a three-phase currents in CTs input terminals of FDCU following figure 1
- 2) Increase the current injected in FDCU to under the threshold point values for more than the specified time duration to detect momentary as well as sustained faults.
- 3) Increase the current injected in FDCU to exceed the threshold point values for more than the specified time duration to detect momentary as well as sustained faults

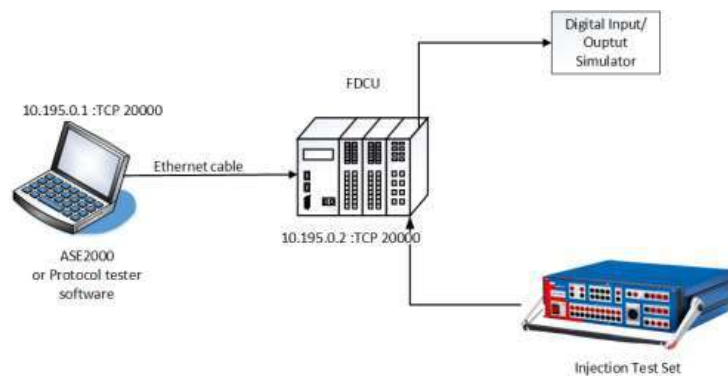


Figure 1

Remark: TDMS\*= Protocol Simulator

### Expected Result :

- FDCU shall be able to detect, store events and able to show Remotely on TDMS\* all types of faults

### Test Result / Observation

Able to detect, store Fault events and send it to TDMS\*

Pass  Not pass

**Remark**

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**Requirement****Overcurrent Fault**

Fault passage detection shall include reporting features for the different types of fault that can occur. In this respect, for example, the fault detection features associated with such relays as follows shall be incorporated, where equivalent IEC 60617 codes as well as the referenced ANSI codes may apply:

- Overcurrent (ANSI 50/51, 50G/51G)

**Test Process :**

Overcurrent Fault (Imax) test:

- Set Overcurrent fault threshold to 600A in FDCU and acknowledgement time to 225 ms
- Apply simulator test set following figure 2
- Increase injected current to exceed Overcurrent fault threshold
- When value is reached above thresholds limit, Fault indicator on FDCU should be indicated

Remark: TDMS\*= Protocol Simulator

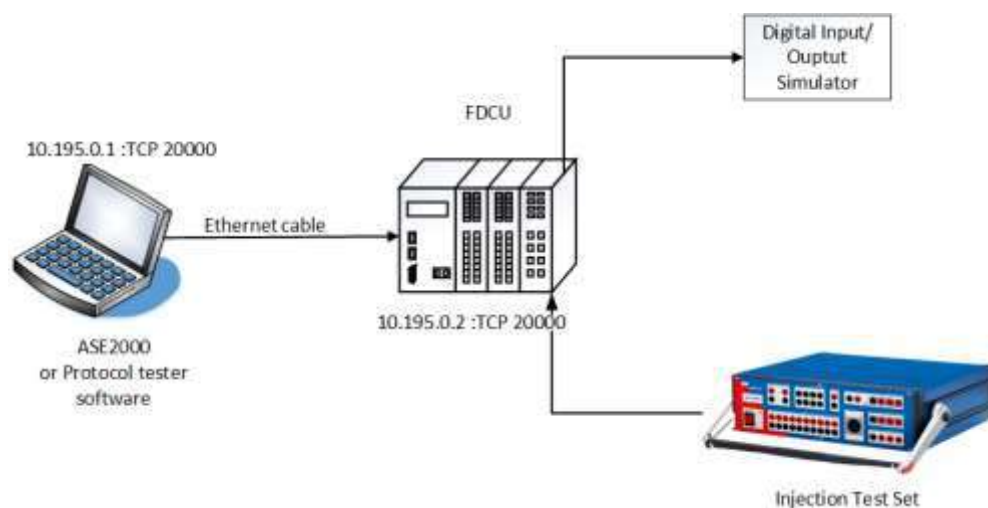


Figure 2

Expected Result :



- FDCU shall detect & indicates the fault event and able to show :
  1. Locally on the FDCU
  2. Remotely on the TDMS\*.
- FDCU shall able to show Fault current detection curve with three instances :
  - Instance 1: IDMT curve (overload)
  - Instance 2: DT curve (short-circuit)
  - Instance 3: DT curve (instantaneous short-circuit)
- Repeat for other threshold values to verify it works properly for all possible configurations of the FDCU.

Test Result / Observation

Pass     Not pass

Able to detect and indicate fault locally on FDCU:

Yes     No

Able to detect & indicate fault remotely through TDMS\* :

Yes     No

Able to show Fault current detection curve with three instances:

Yes     No

**Remark**

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## Requirement

**Sensitive earth fault**

Fault passage detection shall include reporting features for the different types of fault that can occur. In this respect, for example, the fault detection features associated with such relays as follows shall be incorporated, where equivalent IEC 60617 codes as well as the referenced ANSI codes may apply:

- Sensitive earth fault (ANSI 50SEF)

## Test Process :

**Sensitive Earth Fault test:**

- Set Earth fault threshold (Zero sequence) to 30A in FDCU and acknowledgement time to 225 ms
- Apply simulator test set following figure 3
- Increase injected current under the Earth fault threshold. FDCU shall not detect any fault.
- Check displayed current value for 3 phases on TDMS\*
- Increase injected current to exceed the threshold for more than the specified time duration (225 ms in this example) to detect sensitive earth fault.
- When value is above threshold (30A), Fault indicator on FDCU shall be indicated
- Set injected current to 0 in all three phase current sensors (CT's) & so as the phase voltages
- Check creation of an event in 'Events' log file on TDMS\*

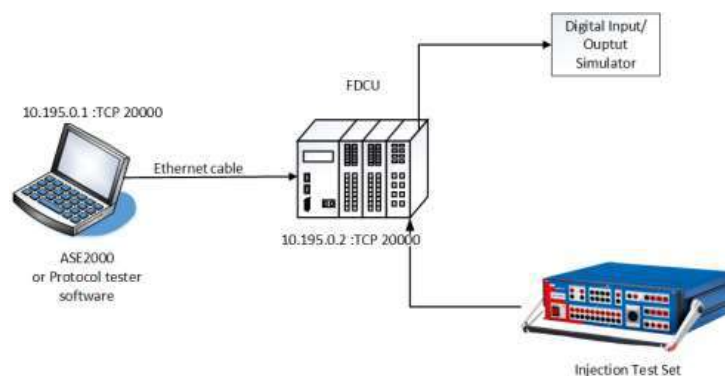


Figure 3

Remark: TDMS\*= Protocol Simulator

## Expected Result :

- FDCU shall detect & indicates the fault event and able to show :
  1. Locally on the FDCU
  2. Remotely on the TDMS\*.
- FDCU shall able to show Fault current detection curve with three instances :
  - Instance 1: IDMT curve (overload)
  - Instance 2: DT curve (short-circuit)
  - Instance 3: DT curve (instantaneous short-circuit)
- Repeat for other threshold values to verify it works properly for all possible configurations of the FDCU.

Test Result / Observation

Pass     Not pass

Yes     No

Able to detect and indicate fault locally on FDCU:

Able to detect & indicate fault remotely through TDMS\* :

Yes     No

Able to show Fault current detection curve with three instances:

Yes     No

**Remark**

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**Requirement :****Directional relay**

Fault passage detection shall include reporting features for the different types of fault that can occur. In this respect, for example, the fault detection features associated with such relays as follows shall be incorporated, where equivalent IEC 60617 codes as well as the referenced ANSI codes may apply:

- Directional relay (ANSI 67)

**Test Process :**

Apply current and polarization voltage with simulator test set to FDCU following figure 4 to simulate a fault condition such as :

- Polarization voltage is the phase-to-phase voltage in quadrature with the current for  $\cos \phi = 1$  (phase-to-phase voltage creating a  $90^\circ$  angle in relation to the current).
- Forward tripping operation check (Simulation scenario with angle  $> 120^\circ$  )
- Reverse blocking operation check (Simulation scenario with angle  $< 60^\circ$  )
- Time characteristic tests (operate delay time) in forward direction at 3 current levels

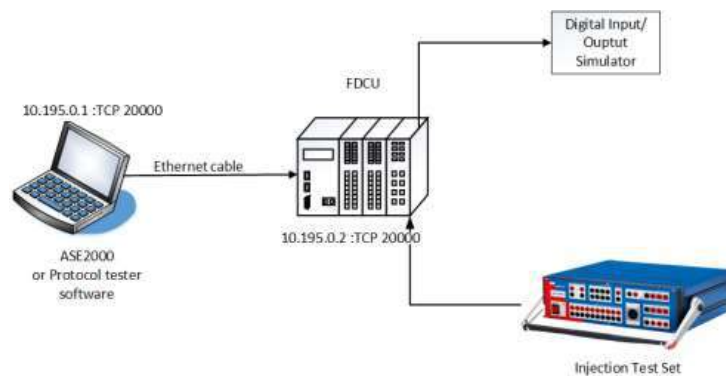


Figure 4

**Expected Result :**

- The FDCU operate as a directional relay
- FDCU detects the fault event.
- Works properly for all possible configurations of the FDCU

**Test Result / Observation**

Remark

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**Requirement :****Broken conductor**

Fault passage detection shall include reporting features for the different types of fault that can occur. In this respect, for example, the fault detection features associated with such relays as follows shall be incorporated, where equivalent IEC 60617 codes as well as the referenced ANSI codes may apply:

- Broken conductor function (Negative sequence voltage (ANSI 47) or Negative sequence current value (ANSI 46))

**Test Process :****Broken conductor test**

Method for ANSI 47 Apply simulator test set as following figure 5

- Apply 3 phase voltage to FDCU (with injection case 0-230V to Activate Instance 1)
- Parameter Threshold 10% and Operate delay time 10 ms

Test principle consists in "cutting" 1 phase conductor and demonstrate that the alarms goes high in event log, then down when restoring the cable.

More simply this may be simulated by injecting balanced voltage on 3 phases then stopping injection on 1 phase or disconnecting 1 phase measurement on either primary or secondary side of voltage adapter Or

Method for ANSI 46 Apply simulator test set as following figure 5

- Apply current to FDCU on 3-phase injection.
- Complete functional tests verifying proper speed, sequence of operation and equipment control required from the control system and protective devices.

Verify proper pick up levels of relay elements

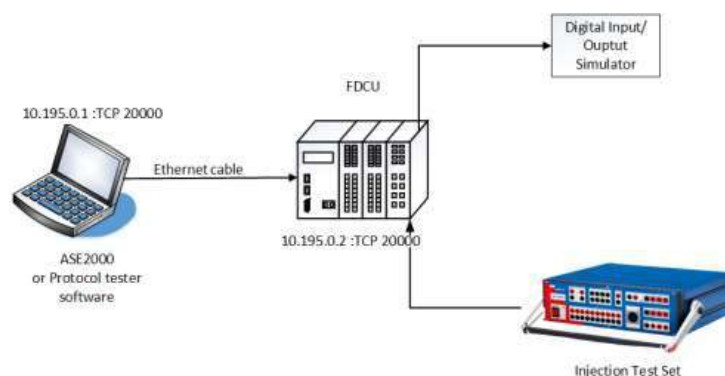


Figure 5

**Expected Result :**

- The FDCU operate as a Negative sequence voltage (ANSI 47) or Negative sequence current (ANSI 46)
- FDCU indicates the fault event.
- Works properly for all possible configurations of the FDCU.

Test Result / Observation

Pass  Not pass

**Remark**

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**Requirement :****Return-to-normal state**

Detection of a return-to-normal state shall be based on recognizing that the voltage level has been above a configurable set point for a specified time, in which case a Fault Cleared Event shall be registered, reported to the TDMS\*, and used to reset the FDCU so it is ready to detect any subsequent fault.

**Test Process :**

- Apply simulator test set as following figure 6
- Apply current to FDCU to simulate a fault condition as mentioned in Test Item 2b and 2c.
- When FDCU will be indicating the Fault, Simulate a return-to-normal voltage condition.
- On the reappearance of voltage above a configurable threshold value, Fault indicator shall be OFF
- Check creation of an event in 'Events' log file on TDMS\*

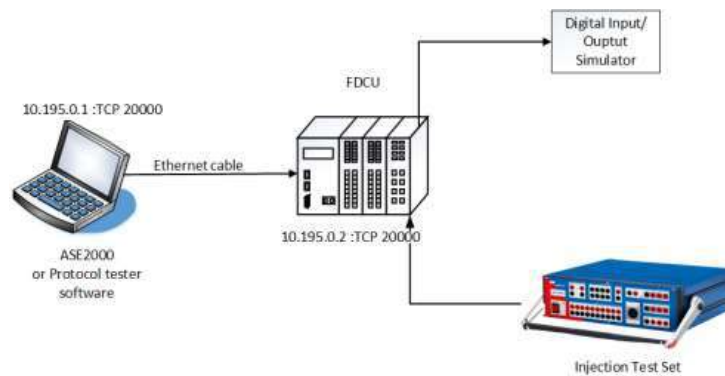


Figure 6

Remark: TDMS\*= Protocol Simulator

**Expected Result :**

- The FDCU shall reset the fault indication and return-to-normal state on recognizing the voltage level has been above a configurable set point for a specified time.
- Verify the fault reset event & voltage reappearance on webserver/ TDMS\*.
- Works properly for all possible configurations of the FDCU.

**Test Result / Observation**



Remark

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**Requirement :**

The FDCU's feeder fault detection function shall: Verify activities

- a) Report the fault current level with time stamp to the TDMS\* and reset the fault current register to zero.
- b) Report Fault Event, Fault Direction, and Fault Clearance Event details as time-stamped Sequence of Events (SOEs).
- c) Support a configurable format for local fault record reporting including the Comma separated Variable (CSV) format for use in spreadsheet and the COMTRADE (IEEE C37.111-1999) format for use with commercial COMTRADE viewer.

**Test Process :**

- Apply current to FDCU to simulate all types of fault conditions.
- Verify Fault Events with time stamp on TDMS\*

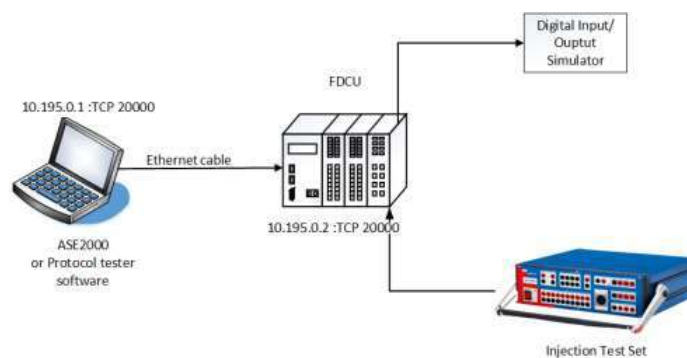


Figure 7

Remark: TDMS\*= Protocol Simulator

**Expected Result :**

- FDCU shall indicate the fault event when the fault criteria are met for all types of faults.
- FDCU shall able to log Fault Events with direction with time stamp & can be seen through TDMS\*
- Works properly for all possible configurations of the FDCU

**Test Result / Observation**

Remark

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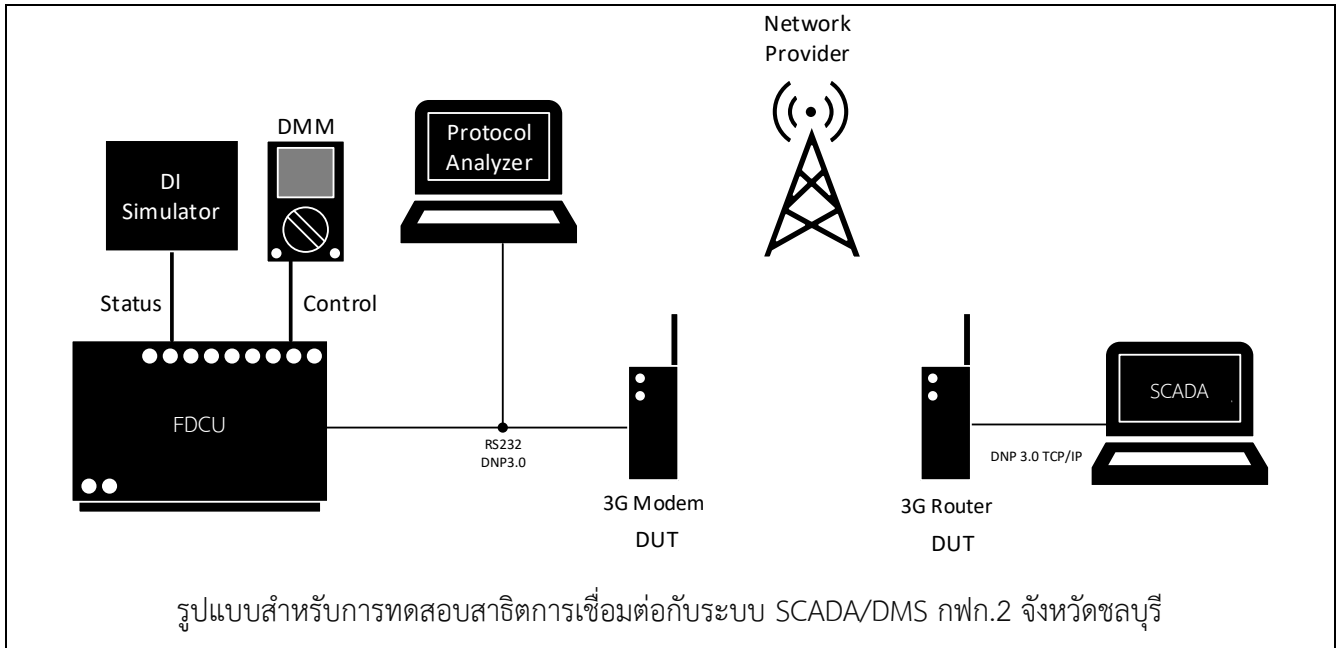
**Requirement :****Input/Output Points**

The FDCU shall include facilities for handling all required analog input, status input, and control output points. The requirements for each type of I/O point are described in the following sub-clauses. Also, refer to Appendix A where an example of the I/O points currently handled by existing FRTUs at some of the project RCS sites are identified. The FDCU shall handle similar points. However, all points to be handled will be confirmed during project implementation, i.e., during the initial design phase. Within this context, the Contractor's proposal shall have referenced the standards to which the FDCU complies such as IEC 61557-12, IEC 61000-4-30 or equivalent

**Test Process :****Analog Inputs**

The FDCU shall: Verify activities

- 14) Acquire analog inputs directly without transducers from each of three power system voltage and current terminals in the existing or Contractor-provided RCS control cabinets.
- 15) Use voltage and current inputs for calculations that support TDMS\* acquisition of the following data as a minimum:
  - e) Line-to-line voltages.
  - f) Phase current magnitudes and phase angles.
  - g) Real and reactive powers (three-phase kW and kVar totals with sign).
  - h) Power factor.
- 16) Accept ac voltage input signals with a normal input level of 110 V.
- 17) Accurately resolve ac voltage input signal levels from 0 to 150 V.
- 18) Accurately resolve ac current input signals with normal ranges of 0 to 5 A or 0 to 1 A.
- 19) 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 TDMS\*.



Expected Result :

- Apply current to FDCU to simulate a Analog Inputs : Acquire analog inputs directly
- Verify activities: items1-6
- FDCU indicates analog value inputs over TDMS
- Work properly for all possible configurations of the FDCU.

Test Result / Observation

Pass     Not pass

Remark

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Test Item 9

Clause Reference 3.2

**Requirement :**

**Input/Output Points**

The FDCU shall include facilities for handling all required analog input, status input, and control output points. The requirements for each type of I/O point are described in the following sub-clauses. Also, refer to Appendix A where an example of the I/O points currently handled by existing FRTUs at some of the project RCS sites are identified. The FDCU shall handle similar points. However, all points to be handled will be confirmed during project implementation, i.e., during the initial design phase. Within this context, the Contractor's proposal shall have referenced the standards to which the FDCU complies such as IEC 61557-12, IEC 61000-4-30, or equivalent.

**Test Process :**

**Status Inputs**

As a minimum, the FDCU shall accept isolated wet or 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 timestamped to a precision of 1 millisecond. Within this context:

- 6) All necessary wetting voltage, current limiting, input isolation and bounce filtering shall be provided.
- 7) Contact de-bounce time periods shall be individually configurable.
- 8) The input circuits shall be optically isolated from the external signal.
- 9) Input contact wetting voltages shall be 24 Vdc or less as obtained from the dc power supply in the existing or Contactor-provided RCS control cabinets.

Each wetting voltage circuit shall be protected with its own circuit breaker.

**Expected Result :**

- Energize one digital input on FDCU
- Poll FDCU for new events
- Verify activities: items 1-4 as per test process above
- FDCU should report recent changes through TDMS
- Work properly for all possible configurations of the FDCU.

**Test Result / Observation**

Pass  Not pass

Remark

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**Requirement :****Input/Output Points**

The FDCU shall include facilities for handling all required analog input, status input, and control output points. The requirements for each type of I/O point are described in the following sub-clauses. Also, refer to Appendix A where an example of the I/O points currently handled by existing FRTUs at some of the project RCS sites are identified. The FDCU shall handle similar points. However, all points to be handled will be confirmed during project implementation, i.e., during the initial design phase. Within this context, the Contractor's proposal shall have referenced the standards to which the FDCU complies such as IEC 61557-12, IEC 61000-4-30 or equivalent.

**Test Process :**

Control Outputs The FDCU shall support the following control output features: Verify activities

3) A Select-Check Back-Before-Operate (SCBO) procedure for all control operations. In this respect, the following concepts shall apply:

- f) 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.
- g) 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.
- h) 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.
- i) 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.

Any further attempt at control shall require a new SCBO procedure

4) RCS opening and closing by sending commands to a complimentary pair of contact outputs such that:

- d) One command activates the contact used to open the switch.



- e) The other command activates the contact used to close the switch.
- f) Only one contact output in a complimentary pair can be activated at a time.

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.

Expected Result :

The following requirements shall also apply: Verify activities

1. The FDCU in combination with the ACC (if required) shall be capable of direct control of the RCS. For ACC details refer to Clause
  2. The voltage rating of the control output contacts shall be 24 VDC
  3. The FDCU shall monitor all operations and local status information and give warnings or advisory messages when any wrong operational sequence is requested.
  4. Abnormal conditions shall inhibit control operations, e.g., low gas-pressure lockout of an RCS.
- Apply current to FDCU to simulate a Control Outputs :
  - Verify activities: items 1-4
  - FDCU indicates Status inputs.
  - Work properly for all possible configurations of the FDCU.

Test Result / Observation

Pass     Not pass

Remark

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Test Item 11	Clause Reference 3.1
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**Requirement :**

**Input/Output Points**

The FDCU shall be possible for the data to be sent under the following DNP 3.0 defined modes of operation

**Test Process :**

- Use test set to simulate class 1 to verify the multi-fragment

**Expected Result :**

- The FDCU shall send data properly following the multi-fragment under the DNP 3.0 Protocol

**Test Result / Observation**

Pass     Not pass

**Remark**

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# Appendix E:

BOM





# Appendix F:

Compliance



Invitation to Bid No: .....

Technical Specification: FDCU Specification

Manufacture:

Bidder:

Item	Description	Requirement		Compliance Status	
				C	N
<b>1</b>	<b>Common Requirements</b>				
1.3	Service Conditions				
	1. Temperature (IEC 60068-2-1, 2, 3, and 14, or equivalent)	0°C to 70°C	Yes		
	2. Temperature Gradient (IEC 60068-2-1, 2, 3, and 14, or equivalent)	Up to 30°C	Yes		
	3. Relative Humidity (IEC 60068-2-30 and 38, or equivalent)	Up to 95% at 40°C	Yes		
	4. Cyclic Damp Heat (IEC 60068-2-30 and 38, or equivalent)	40°C to 25°C at 95% Relative Humidity	Yes		
	5. Absolute Humidity (IEC 60068-2-30 and 38, or equivalent)	Up to 29g/m <sup>3</sup>	Yes		
	6. Vibration (sinusoidal) (IEC 60068-2-6, or equivalent)	2g acceleration, 9 to 350Hz	Yes		
	7. Shock (IEC 60068-2-27, or equivalent)	15g, 11ms test			
	8. Tilted Pole	Up to 10 degrees from vertical in any direction			
	9. Altitude	Up to 1,000 meters			

Item	Description	Requirement		Compliance Status	
				C	N
1.4	Fail Safe Design	yes			
1.5	Maintainability	yes			
1.6	Corrosion Protection	yes			
1.6.1	Galvanizing	yes			
	All structural shall be hot-dipped galvanized or electrolytic galvanized, as appropriate in particular cases, and in accordance with ASTM Specification A123/A123M-15, "Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products", or equivalent	yes			
1.6.2	Powder Coating Paint				
	1. The surface shall be cleaned to bare material by mechanical or chemical means.	yes			
	2. One or more phosphatizing or priming coats of paint shall be applied to the bare surface using a zinc-based or lead-based primer.	yes			
	3. Polyester spray powder finish paint shall be applied over the primer coat to a thickness of 50-75 micrometers (0.002-0.003 inches). The finish-coat color shall be grey (RAL 7032).	yes			
1.7	Marking	yes			
1.8	Immunity to Electrical Stress and Disturbance	yes			

Item	Description	Requirement		Compliance Status	
				C	N
1.8.1	Minimum Insulation of Equipment				
	Rated Insulation Voltage (IEC 60255-5 Table I)	500V			
	Dielectric Test Voltage (IEC 60255-5 Table I Series B (Clause 6))	2.0kVrms			
	Insulation Resistance Test (IEC 60255-5(Clause 7))	Yes			
	Impulse Voltage Test (IEC 60255-5 (Clause 8))	5kV 1.2/50 $\mu$ s /0.5J			
1.8.2	Immunity from EMI, Radiated Disturbance, and Electrostatic Discharge				
	High Voltage Impulse (IEC 60060-1)	5 kV, 0.5 J			
	Electrical Disturbances (1 MHz Burst) (IEC 60255-22-1,class 3)	yes			
	CM	2.5 kV			
	DM	1 kV			
	Electrostatic Discharge Immunity IEC 61000-4-2)	yes			
	Air (Level 3)	8kV			
	Direct (Level 4)	8kV			
	Radiated Immunity (IEC 61000-4-3) (Level 3)	80 MHz-1 GHz			



Item	Description	Requirement		Compliance Status	
				C	N
	Fast Transient/Burst Immunity (IEC 61000-4-4, IEC 60255-22-4 ANSI/IEEE C37.90.1) (Level 3) (Class 4)	4 kV			
	Surge Immunity (IEC 61000-4-5) (Level 4)	2 kV/4 kV			
	Conducted Immunity (IEC 61000-4-6)	10 V			
	Harmonics Emissions (IEC 61000-4-7)	yes			
	Power Frequency Magnetic Field Immunity (IEC 61000-4-8)	30 A/m			
	Pulse Magnetic Field (IEC 61000-4-9)	1000 A/m			
	Damped Oscillatory Magnetic Field Immunity (IEC 61000-4-10)	30 A/m			
	Oscillatory Transient Immunity (IEC 61000-4-12)	yes			
	Ring Wave (Level 3)	2.0 kV CM			
	Damped Oscillatory (Level 3)	2.0 kV CM			
2.	<b>FDCU Functional Requirements</b>				
2.2	Input / Output Points				
2.2.1	Analog Inputs				

Item	Description	Requirement		Compliance Status	
				C	N
	1. Line-to-line voltages.	yes			
	2. Phase current magnitudes and phase angles.	yes			
	3. Real and reactive powers (three-phase kW and kVar totals with sign).	yes			
	4. Power factor.	yes			
	5. AC voltage input signal levels from 0 to 150 V with a normal input level of 110 V.	yes			
	6. AC current input signals with normal ranges of 0 to 5 A or 0 to 1 A	1A or 5A			
2.2.2	Status Inputs				
	1. All necessary wetting voltage, current limiting, input isolation, and bounce filtering shall be provided.	yes			
	2. Contact de-bounces time periods shall be individually configurable.	yes			
	3. The input circuits shall be optically isolated from the external signal.	yes			
	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 RCS control cabinets.	24 Vdc			

Item	Description	Requirement		Compliance Status	
				C	N
2.2.3	Control Outputs				
	1. A Select-Check Back-Before-Operate (SCBO) procedure for all control operations	yes			
	2. RCS opening and closing by sending commands to a complimentary pair of contact outputs	5 to 30 second			
	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.	yes			
2.2.4	Feeder Fault Current Detection				
	1. Overcurrent (ANSI 50/51, 50G/51G)	yes			
	2. Sensitive earth fault (ANSI 50SEF)	yes			
	3. Directional relay (ANSI 67)	yes			
	4. Broken conductor (ANSI 46BC or ANSI 47BC)	yes			
	5. Negative sequence voltage (ANSI 47)	yes			
	6. Report Fault Event, Fault Direction, and Fault Clearance Event details as time-stamped Sequence of Events (SOEs)	yes			
	7. Save the last 128 Fault Events along with their corresponding Fault Direction and associated Fault Clearance Event details and, on demand, report them to the TDMS.	yes			

Item	Description	Requirement		Compliance Status	
				C	N
	8. Support a configurable format for local fault record reporting including the Comma Separated Variable (CSV) format for use in a spreadsheet and the COMTRADE (IEEE C37.111-1999) format for use with a commercial COMTRADE viewer.	yes			
2.3	FDCU Architecture				
2.3.1	Central Processing Module				
	1. Support a high-level language processing capability per the open IEC-61131-3 standard for programmable logic controllers.	yes			
	2. Support management of the FDCU database from a local test set including the DAC Simulator.	yes			
	3. Support download and upload of FDCU parameters and configuration data.	yes			
	4. Implement the DNP 3.0 Secure Authentication protocol interface with the TDMS	yes			
	5. Include a watch-dog timer that is reset regularly by FDCU software.	yes			
2.3.2	I/O Module				

Item	Description	Requirement		Compliance Status	
				C	N
	1. Capability to accept analog and status inputs and send control outputs. This shall include fault current measurements.	yes			
	2. Capability of being replaced without reprogramming, redefinition of configuration parameters, or rewiring.	yes			
2.3.3	Communications Module				
	1. Remote data communications with external systems and devices over an Ethernet/IP network using the latest secure DNP 3.0 communications protocol.	yes			
	2. Local and remote configuration with a static IP address.	yes			
	3 The fully implemented message security features of the DNP 3.0 protocol running over TCP/IP.	yes			
	4. Blocking or disabling of ports to prevent unauthorized access.	yes			
	5. Features such as HTTPS for web server functionality	yes			
2.3.4	Time and Date Module				
	1. Include an internal time-of-day clock for data collection coordination. The time resolution of the internal clock shall be one (1) ms or better and, without synchronization, the time shall drift	≤1 ms internal clock and ≤5 ms/hr. Time drift			

Item	Description	Requirement		Compliance Status	
				C	N
	by no more than 5 ms per hour.				
	2. Be able to receive a DNP 3.0 compliant time and date message that contains a Greenwich Mean Time (GMT) reference signal, generated by the TDMS in long format and in such a way as to properly account for communication path delays.	yes			
	3. Be able to synchronize the internal clock to the GMT time and date received from the TDMS.	yes			
2.3.5	Web Server Module	yes			
2.4	Software/Firmware	yes			
2.4.1	Operating System	yes			
2.4.2	Operating Software	yes			
2.4.3	Diagnostic Software	yes			
2.5	Interlocking	yes			
3.	<b>Documentation</b>	yes			
4.	<b>Quality Assurance Program</b>				
4.1	Variance Recording and Resolution	yes			

Item	Description	Requirement		Compliance Status	
				C	N
5.1	Training	yes			

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Invitation to Bid No: .....  
 Technical Specification: RMIS-102/2559 Cellular Router

Manufacture:  
 Bidder:

Item	Description	Requirement	Compliance Status	
			C	N
1.	<b>3G Modem</b>			
	Cellular technology	GSM, GPRS, EDGE, UMTS and HSPA, or more		
	Frequency bands	850, 900, 1,800 and 2,100 MHz, or more		
	Maximum output power	according to Thailand's telecommunication standards and regulations and approval certificate from NBTC shall be submitted		
	Protocol support	UDP, TCP, IP, and PPP, or more		
	Functions and securities	<ul style="list-style-type: none"> <li>- automatic connection</li> <li>- transparent (for TCP client/server and UDP protocol for serial interface)</li> <li>- keep alive</li> <li>- built-in watchdog or equivalent function</li> </ul>		



Item	Description	Requirement		Compliance Status	
				C	N
		- or more			
	SIM card interface	1 x SIM card holders, or more			
	Communication interface:				
	- RS-232, with:				
	- number of ports	not less than 1 port			
	- baud rate	1,200 bps – 115,200 bps, or better			
	- data format	8 bits, 1 stop bit, None/Odd/Even parity			
	External antenna interface	SMA female, or other interface connectors provided with adaptor			
	Mounting	wall mounted or standard DIN rail mounted			
	Signal strength and status indicators	LED indicators			
	Operating temperature	up to 70°C			
	Operating relative humidity	up to 90% non-condensing			
	Nominal power supply voltage	12 V DC and 24 V DC, or			

Item	Description	Requirement		Compliance Status	
				C	N
		better			
	Complete with:				
	1) One set of communication cable, not less than 1 meter length, with connector for connecting the Modem to the field device via RS-232 port.	1			
	2) One set of communication cable, not less than 1 meter length, with connector (SMA male to SMA female) for connecting the Modem via external antenna interface to surge arrester.	1			
	3) Power supply cord	Yes			
	4) Mounting kit	Yes			
	5) Software for modem configuration with Graphic User Interface (GUI) and instruction manual	Yes			
	6) Other accessories according to manufacturer's design and auxiliary equipments necessary to complete	Yes			
<b>1.2</b>	<b>Surge arrester</b>				
	Working frequency range	DC to 3 GHz, or better			
	DC breakdown voltage	not less than 90 V DC			

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Item	Description	Requirement	Compliance Status	
			C	N
	Voltage protection level	not more than 700 V		
	Maximum discharge current	not less than 10 kA		
	Voltage Standing Wave Ratio (VSWR)	not more than 1.5:1		
	Insertion loss	not more than 0.9 dB		
	Interface	SMA male (Modem/Router side) to SMA female (Antenna side) or other interface connectors provided with adaptor		
	Operating temperature	up to 70°C		
	Operating relative humidity	up to 90% non-condensing		
	Complete with:			
	1) Instruction manual	Yes		
	2) Other accessories according to manufacturer's design and auxiliary equipments necessary to complete	Yes		
<b>1.3</b>	<b>Antenna</b>			
	Polarization type	vertical		

Item	Description	Requirement		Compliance Status	
				C	N
	Gain	not less than 3 dBi			
	Frequency	850, 900, 1,800 and 2,100 MHz, or more			
	Voltage Standing Wave Ratio (VSWR)	not more than 2.0:1			
	Material	waterproof fiberglass			
	Complete with:				
	1) Antenna mounting, suitable for installation the antenna on the top of the existing field device's control cabinet or beside of the concrete pole.	Yes			
	2) One set of communication cable, not less than 1 meter length, with connector for connecting the antenna to surge arrester. The antenna interface of the arrester is SMA female.	1			
	3) Instruction manual	Yes			
	4) Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.	Yes			
<b>2.1</b>	<b>3G Router</b>				
	Electromagnetic compatibility (EMC) standards compliance	- IEC/EN 61000-4-3 level 3, or better - IEC/EN 61000-4-4 level 3,			

Item	Description	Requirement		Compliance Status	
				C	N
		or better - IEC/EN 61000-4-5 level 3, or better - IEC/EN 61000-4-6 level 3, or better - IEC/EN 61000-4-12 level 3, or better			
	Cellular technology	GSM, GPRS, EDGE, UMTS and HSPA, or more			
	Frequency bands	850, 900, 1,800 and 2,100 MHz, or more			
	Maximum output power	according to Thailand's telecommunication standards and regulations and approval certificate from NBTC shall be submitted			
	Protocol support	UDP, TCP, IP, PPP and Telnet, or more			
	Functions, features and securities	- automatic connection - transparent (for TCP client/server and UDP protocol for serial interface)			

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Item	Description	Requirement		Compliance Status	
				C	N
		- keep alive - Network Address Translation (NAT), port forwarding, intrusion protection, filtering and Access Control List (ACL) or equivalent function - or more			
	SIM card interface	1 x SIM card holders, or more			
	Communication interface:				
	- Ethernet port (RJ-45), with:				
	- number of ports	not less than 1 port			
	- baud rate	10/100 Mbps, or better			
	- protection	not less than 1.5 kV Electro Static Discharge (ESD) protection			
	- RS-232, with:				

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Item	Description	Requirement		Compliance Status	
				C	N
	- number of ports	not less than 1 port			
	- baud rate	1,200 bps – 115,200 bps, or better			
	- data format	8 bits, 1 stop bit, None/Odd/Even parity			
	- protection	not less than 6 kV Electro Static Discharge (ESD) protection			
	External antenna interface	MA female, or other interface connectors provided with adaptor			
	Mounting	wall mounted or standard DIN rail mounted			
	Signal strength and status indicators	LED indicators			
	Degree of protection	IP 20, or better			
	Operating temperature	up to 70°C			
	Operating relative humidity	up to 90% non-condensing			

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Item	Description	Requirement		Compliance Status	
				C	N
	Nominal power supply voltage	12 V DC and 24 V DC, or better			
	Complete with:				
	1) One set of communication cable, not less than 1 meter length, with connectors for connecting the Router to the field device via Ethernet port.	1			
	2) One set of communication cable, not less than 1 meter length, with connectors for connecting the Router to the field device via RS-232 port.	1			
	3) One set of communication cable, not less than 1 meter length, with connector (SMA male to SMA female) for connecting the Router via external antenna interface to surge arrester.	1			
	4) Power supply cord	Yes			
	5) Mounting kit	Yes			
	6) Software for router and Telnet configuration with Graphic User Interface (GUI) and instruction manual	Yes			
	7) Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.	Yes			
<b>2.2</b>	<b>Surge arrester</b>				
	Working frequency range	DC to 3 GHz, or better			



Item	Description	Requirement		Compliance Status	
				C	N
	DC breakdown voltage	not less than 90 V DC			
	Voltage protection level	not more than 700 V			
	Maximum discharge current	not less than 10 kA			
	Voltage Standing Wave Ratio (VSWR)	not more than 1.5:1			
	Insertion loss	not more than 0.9 dB			
	Interface	SMA male (Modem/Router side) to SMA female (Antenna side) or other interface connectors provided with adaptor			
	Operating temperature	up to 70°C			
	Operating relative humidity	up to 90% non-condensing			
	Complete with:				
	1) Instruction manual	Yes			
	2) Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.	Yes			

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Item	Description	Requirement		Compliance Status	
				C	N
<b>2.3</b>	<b>Antenna</b>				
	Polarization type	vertical			
	Gain	not less than 3 dBi			
	Frequency	850, 900, 1,800 and 2,100 MHz, or more			
	Voltage Standing Wave Ratio (VSWR)	not more than 2.0:1			
	Material	waterproof fiberglass			
	Complete with:				
	1. Antenna mounting, suitable for installation the antenna on the top of the existing field device's control cabinet or beside of the concrete pole.	Yes			
	2. One set of communication cable, not less than 1 meter length, with connector for connecting the antenna to surge arrester. The antenna interface of the arrester is SMA female.	1			
	3) Instruction manual	Yes			
	4) Other accessories according to manufacturer's design and auxiliary equipments necessary to complete.	Yes			

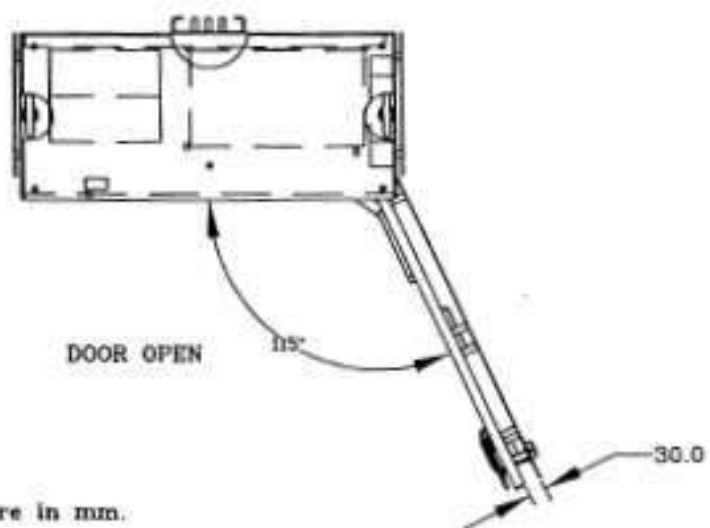
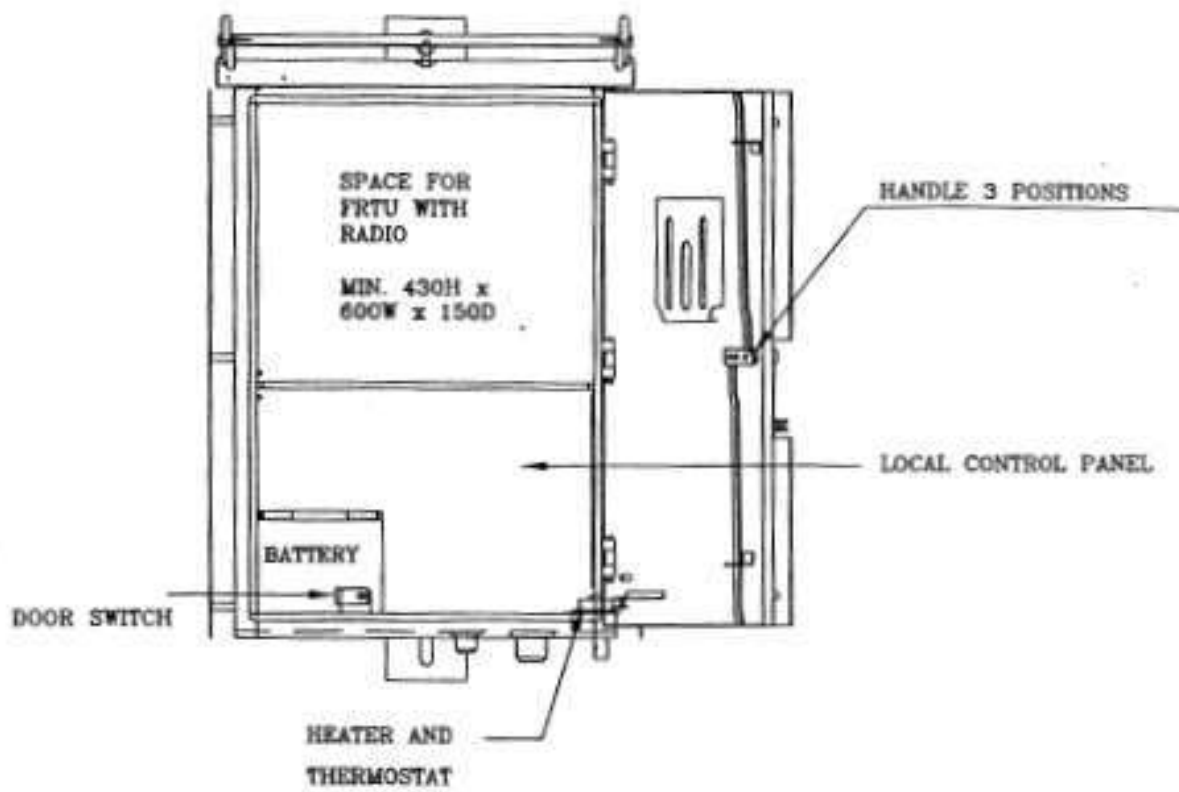
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# Appendix G:

RCS Layout

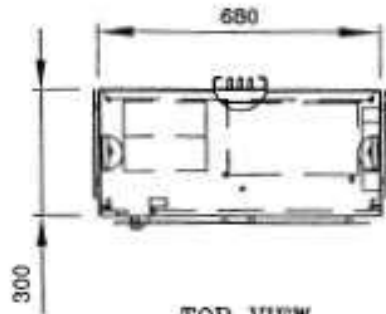


PRELIMINARY

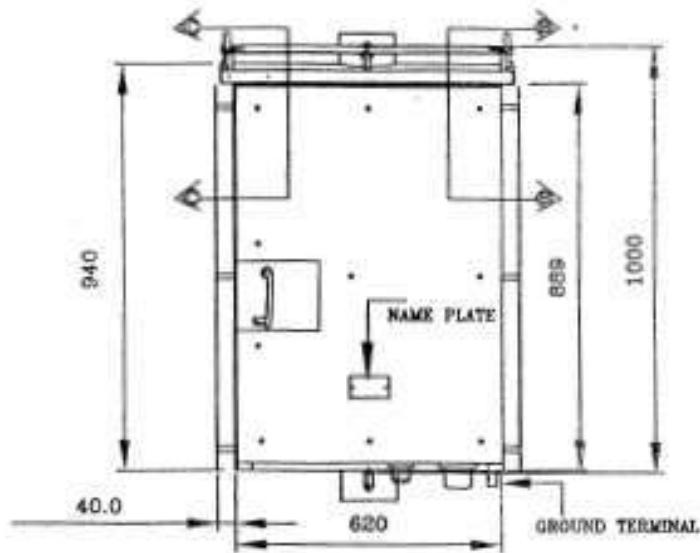


Note : All diminsions are in mm.

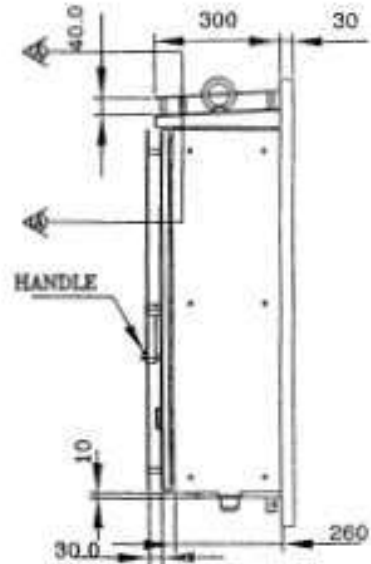
PRELIMINARY



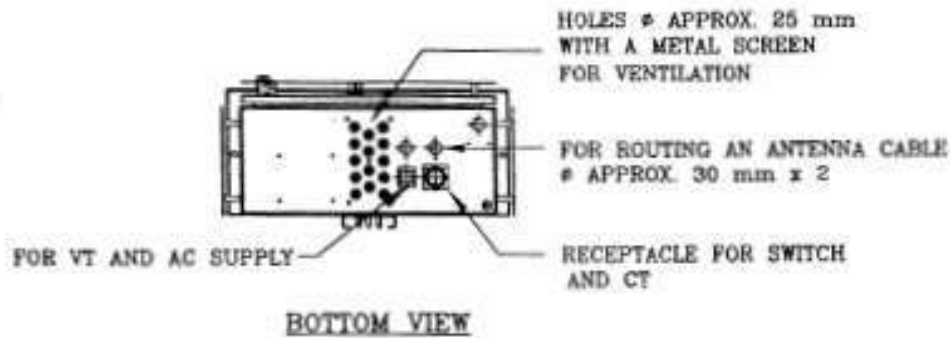
TOP VIEW



FRONT VIEW



SIDE VIEW



BOTTOM VIEW

HOLES  $\phi$  APPROX. 25 mm  
WITH A METAL SCREEN  
FOR VENTILATION

FOR ROUTING AN ANTENNA CABLE  
 $\phi$  APPROX. 30 mm x 2

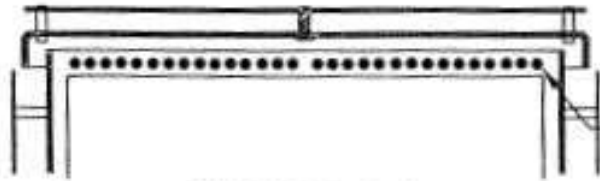
FOR VT AND AC SUPPLY

RECEPTACLE FOR SWITCH  
AND CT

Note : All dimensions are in mm.

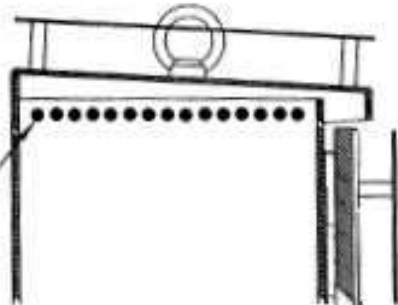
: Dimension in tolerance  $\pm 10\%$

PRELIMINARY



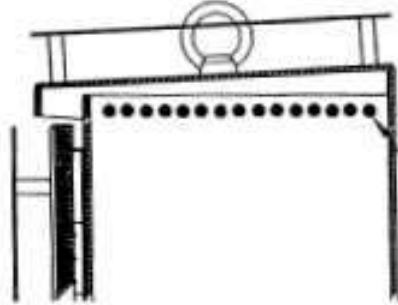
SECTION A-A

HOLES  $\phi$  APPROX. 10 mm  
WITH A METAL SCREEN  
FOR VENTILATION



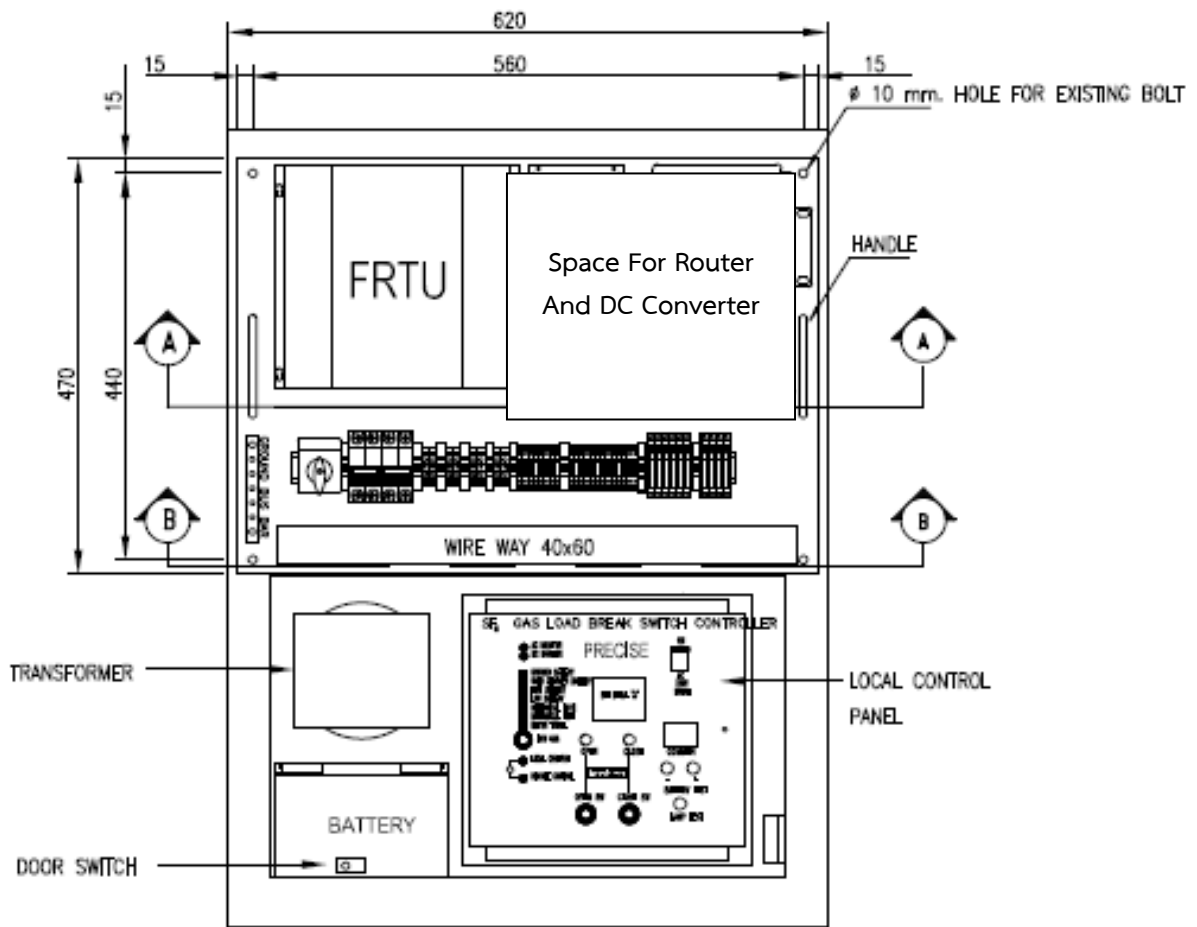
HOLES  $\phi$  APPROX. 10 mm  
WITH A METAL SCREEN  
FOR VENTILATION

SECTION B-B



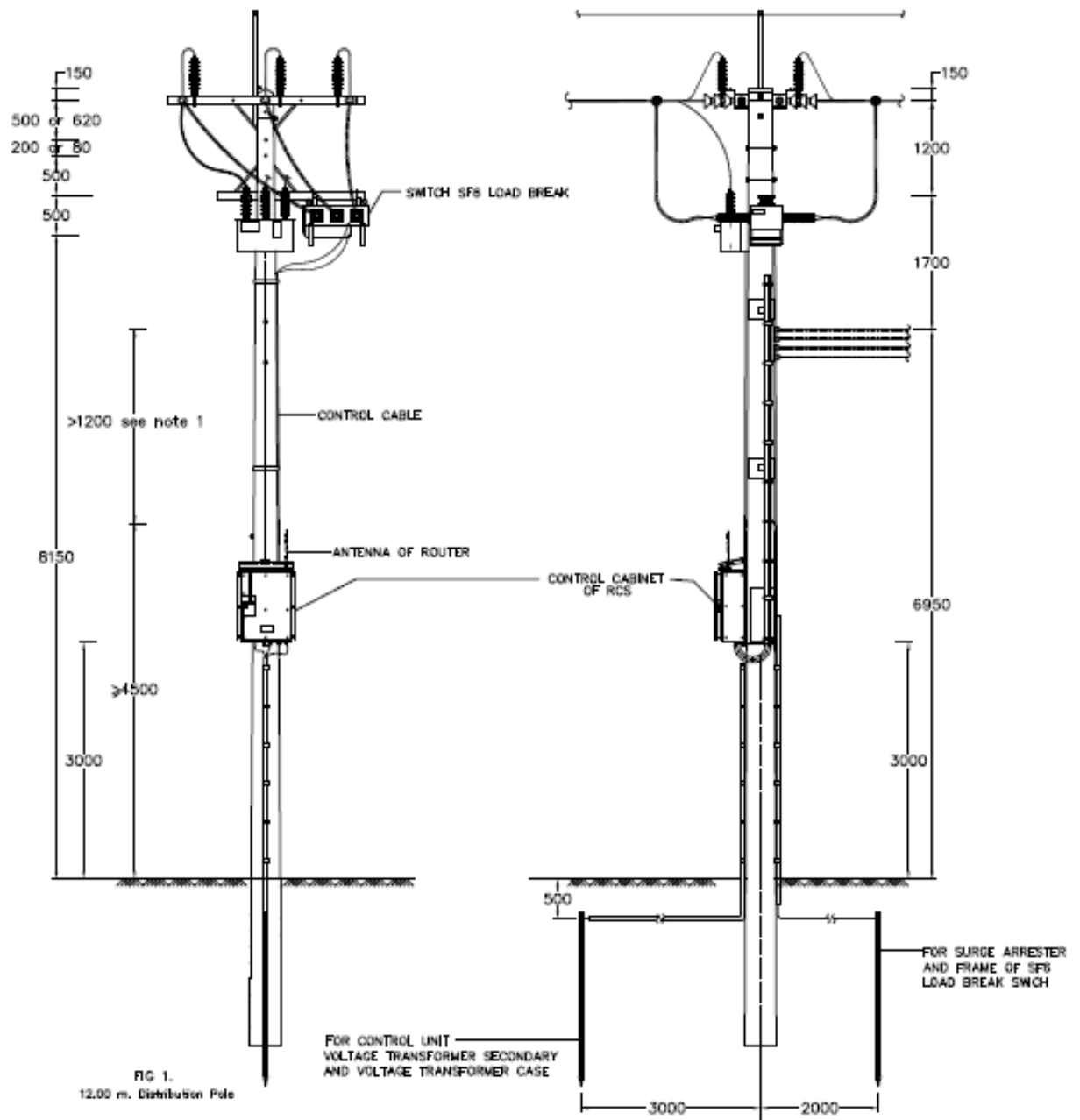
HOLES  $\phi$  APPROX. 10 mm  
WITH A METAL SCREEN  
FOR VENTILATION

SECTION C-C



ตัวอย่าง

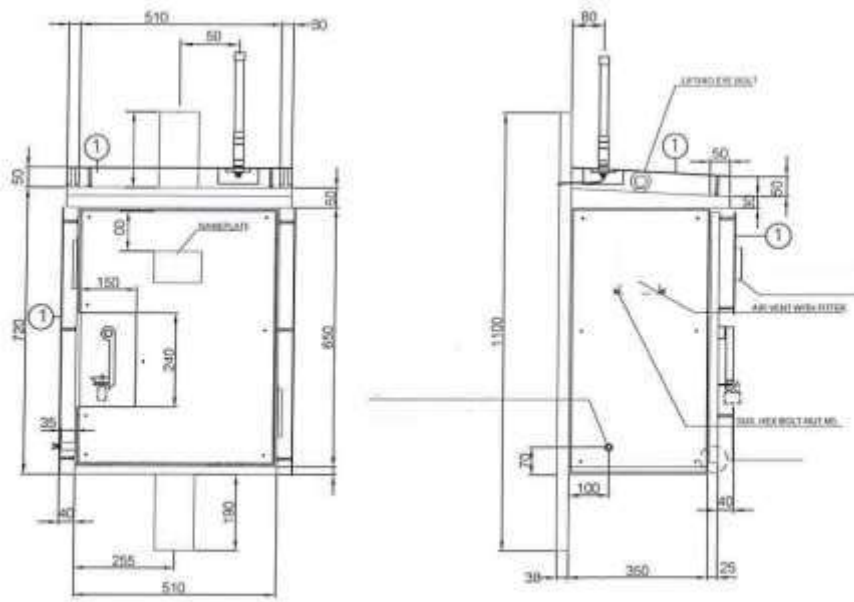
แบบการติดตั้ง FRTU, Cellular Router และ DC to DC Converter พร้อมอุปกรณ์ประกอบ



ตัวอย่าง

แบบการติดตั้ง FRTU, Cellular Router และ DC to DC Converter พร้อมอุปกรณ์ประกอบ





ตัวอย่าง  
 แบบการติดตั้งเสาอากาศของอุปกรณ์ Cellular Router บนหลังคาตู้ควบคุม RCS

# Appendix H:

ASD-002/2560: Protocol Analyzer





การไฟฟ้าส่วนภูมิภาค  
PROVINCIAL ELECTRICITY AUTHORITY

## PROVINCIAL ELECTRICITY AUTHORITY

### AUTOMATION SYSTEM DIVISION

Specification No.: ASD-002/2560: PROTOCOL ANALYZER

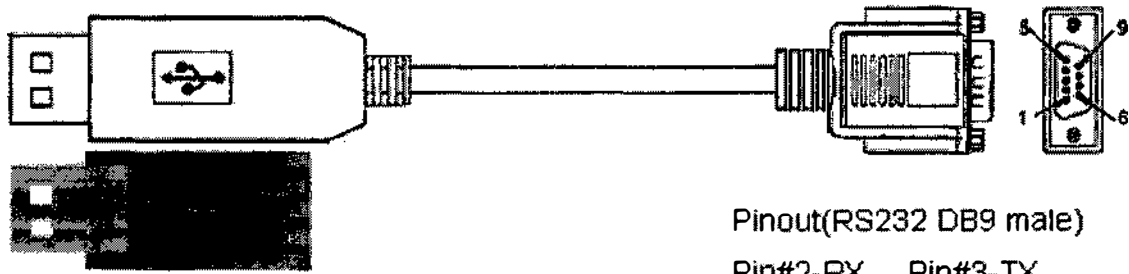
Page 1 of 7

Item	PEA Material No.	Quantity	Description
1.	-	set(s)	<p><b>1 unit.</b> Portable computer system, for single-phase 220 VAC 50Hz power supply and battery-operated, with:</p> <p><b>CPU</b> : Intel Core i7 (2.50 GHz) , or better</p> <p><b>Memory (Installed)</b> : 4 GB DDR3L, or better e</p> <p><b>Hard disk</b> : 256 GB SSD, or better</p> <p><b>Disk drive</b> : External DVD+/-RW Drive</p> <p><b>Battery</b> : Lithium Ion three(3) Cell, or more</p> <p><b>Monitor</b> : 14-inch, or more</p> <p><b>Port/Interface</b> : 1. Built-in 10/100/1000 Mbps Ethernet LAN 2. USB 2.0, or better, at least two (2) ports 3. Two(2) Serial ports (DB9), or USB to RS-232 DB9 Adapter two(2) sets (Appendix I)</p> <p><b>Operating System(OS)</b> : Microsoft Windows 7 (64 Bit), or better</p> <p><b>Mouse</b> : Microsoft Mouse(USB Mouse)</p>

			<p><b>Complete with :</b></p> <ol style="list-style-type: none"><li>1) Batteries of two (2) sets, (one(1) set as spare)</li><li>2) ASE2000 with ASE License (No Expire) and Hard-Lock, Support Protocol DNP3.0, DNP3.0 Over IP, Modbus, IEC 60870-5-101, IEC 60870-5-103, IEC 60870-5-104 and Spa Bus</li><li>3) Interconnecting cable between the FRTU and Computer system for Communication, consist of :<ol style="list-style-type: none"><li>3.1 Cable for Master Simulator one(1) set (Appendix II)</li><li>3.2 Cable for Hyper Terminal one(1) set (Appendix III)</li><li>3.3 Cable for RTU Simulator one(1) set (Appendix IV)</li><li>3.4 Cable for Line Monitor one(1) set (Appendix V)</li></ol></li><li>4) Transportation/storage case(s), for contain portable computer system, accessories and interconnecting cables.</li><li>5) Instruction manual</li><li>6) Other according to manufacturer's design, which shall be clearly described</li></ol>
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**Appendix I**

**USB to RS-232 DB9 Adapter**



Pinout(RS232 DB9 male)

Pin#2-RX Pin#3-TX

Pin#5-GND Pin#7-RTS

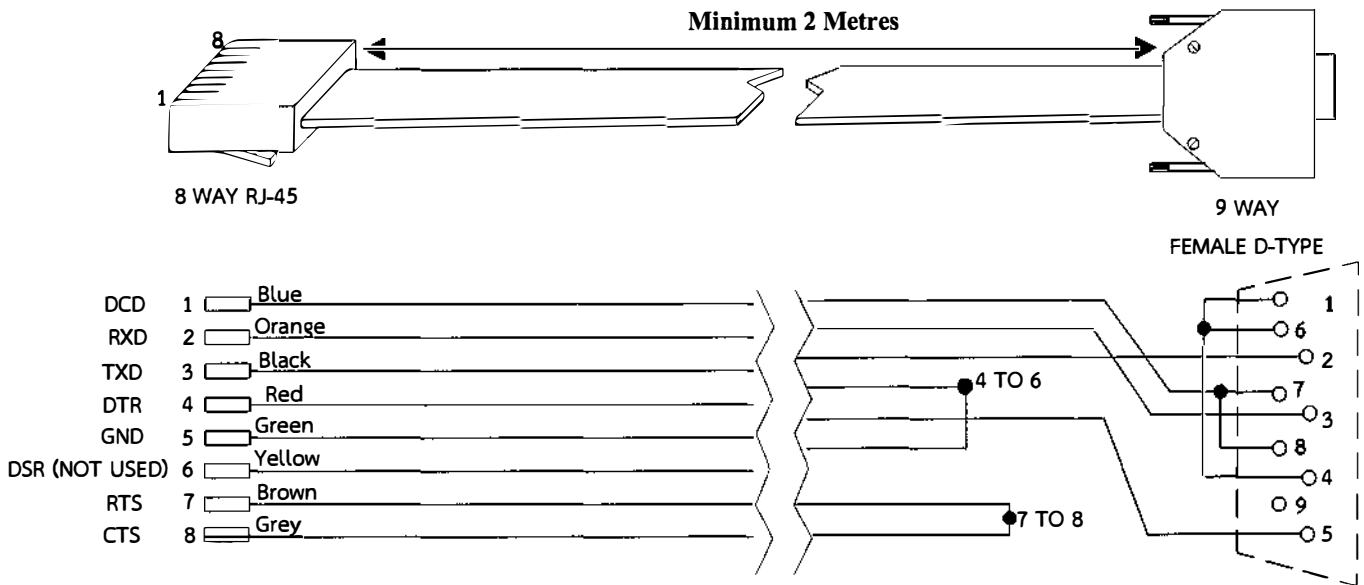
Pin#8-CTS

**Example of Cable for USB to RS-232 DB9 Adapter**



**Appendix II**

**Cable for Master Simulator**

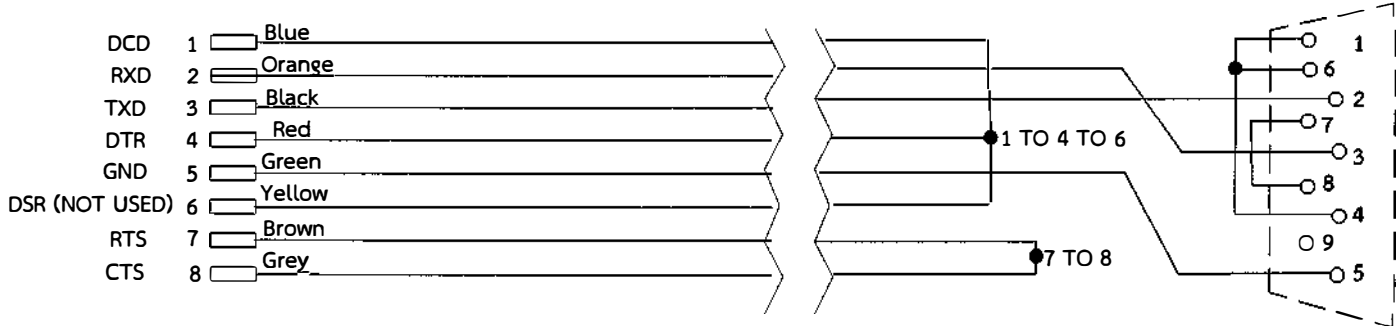
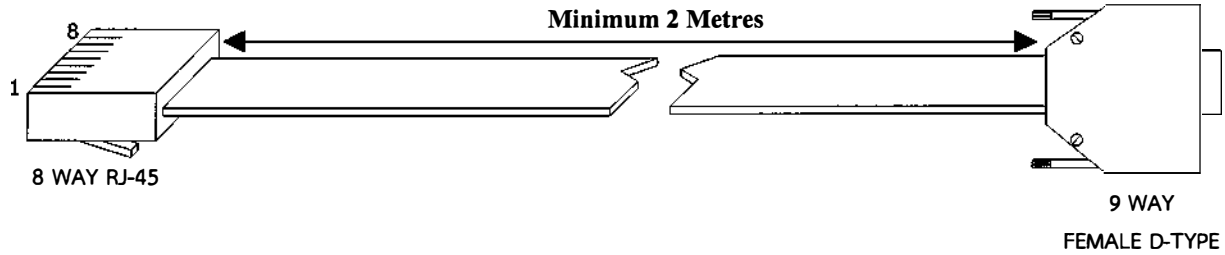


**Example of Cable for Master Simulator (Console Cable)**



**Appendix III**

**Cable for Hyper Terminal**



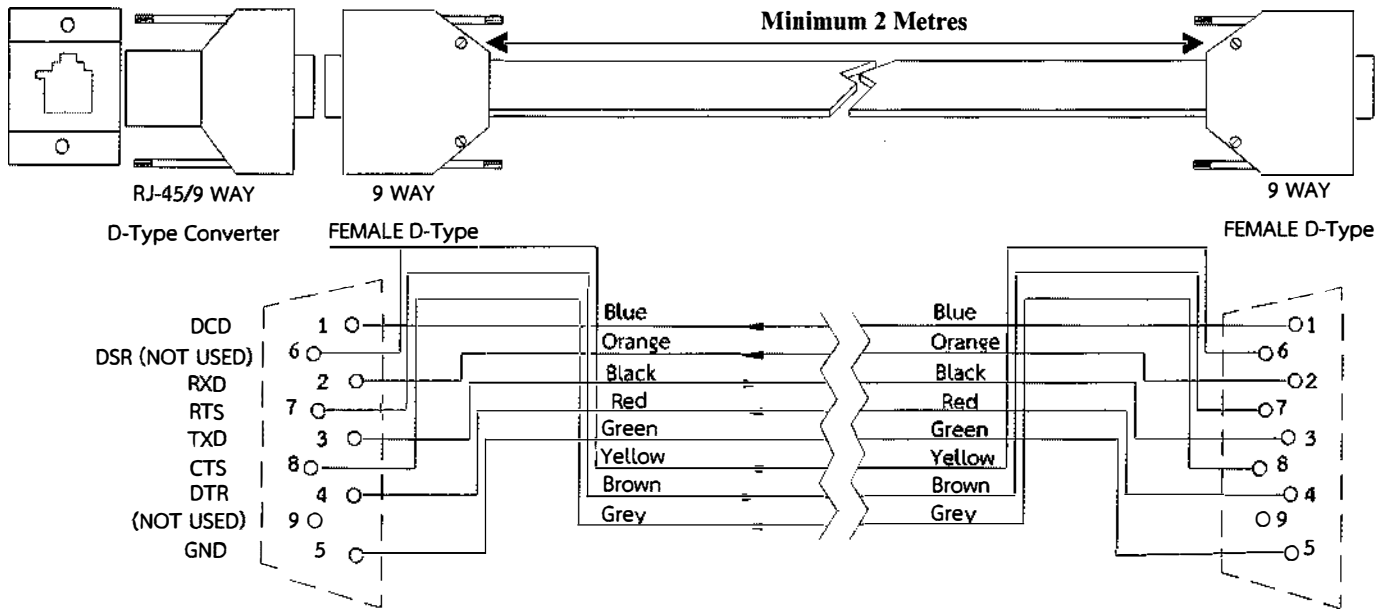
**Example of Cable for Hyper Terminal (Console Cable)**



**Appendix IV**

Bid No. 66IACEB190

**Cable for RTU Simulator**



**Example of Cable for RTU Simulator**



RJ-45/9 WAY To D-Type Converter



9 WAY FEMALE D-Type to 9 WAY FEMALE D-Type



**Appendix V**

Bid No. 66IACEB190

**Cable for Line Monitor**

