Book 4
Technical Specification and Requirements of Communication System

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1. Introduction

This Technical Specification presentsthe communication system in the bidding document of Microgrid Development Project at Mae Sariang District, Mae Hongson. The communication system provides communication links between MGC, DERs and SWs within the scope of MGDP, and backup SCADA control. This document specifies the necessary details of communication requirements to ensure the interoperability of all devices whilst allowing flexibility of implementations.

Scope

This Technical Specifications define the requirements for communication links between MGC, DERs and SWs within the scope of MGDP. The document defines the following aspects

- Functionalities and interface requirements between devices.
- Physical media of the communication links
- Redundant communication links within the microgrid optical fiber network
- Functionalities and interfaces with PEA backbone network

2. Principal Requirement

2.1 Overview of the communication system

Communication system consists of 3 sections as shown in Fig. 1. Note that this figure is used for classification purpose, the actual implementation may be different from this figure. The contractor shall provide fully working communication system to carry all microgrid functions in all sections.

2.1.1 Communication with the authority's backbone network. This section allows communication between MGC and ADDC North 1's SCADA network via gateway equipment to the backbone network.

2.1.2 Communication with CSCS, Battery and Diesel Generators. This section allows communication between MGC to CSCS, Battery and Diesel Generators via an Ethernet Switch. The links shall be optical fiber which support the required lengths (Appendix B).

2.1.3 Communication in Power distribution system within Microgrid. This section allows communication between MGC and all 13 SWswithin the microgrid. The communication system consists of two Ethernet root switches and other switches in ring topology. Due to geographic locations and the number of total switch, the contractor should implement two rings.

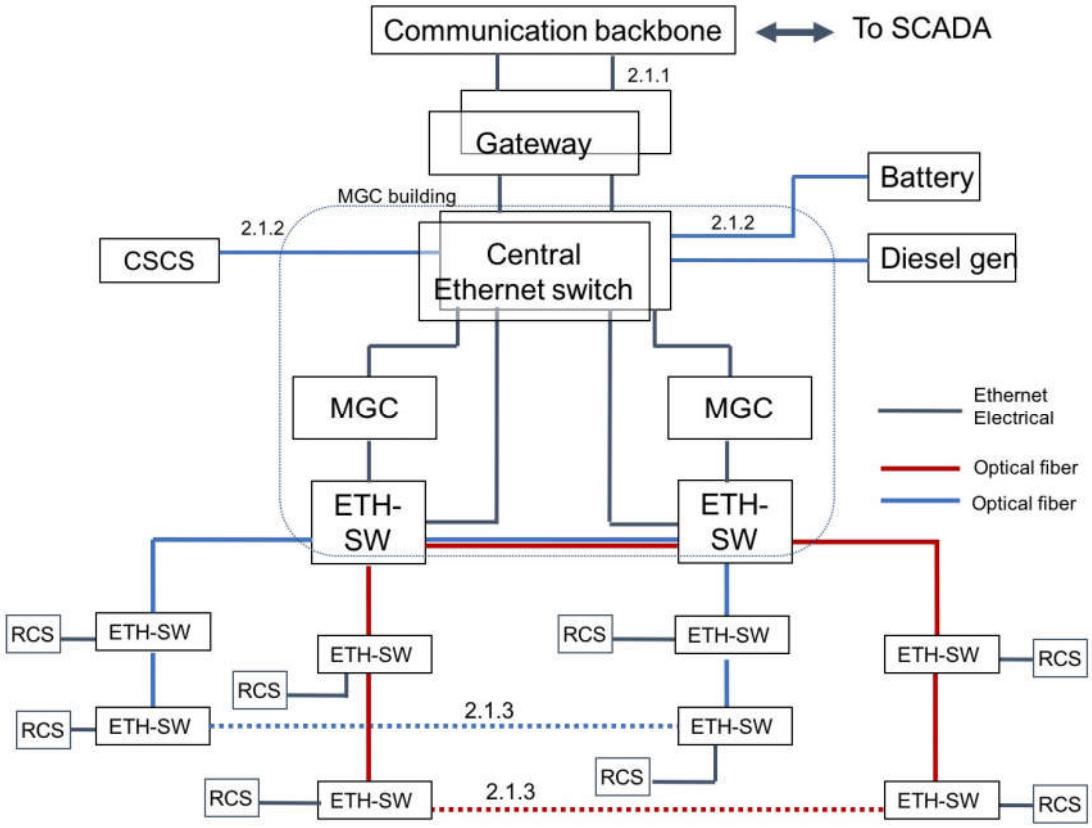

Fig. 1 Basic concept of Microgrid communication (May not be actual implementation)

2.2 Necessary hardware requirements

2.2.1 Communication with the authority's backbone network

Between the MGC via the gateway and PEA backbone network, two physical links shall be installed from the gateway to different SDH routers, located at different sites.

If links from Gateway to communication backbone equipment are only indoor, the links may be electrical cables, otherwise optical fiber links shall be used which support full-duplex over single mode fiber or better. In the case of optical fiber links additional equipment must be provided by the contractor to enable seamless connection to the backbone routers, such as electrical-optical media converters. Spare communication ports must be available and installed at both ends of each link in case of malfunction.

2.2.2 Communication with CSCS, Battery and Diesel Generator

Physical optical fiber links shall be installed from Ethernet switch to the communication interface of MSR substation control system, battery control unit and diesel generator control unit. If necessary, media converter will be required at both ends. The communication link shall support the lengths specified in Appendix B and the optical cable to be installed shall be either single-mode or multi-mode. Two sets of physical duplex links shall be available, one link to be in operation and one link to be spare.

2.2.3 Communication in Power distribution system within Microgrid

All 13SWs shall be connected to the MGC via 13 industrial Ethernet switches and two root Ethernet switches each connected to each MGC. Ethernet switches as shown in Fig. 2, shall be ring connected. Geographic locations of the switches are shown in Fig. 3. Ethernet switches are connected to one another by optical fiber using duplex connector via SFP pluggable modules (with specification in Appendix C). Thus the field industrial Ethernet switches ETH-SW1 to ETH-SW13 each contain 3 optical ports as minimum (2 for two-direction of the ring and 1 spare). Wavelength in use shall be in 1550 nm window. Note that the Ethernet switches are physically located at the same site as SW, where they can share the same cabinet; and each SW is connected to one of electrical Ethernet ports of each Ethernet switch. The distances between each adjacent pair of Ethernet Switches are summarized in Appendix B.

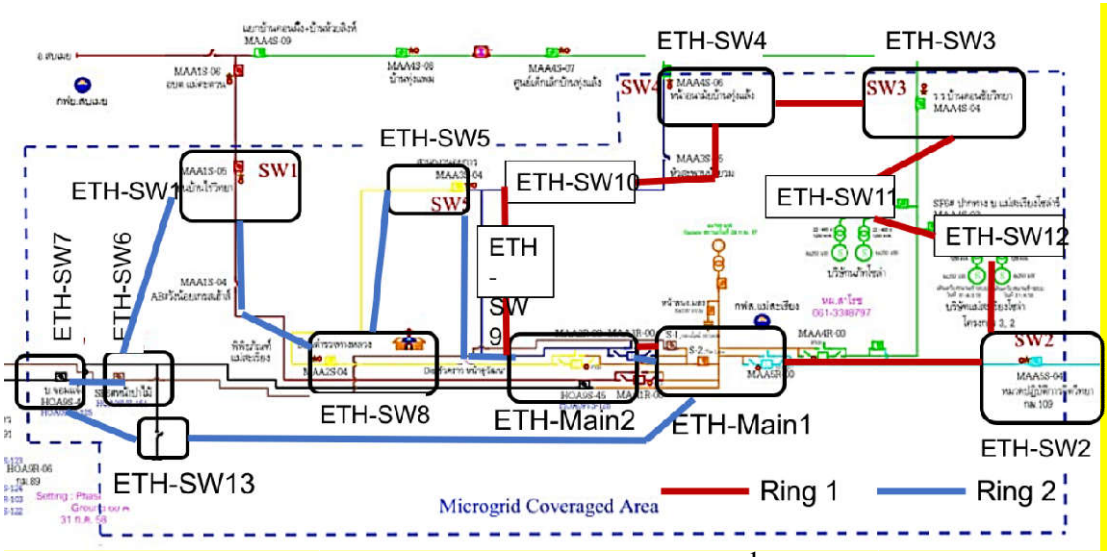

Fig. 2Network topology diagram[1]

2.2.3.1 Ethernet switch location and topology

It is required that each Ethernet switch has two physical connection paths in ring topology. The contractor shall design the topology such that the optical fiber length between two adjacent Ethernet switches is below 10 km that satisfies the service level agreement. If necessary, two physical rings should be considered to limit the ring dimension, as shown in Fig. 2.

[1] Abbreviation note: Eth-SWX refers to Ethernet switch corresponding to feeder switch no. X
- Main suffix refers to root Ethernet switch located at MGC building

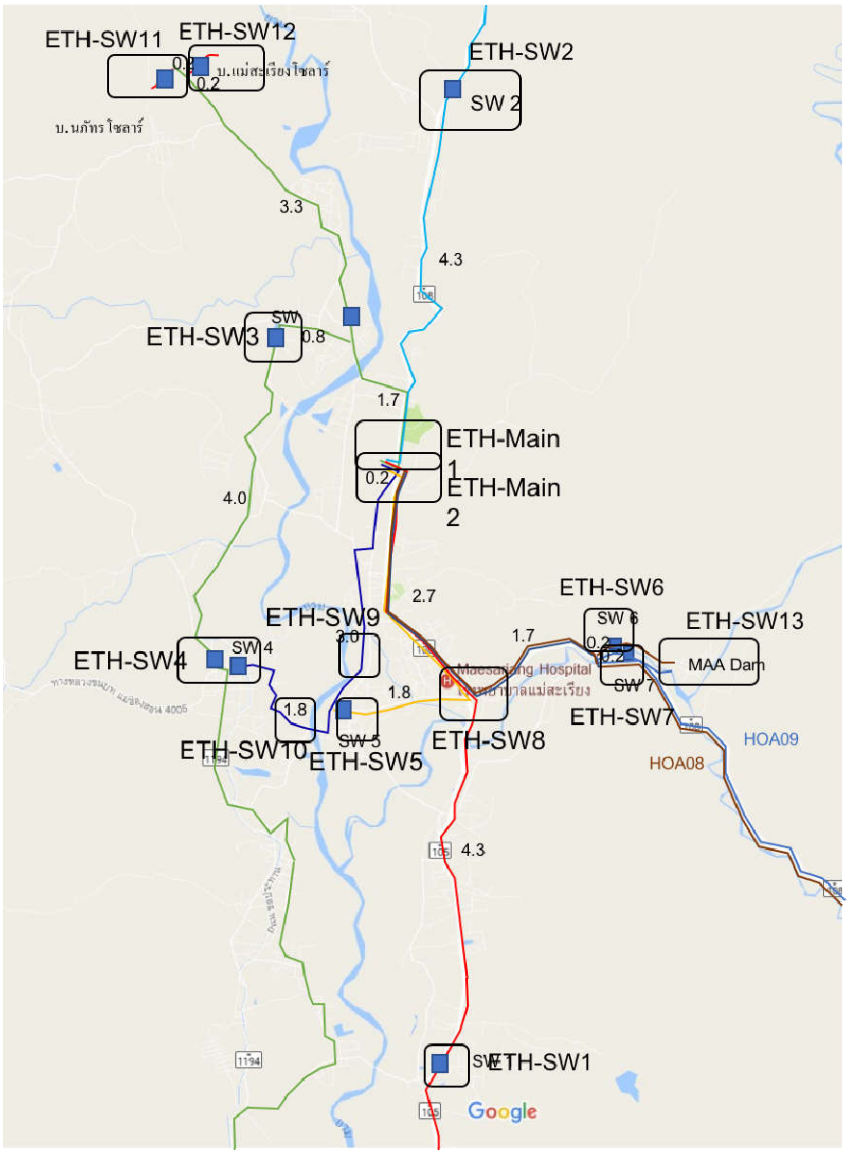

Fig. 3 Diagram of Ethernet Switches locationswith distances in km

2.2.3.2 Optical Fiber Installation

Optical cables shall be installed along the PEA distribution power lines. Optical cables shall be single mode and follow specifications in Appendix A. The number of usable cores shall be 24 cores. Where necessary, attenuation should be inserted in if any fiber section is too short in order that the received optical power is within range.

In actual installation, it may be necessary that a ring topology is formed by loop-back along the same route, the loop-back fiber may use a fiber core in a different tube within the same cable.

Fiber cable installation, where applicable, shall adhere to the requirements with the authority's approved specification numbers in Appendix A, such specifications are obtainable from the authority's database.

2.2.3.3 Ethernet switches

Ethernet switches are substation hard end grade and have either layer 3 or layer 2 routing capability. The **Central Ethernet Switch**, as shown in Fig.1, is specifically required to have at least **layer 3 routing** capability while **other Ethernet switches** may operate in **layer 2 as minimum**. Ethernet switch specifications are given in Appendix C. They can be classified in 2 types, indoor and outdoor Ethernet switches.

Indoor switches are 3 Ethernet switches located in the building as shown in Fig. 1, their mounting type is rackmount. The number and type of communication ports shall equal to the required connections in contractor's designed network, plus at least additional 100% of total use ports to be used as spare ports. Spare ports for Electrical and optical interfaces are counted separately. The Central Ethernet Switch that is next to the gateway shall contain redundancy in active-standby mode.

Outdoor or offsite switches are 13 Ethernet switches in the field. They may have DIN rail mounting which can be installed in the same cabinet as each SW. The number and type of communication ports shall equal to the required connections in contractor's designed network, plus at least additional 50% of total use ports to be used as spare ports. Spare ports for Electrical and optical interfaces are counted separately.

3. Functional requirements and communication use cases

3.1 Communication with PEA backbone network

The system shall provide seamless communication integration with PEA existing backbone communication and future backbone networks. The communication protocol used in this section of communication system is DNP3.0 over IP.

3.2 Communication with CSCS

3.2.1 Normal operation

Gateway bypasses command data from SCADA network to CSCS which uses DNP3.0 over IP protocol. CSCS returns data to SCADA network via Gateway also using DNP3.0 over IP. The Gateway stores events in the buffer. The gateway responds to MGC commands and send the stored data to MGC, all using IEC61850 protocol, the buffer is then cleared. Protocol conversion is performed by the gateway.

3.2.2 Backbone communication failure

Gateway should periodically check the link to ADDC N1, once timeout occurs, the gateway should instead convert commands from MGC in IEC61850 format to DNP3.0

over IP and route to CSCS. The event data from CSCS are once again stored in the buffer. If the gateway re-establishes connection with ADDC N1, the operation should revert to case 3.2.1.

3.2.3 Both MGC failure

Gateway continues to operate as in case 3.2.1, but the events are stacked up at the gateway.

3.3 Communication in Power distribution system within Microgrid including Battery and Diesel Generator

3.3.1 Normal operation

MGC and SWs, Battery and Diesel Generator communication uses IEC61850 protocol. Ethernet switches are using spanning tree / rapid spanning tree protocol and ring protocol so that alternative route to SW can be restored within acceptable time as approved by the authority. Alternative route should be found within the fiber network as the priority. If a fiber connection to any SWs is not reachable in typical route, MGC shall be able to connect to the affected RTU via the other route.

Gateway checks for at least one active MGC and obtain SW data, the data are stored in gateway's buffer. ADDC N1 should access SW data from the buffer.

3.3.2 Backbone communication failure

MGC and Gateway work as in 3.3.1 case, but SWs data are not accessed by ADDC N1.

3.3.3 Both MGC failure

If gateway cannot establish connection to either MGC, the status shall be sent to ADDC N1. ADDC N1 then takes control of the SW by DNP3.0 over IP protocol and the gateway convert the protocol to IEC61850 and relay commands to SWs. Once gateway can establish connection to MGC after periodic attempts, normal operation resumes.

4. Electrical power supplies to the communication equipment

Communication equipment at the microgrid controller building shall be able to use the AC electricity through uninterruptible power supply (UPS) and shall have necessary AC-to-DC converter supply module with redundancy. (See Book9)

Communication equipment in outdoor cabinets and at remote sites shall be able to use the power supplied to the SW equipment and shall have necessary backup.

All electrical supplies shall have surge protection. Communication racks and cabinets shall have appropriate grounding system.

All required electricity cabling must be provided and installed meeting safety standards and with tidiness.

5. Fiber cabling and other signal cabling

Optical fiber outdoor cables follow all specified items in Appendix A. Cables are laid along the authority's distribution power lines and the installation should adhere to the cable installation manual in Appendix A.10

The contractor provides all necessary cabling, wiring, terminal blocks, connectors, and other hardware that may be necessary to ensure a fully functioning communication system.

Optical cables and signal cables must be installed aesthetically and following industrial safety standards.

6. Service Level Agreement

6.1 Continuation guarantee

In the case that a communication port malfunctions, the fiber or communication media should be able to be swapped to a spare port without restarting. Transceiver, transmitter, receiver modules shall be hot-pluggable for replacing purpose. The fiber breakage and re-splicing do not interrupt the unaffected communication links and nodes.

6.2 Network availability guarantee

The contractor shall guarantee the availability of network service at least 99.9% up time.

In the case of topology change such as a single fiber section breakage, the network shall be restored with convergence time according to the spanning tree protocol standard IEEE802.1D-2004 or faster.

In the case of double section breakage, the physical link and network availability shall be restored within 24 hours.

6.3 Network performance guarantee

The average monthly network latency shall be in the order of 40ms or lower. If the latency is found to be greater than specified, the contractor shall find the cause and rectify the problem within 24 hours after being notified of the problem.

The performance parameters of the Ethernet ring network including frame delay, frame jitter and frame loss shall be according to latest IEEE802.1q standard as minimum. In addition, the parameters shall satisfy the requirement of microgrid operation.

6.4 Order of transmission of data packets

All links in the communication system shall have standard implementation to ensure that all received data packets at any communication device are interpreted in chronological order as the transmitted data. Consequently, it is necessary that when several commands are issued to a device, the device must respond to the commands in order that they were issued.

7. Gateway

The gateway is the equipment that enables communication between microgrid and the authority's backbone network. The equipment has protocol conversion capability and security functions including secure communication and firewall. The specification of the gateway is given in Appendix D. Support protocols shall includeIEC61850, and DNP3.0 over IP as minimum with other protocols to support the operation of microgrid under all use cases. There shall be redundant links to both backbone network and MGC (via Ethernet Switch) as in Fig. 1.

The gateway contains buffer which store at least 512 events or more. The storage shall be flash memory and the buffer is first in first out. The gateway should have redundancy, where two units are deployed in active-standby mode.

8. Deliverables

The following documentation shall be provided by the contractor for the whole communication system.

1) List of deliverables

2) Configuration diagrams

3) Site installation drawings and procedures

4) Instruction manuals

8.1 List of Deliverables

The list of deliverables shall itemize each hardware and software component. The hardware list shall include associated hardware accessories such as cables and connectors. It shall also include equipment configuration information of sufficient detail that the Authority can procure an identical equipment item from the manufacturer. As a minimum, the document shall include the equipment name, product name, product model, and serial number (or other ID in case some of the equipment does not have a serial number).

The software list shall include the name of the software item and its supplier along with the software version number. For each software item, it shall also identify the distribution media and whether or not a software license is required. The Contractor shall provide all such software licenses including a description of any significant restrictions that apply.

8.2 Configuration Diagrams

The configuration diagrams shall depict, in detail, the specific equipment comprising each communication sections and the logical and physical interconnection of this equipment operating as an integrated system. The configuration diagrams shall also show how the Contractor-supplied communications equipment interconnects with the equipment supplied by others. This includes, for example, the field device interfaces and the terminal equipment of the Authority's backbone communications system and specific standard compliances.

8.3 Site Installation Drawings and Procedures

Microgrid communication system as well as individual communication component drawings shall be provided. These drawings, including the required as-built drawings, shall show all major components of the system along with individual equipment details and shall include all necessary materials and installation data. As a minimum, the Contractor shall provide:

1) Configuration/assembly drawings for each device showing the placement of all subassemblies.
2) Drawings of the materials for each type of equipment, identifying all subassemblies and components used to assemble the equipment.
3) Equipment internal wiring and/or cabling drawings.
4) Equipment external connection drawings. These drawings shall include the communication ports as used to interconnect the Contractor-provided equipment such as to the backbone network and to Mae Sariang substation.

8.4 Instruction Manuals

Instruction manuals shall include all information and instructions needed by Authority technicians to maintain the equipment and to troubleshoot and repair the equipment to the level of replacing printed circuit boards and other easily replaceable modules and assemblies.

Appendix A

Optical Fiber Specification and installation requirements

Optical fiber specifications shall be referred to the authority's approved specifications according to the given codes. The contractor has the responsibility to ensure the conformance.

A.1 Figure 8 Optical Cable specification

The specification for 24 core optical cable of Figure 8 type shall follow PEA specification.

: CDD-OFC-FIG8-G652D

A.2 Optical Fiber Cable (Fig-8) Aluminum Clamp

The aluminium clamp for Figure 8 cable shall follow PEA specification

: DAS-FAC-001

A.3 Optical Fiber Cable Dome closure

The requirement of outdoor fiber cable splice closure shall follow PEA specification

: CDD-OFC-ACC-DC01

A.4 Optical Fiber Cable (Fig-8) Preform

Preform for fiber optic line construction shall follow PEA specification

: CDD-OFC-ACC-FIG8-PF01

A.5 Optical Fiber Cable Machine Bolts

Bolts and nuts for fiber cable installation shall follow PEA specification

: CDD-OFC-ACC-MB01

A.6 Straight Thimble Eye Bolts and Nuts

Straight thimble eye bolts and nuts for fiber optic line installation shall follow PEA specifications

: CDD-OFC-ACC-TB01

: CDD-OFC-ACC-TN01

A.7 Cross armin fiber pole installation

Steel cross arm type-c for use to support optical cable installation on poles shall follow PEA specification

: CDD-OFC-ACC-CA01

A.8 Hook bolt

The steel hook used with the suspension clamp in optical fiber installation shall follow PEA specification

: CDD-OFC-ACC-HB01

A.9 Figure 8 Cable J-clamp

The requirement of clamps for the suspension of Fig-8 type cable shall follow PEA Specification

: CDD-OFC-ACC-JC01

A.10 Optical Fiber Cable Installation Standards Figure -8

The installation of Fig-8 type optical fiber cable should abide the standards as specified by PEA in the installation manual number

: CDD-MAN-FIG8-003

Appendix B

Distances of optical fiber

B.1 Distances of optical fiber installation between each switch location in kilometers.

Ring 1		
From	**To**	**Distance (km)**
Eth-Main 1	ETH-SW2	4.5
Eth-SW2	Eth-SW12	9.5
Eth-SW12	Eth-SW11	0.4
Eth-SW11	ETH-SW3	4.3
Eth-SW3	ETH-SW4	4
ETH-SW4	ETH-SW10	1.8
Eth-SW10	ETH-SW9	1
ETH-SW9	ETH-Main2	2
Eth-Main 2	Eth-Main 1	0.1

Ring 2		
From	**To**	**Distance (km)**
Eth-Main 1	Eth-SW13	5.5
ETH-SW13	Eth-SW7	0.9
ETH-SW7	ETH-SW6	0.5
ETH-SW6	ETH-SW1	6.2
ETH-SW1	ETH-SW8	4.3
ETH-SW8	ETH-SW5	1.8
ETH-SW5	ETH-Main2	5
Eth-Main 2	ETH-main 1	0.1

B.2 Distances of links from gateway Ethernet switch to CSCS, Battery and Diesel Generator

From	To	Distance (km)
Gateway Ethernet SW	CSCS	1
Gateway Ethernet SW	Battery	0.5
Gateway Ethernet SW	Diesel Generator	1

Appendix C

Indoor / Outdoor Ethernet Switch Specifications

Minimum requirements for indoor and outdoor Ethernet switch are given in this appendix.

C.1 General features

- Gigabit Ethernet Switch Layer 2or Layer 3 (for some switches specified in the main text) switching functionality, IEEE802.3 compliant
- IEEE 1558v2 (PTP) Precision Time Protocol for time synchronization of networks
- VLAN capability with Q-in-Q tagging
- DHCP Option 82 for IP address assignment
- SNMP protocols for device management and monitoring
- IGMP snooping and GMRP for filtering multicast traffic
- IEEE 802.1Q VLAN and GVRP protocol
- Redundant ring protocol
- Spanning tree protocol RSTP/STP, and MSTP QoS (IEEE 802.1p/1Q and TOS/DiffServ)or better
- Port Trunking for optimum bandwidth utilization
- TACACS+, SNMPv3, IEEE 802.1X, HTTPS, and SSH
- SNMPv1/v2c/v3 for different levels of network management
- Bandwidth management prevents unpredictable network status
- Lock port function for blocking unauthorized access based on MAC address
- Port mirroring for online debugging
- LED status & error indicators

C.2 Optical Interface

- Pluggable SFP Transceiver
- Fiber type: Single mode fiber
- Wavelength: 1550 nm
- Connector: LC duplex
- Flow control: Pause frames (IEEE802.3x), configurable
- Data rate: Gigabit Ethernet (1000 Mbit/s) 1488.000 packets per second

The number of optical ports shall include operating ports as required in the designed system and at least one spare port per Ethernet switch. Pluggable transceivers are provided in all ports which support single mode fiber link up to 10 km.

C.3 Electrical Interface

- Fast Ethernet 10/100/1000base TX
- Connector: RJ-45, shielded
- Cable type: Cat 5e, Impedance 100Ω, support length up to 100 m
- Flow control: Pause frames (IEEE802.3x), configurable
- Pinout: Auto MDI/MDI-X, auto polarity
- The number of Electrical Ethernet ports shall include operating ports in the designed system and at least additional equal number of ports as spare. For example, if two devices are connected to two Ethernet ports on the switch, this switch must have at least twoRJ-45 ports where four will be available as spare.
- The electrical ports shall have surge protection which have the following specificationsor better.
- ESD/EMP Protection Absorbing Transient Current with Response to Surge Voltage from 100V/s to 1kV/μs
- DC Spark-Over Voltage 90V @ 100V/s
- Maximum Impulse Spark-over Voltage 700V @ 1kV/μs
- Discharge Current 2kA (Maximum) 100A (Normal)
- Maximum Insulation Resistance 1G ohm @ 50V
- Maximum Capacitance 50 pF

C.4 Switching performance

- Store-and-forward, Full wire-speed, non-blocking on all ports
- Max number of VLANs: 256
- VLAN ID Range: VID 1 to 4094
- IGMP Groups: 4096
- MAC Table Size: 16K
- Packet Buffer Size: 12 Mbit
- DRAM Size: 128 MB
- Flash Size: 16 MB
- Jumbo Frame Size: 9.6 KB

Additional requirements for Layer 3 Ethernet switch as specified in the main text.

Layer 3 Switching: Static routing, RIP V1/V2, OSPF, DVMRP, PIM-DM
Layer 3 Switching Redundancy: VRRP

C.5 Mounting type

Outdoor Ethernet switch: Offsite Ethernet switches mounting type is DIN Rail.
Indoor Ethernet switch: Mounting type for Ethernet switches in MGC Building is rack mount under 2U size.

C.6 Operating condition

Temperature: -10°C to 60°C or better (Indoor Ethernet switch)

-10°C to 70°C or better (Outdoor Ethernet switch)

Humidity: 5-90% non condensing

C.7 Management

Web based HTTP, Telnet, SNMP

C.8 Standard Compliance

- IEEE 802.3 for 10BaseT
- IEEE 802.3u for 100BaseT(X) and 100BaseFX
- IEEE 802.3ab for 1000BaseT(X)
- IEEE 802.3z for 1000BaseSX/LX/LHX/ZX
- IEEE 802.3x for Flow Control
- IEEE 802.1D-2004 for Spanning Tree Protocol
- IEEE 802.1w for Rapid Spanning Tree Protocol
- IEEE 802.1s for Multiple Spanning Tree Protocol
- IEEE 802.1Q for VLAN Tagging
- IEEE 802.1p for Class of Service
- IEEE 802.1X for Authentication

C.9 Certification

- Safety: UL 60950-1, EN 60950-1
- EMC: EN 55032/24
- EMI: CISPR 32, FCC Part 15B Class A
- EMS:
- IEC 61000-4-2 ESD: Contact: 4 kV; Air: 8 kV
- IEC 61000-4-3 RS: 80 MHz to 1 GHz: 10 V/m
- IEC 61000-4-4 EFT: Power: 2 kV; Signal: 1 kV
- IEC 61000-4-5 Surge: Power: 2 kV; Signal: 1 kV
- IEC 61000-4-6 CS: Signal: 10 V
- IEC 61000-4-8
- Rail Traffic: EN 50121-4
- Shock: IEC 60068-2-27
- Freefall: IEC 60068-2-32
- Vibration: IEC 60068-2-6

Appendix D

Gateway specification

D.1 General specification

Network protocol: TCP/IP, UDP/IP, SMTP, POP, HTTP, FTP, SNMP, ICMP,DHCP, BOOTP, DNS, ARP, PPPoE
Security: NERC/CIP compliant, SSL, SSHv2
Features: -Multi master/SCADA communication capability
- protocol conversion capability–IEC61850, DNP3.0
- Automatic startup and initialization following power Restoration
- Time synchronization using IEC60870/DNP3/SNTP/NTP/IEEE1588
- Management using SNMP/Webserver

D.2 Communication Interface

Ethernet port (copper)	10/100/1000 BaseTX
Ethernet Optical port (SFP)	Gigabit Ethernet
RS232 Serial ports (DB9)	9-pin, DTE, 16550-compatible

Redundancy:
All port types must have required number and redundancy according to the required specifications of the communication system in this book.

D.3 Controller protocol

Master/Client Protocol	DNP3.0 Serial and TCP, IEC 60870-5, IEC61850
Slave/Server Protocol	DNP3.0 Serial and TCP, IEC 60870-5, IEC61850
Number of supported connections upstream	As required
Number of supported connections downstream	As required

D.4 Mounting
Rack mounting under 3U

D.5 Power supply

Primary supply	100–240 V, 50/60 Hz
Hot-plug, redundant supply	100–240 V, 50/60 Hz

D.7 Buffer storage
Flash storage for minimum of 512 events

D.8 Redundancy
Dual unit (Active-standby) with automatic swapping between two modules.