SECTION – 2.17

FIBER OPTIC TERMINAL EQUIPMENT (FOTE)

1.0.0 INTRODUCTION

The intent of this specification is to define the functional, design, supply, installation, testing, commissioning, and documentation requirements for the Fiber Optic Telecommunication System to be implemented at the 132/11 kV Substation at the Project Location (GIPCL end).

This section outlines the Fiber Optic Communication network configuration and specifies the technical characteristics of the communication system to be provided under this Project. The scope of this section includes, but is not limited to, the following subsystems:

- Fiber Optic Transmission System (FOTS)
- Termination Equipment Subsystems
- Network Management System (NMS)
- Main Distribution Frame (MDF), Digital Distribution Frame (DDF), and associated cabling

The requirements specified herein apply to the overall network configuration and the Network Management System (NMS) intended for monitoring, supervision, and control of the communication network. For the purpose of this specification, the terms Telecommunication Management Network (TMN) and Network Management System (NMS) are used interchangeably.

Under this Project, the Fiber Optic Terminal Equipment (FOTE), SDH equipment, and all associated telecommunications hardware shall be supplied, installed, tested, and commissioned at the Project Substation end (GIPCL end).

The corresponding remote-end FOTE installed at the GETCO Substation is existing, operational, and is excluded from the scope of supply under this Contract. However, the Contractor shall be fully responsible for interfacing with the existing GETCO equipment, including configuration, coordination, and execution of end-to-end testing up to SLDC to ensure seamless communication performance.

Considering the limited quantity (1 Number), the need for standardization across GETCO's installations, existing availability of spares, ease of operation and maintenance, and proven compatibility with existing systems, as well as established approvals from competent statutory authorities, the specified make and model are mandatory requirements.

Accordingly, the Bidder shall supply GE T&D (India) Limited, eDXC (STM-4) & Amplifier and DIP with required modules, accessories and communication interfaces. However, power supply and interrogation voltage shall be as GIPCL substation requirement.

However, for general technical requirements, the Bidder shall comply in all respects with the specifications outlined in this section

It shall be Bidder's sole responsibility to visit the GETCO Substation, collect all necessary technical and interface details, and incorporate the same into the design, engineering, and supply of the proposed system. The Bidder shall be entirely responsible for achieving proper integration, interoperability, and reliable operation between the GIPCL and GETCO ends.
The Bidder's scope shall include the supply, installation, testing, and commissioning of all necessary hardware for transmission line differential protection for Line-3 and Line-4 at the GETCO end. This shall include required modules within the FOTE panel (as applicable), integration at the GETCO end, and all associated accessories, interfacing components, and wiring necessary for the proper functioning of the protection scheme.

The make, model, and technical specifications of the existing FOTE shall take precedence over this specification. This detailed specification shall be applicable only as a secondary reference, subject to compliance with the existing FOTE configuration and requirements.

2.0.0 GENERAL REQUIREMENT

This specification describes the functional requirements, major technical parameters for SDH equipment, Termination equipment system and other items to be provided for to establish connectivity between project Substation (GIPCL end) and the existing GETCO Substation telecom network. The fiber optic network shall be based on the lowest bit rate of the Synchronous Digital Hierarchy (SDH) i.e. STM-1 (155Mbps) and must be supporting STM4, STM-16, and capable of upgrading to STM-64. All SDH equipment proposed for supply under this contract shall be of proven design, type-tested, and shall have been in successful field operation for at least three (3) years. The bidder shall offer the type of tested equipment as per relevant standards and shall submit the earlier carried out type test reports.

The security related requirements of the equipment shall be as per DoT (Department of Telecommunication) guidelines and all similar security requirements as amended by DoT on time-to-time basis shall be followed/complied by the vendor at no additional cost to Employer till the implementation of the project.

The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security /threat check any time during the supplies of equipment.

The supplier shall ensure that the supplied equipment have been tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. The certification shall be got done from authorized and certified agency/lab in India or Abroad.

In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the supplier as per guidelines of DoT and any other Government department.

3.0.0 CODES AND STANDARDS

The Equipment shall comply with the latest ITU-T, IEEE, IEC recommendations for the synchronous hierarchies. The equipment shall be CPRI / ERDA / KEEMA type tested. In particular the mentioned recommendations shall be covered:

Applicable Standards and References

Sl. No.	Standard / Regulation	Title / Description
1.	IEC 61000-6-2 (1999-01)	Electromagnetic Compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
2.	IEC 61000-6-5 (2001-07)	Electromagnetic Compatibility (EMC) – Part 6-5: Generic standards – Immunity for power station and substation environments (Tests 1.2, 1.3, 2.3, 2.5)

3.	IEEE C37.1 (1994)	Definition, specification and analysis of systems used for supervisory control, data acquisition and automatic control – Section 6.6 EMI & EMC
4.	IEEE C37.90.2 (1995)	Withstand capability of relay systems to radiated electromagnetic interference from transceiverss
5.	IEEE C37.94	IEEE standard for Nx 64 kbit/s optical fiber interfaces between line differential relay and multiplexer equipment
6.	EN 55022	Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement
7.	ITU-T G.664	Optical safety procedures and requirements for optical transport systems
8.	ITU-T G.702	Digital transmission systems – General aspects – Terminal equipment – Digital hierarchy bit rates
9.	ITU-T G.703	Digital transmission systems – Terminal equipment – Physical/electrical characteristics of hierarchical digital interfaces
10.	ITU-T G.704	Digital transmission systems – Terminal equipment – Synchronous frame structures at 1544, 2048, 6312, 8448 & 44736 kbit/s
11.	ITU-T G.706	Frame alignment and CRC procedures related to G.704 frame structures
12.	ITU-T G.707	Network node interface for the synchronous digital hierarchy (SDH)
13.	ITU-T G.711	Pulse code modulation (PCM) of voice frequencies
14.	ITU-T G.712	Transmission performance characteristics of PCM channels
15.	ITU-T G.732	Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s
16.	ITU-T G.735	Characteristics of primary multiplex equipment operating at 2048 kbit/s with 384 kbit/s / 64 kbit/s access
17.	ITU-T G.736	Characteristics of synchronous digital multiplex equipment operating at 2048 kbit/s
18.	ITU-T G.737	Characteristics of external access equipment at 2048 kbit/s with 384 kbit/s / 64 kbit/s access
19.	ITU-T G.783	Characteristics of SDH equipment functional blocks
20.	ITU-T G.785	Characteristics of a flexible multiplexer in an SDH environment
21.	ITU-T G.803	Architecture of transport networks based on the SDH
22.	ITU-T G.805	Generic functional architecture of transport networks
23.	ITU-T G.813	Timing characteristics of SDH equipment slave clocks (SEC)
24.	ITU-T G.823	Control of jitter and wander in digital networks based on the 2048 kbit/s hierarchy

25.	ITU-T G.825	Control of jitter and wander in digital networks based on SDH
26.	ITU-T G.826	Error performance parameters and objectives for international constant bit rate digital paths
27.	ITU-T G.841	Types and characteristics of SDH network protection architectures
28.	ITU-T G.957	Optical interfaces for SDH equipment and systems
29.	ITU-T G.958	Digital line systems based on SDH for optical fiber cables
30.	ITU-T G.991.2	Single-pair high-speed digital subscriber line (SHDSL) transceivers
31.	ITU-T G.7041	Generic Framing Procedure (GFP)
32.	ITU-T G.7042	Link Capacity Adjustment Scheme (LCAS) for virtually concatenated signals
33.	ITU-T G.8032 / Y.1344	Ethernet ring protection switching
34.	ITU-T G.8113.2 (11/2012)	Operations, administration and maintenance mechanisms for MPLS-TP networks
35.	ITU-T G.8261	Timing and synchronization aspects in packet networks
36.	ITU-T K.20	Resistibility of telecom equipment in telecom centers to overvoltage and overcurrent
37.	ITU-T K.21	Resistibility of telecom equipment in customer premises to overvoltage and overcurrent
38.	ITU-T K.45	Resistibility of telecom equipment in access and trunk networks to overvoltage and overcurrent
39.	ITU-T M.2101.1	Performance limits for bringing into service and maintenance of international SDH paths
40.	ITU-T Q.552	Transmission characteristics at 2-wire analogue interfaces of digital exchanges
41.	ITU-T Q.553	Transmission characteristics at 4-wire analogue interfaces of digital exchanges
42.	ITU-T T.50	International Reference Alphabet (IRA) – 7-bit coded character set
43.	IEEE 802.1D	Media Access Control (MAC) bridges
44.	IEEE 802.1Q	Virtual bridged local area networks (VLAN)
45.	IEEE 802.1p	Traffic class expediting and dynamic multicast filtering
46.	IEEE 802.1t	MAC bridges – Amendment 1

47.	IEEE 802.1w	MAC bridges – Rapid reconfiguration
48.	IEEE 802.3	CSMA/CD access method and physical layer specifications
49.	IEEE 802.3z	Gigabit Ethernet
50.	IEEE 1588-2008 (v2)	Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
51.	IEEE 1613	Environmental and testing requirements for communication networking devices in power substations
52.	CEA Regulations	Technical standards for communication systems in power system operations (27 Feb 2020) and Cyber Security Guidelines (7 July 2021)

4.0.0 SCOPE OF WORK

The contractor shall be responsible for complete design supply, installation, testing, commissioning, and documentation requirements of the fiber optic telecommunication system for the 132kV Substation at the Project Location (GIPCL end).

4.1.0 All interface data and communication cables are covered under scope of this specification.

4.2.0 The OPGW already installed on the 132 kV multi-circuit transmission line shall be utilized, and adequate spare optical fibers are available. The existing OPGW shall not be in the scope of the Bidder.

However, the scope of the Bidder shall include approach optical fiber cable from the existing OPGW Joint Box / Splice Box located in the nearby Station–1 switchyard (common compound wall between Station–1 and Station–2) up to the required location in Station–2.

The Bidder's scope shall also include, but not be limited to, the following:

- Termination of optical fibers at both ends
- Supply and installation of FODP (Fiber Optic Distribution Panel) as required
- Supply, installation, testing, and commissioning of equipment cubicles and enclosures
- All associated connectors, pigtails, and patch cords
- Interconnecting optical fiber cables between equipment and panels
- Required power supplies for communication equipment
- All necessary accessories, mounting hardware, and installation materials

The Bidder shall ensure complete installation, integration, testing, and commissioning of the optical communication system in all respects.

4.3.0 The digital fiber optic communication backbone shall be based on the SDH technology and network architecture. The proposed FOTE system shall be capable of supporting both SDH & Teleprotection (Distance & Differential Protection) interfaces required for the project.

4.4.0 The FOTE system shall be designed for digital transmission using single mode optical fiber and shall conform to ITU-Y recommendations G.703, G.704, G.707, G.783 and G.957.

4.5.0 The multiplexing structure of the proposed FOTE system shall allow existing PDH signals to be carried over the synchronous network and shall permit the extraction of individual circuits from high-capacity systems without having to demultiplex the whole system.

4.6.0 The proposed fiber optic communication network consists of shall support the voice, Teleprotection (both distance protection commands operation & line differential protection) & data communication requirements of RTUs and the EMS system. The communication system shall provide data & voice connectivity of RTUs with SLDC/ RLDC. The RTUs shall communicate using IEC 870-5-101 or IEC 870-5-104 Protocol. The proposed communication system shall also support Ethernet interface for RTUs over TCP/IP protocol and serial interface.

4.7.0 The fiber optic network shall be based on the lowest bit rate of the Synchronous Digital Hierarchy (SDH) i.e. STM-16 or, better, by optical (Laser) SFP. The Contractor shall propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement.

4.8.0 FOTE software License shall be perpetual and FOTE software shall be loaded in Laptop provided by GIPCL. GIPCL Laptop will have one ethernet port, any additional Converter, special cables, hardware and software required for programming, configuration, fault diagnostic etc. Supply of Laptop shall be in scope of bidder. Bidder shall demonstrate programming, configuration etc. from GIPCL Laptop by connecting it to FOTE panel.

4.9.0 Bidder shall give training to GIPCL engineer for Programing, configuring, fault diagnostic etc. of FOTE system.

5.0.0 Craft Terminal

Each equipment on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

a. Change the configuration of the station & the connected NEs.
b. Perform tests
c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices.

6.0.0 Hardware Requirements

6.1.0 Craft Terminal

The craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, HP, IBM, Compaq make shall be supplied.

The Craft Terminal shall be a professional-grade laptop kit featuring a minimum configuration of a 13th or 14th Generation Intel Core i5 processor (Base 2.5 GHz or higher), 16 GB of DDR5 RAM, and a high-performance dual-storage system comprising a 256 GB PCIe NVMe Solid State Drive (SSD) for the operating system and an upgraded 1 TB Hard Disk Drive (HDD) for data storage. The terminal shall include integrated Intel Iris Xe or Intel Arc Graphics with at least 4 GB of shared video memory and a 15.6" Full HD (1920 x 1080) Anti-Glare IPS display. Connectivity shall include integrated Wi-Fi 6E/Bluetooth 5.4, multiple USB 3.2 and Thunderbolt 4 ports to support legacy hardware via provided industrial-grade USB-to-Serial (RS-232) and USB-to-Parallel adapters, alongside DVD+/-RW drive and an internal/external USB 56K Data/Fax modem. The complete kit shall include a dedicated ergonomic optical mouse along with external mouse pad, keyboard, high-speed AC power adapter/charger, and a heavy-duty padded laptop carrying bag. The system must be powered by a high-capacity lithium-ion

battery providing a minimum of 4-6 hours and a maximum of up to 11 hours of operation, and shall come pre-installed with the latest Windows OS, Microsoft Office, and premium Antivirus software.

7.0.0 GENERAL REQUIREMENTS

7.1.0 The digital multiplex equipment shall be designed to operate in 132kV networks and suitable for installations in pooling substations with harsh environment (as per project site condition) and high electromagnetic interference. It shall be highly reliable and provide secure communications for real-time signals such as Voice over Internet Protocol (VoIP), Video Conferencing, Metering, Distance and Differential Teleprotection. The multiplex equipment shall offer the possibility for fan less operation in order to ensure maintenance free operation and comply with the environmental conditions in substation environment. Accordingly, it shall comply with substation relevant standards such as IEEE 1613, IEC61850-3.

7.2.0 The offered Hybrid FOTE equipment shall comply simultaneous functionality of SDH and MPLS-TP with the latest ITU-T and IETF recommendations, ETSI and IEEE standards and be able to communicate over be interconnected with legacy multiplexer. On PACKET TRANSPORT LEVEL interfaces for optical MPLS-TP based transmission up to 10Gbit/s shall be available. Enhanced traffic engineering using MPLS-TP technology as per relevant IETF standards shall be supported by providing VPWS, VPLS and Tree services using the MPLS-TP infrastructure. The Hybrid FOTE shall support SDH and MPLS-TP functionality with same 19" rack equipment.

7.3.0 The wide band network shall be designed in a manner to ensure absolute channel delay less than 25 milliseconds and channel delays that are asymmetrically less than 0.1 milliseconds required for protection applications.

7.4.0 New node when added to the existing network, the terminal equipment shall be compatible to the existing one and shall be possible to integrate with existing respective network management system either at State level or at Central level for complete monitoring, reconfiguration and control.

7.5.0 The terminal equipment shall be designed with the required numbers of directions considering route redundancy and future expansion.

7.6.0 FOTE system shall have required VOIP telephone on both end or as per SLDC/GETCO/STU requirement shall be included in the scope of supply.

7.7.0 On SDH/TDM Transport Level interfaces for optical transmission on STM-16 (2.5Gbit/s) shall be available. Additionally, 2Mbit/s DSL interfaces shall be available for connection to copper cables. For connection to higher order transport equipment also N x 2Mbit/s (E1) and STM-1/16 electrical interfaces shall be available.

7.8.0 MPLS-TP and SDH simultaneous functionality shall be natively integrated with legacy application (true hybrid functionality).

7.9.0 Static configuration of bidirectional and co-routed communication channels shall be supported using the NMS. Dynamic routing shall be prohibited for all critical data channels. End to end channel supervision should be supported. The equipment shall be software controlled, of modular design and all modules shall form an integrated part of a 19" shelf.

7.10.0 The bidder must be original Equipment manufacturer of proposed FOTE SDH & MPLS-TP, Teleprotection interface/Coupler for Distance, Differential IEEE C37.94 and IEC 61850 goose based teleprotection solution for desired inter-tripping application.

7.11.0 The platform shall have means to cross-connect, drop and insert individual channels (64kbit/s time slots), 2Mbit/s framed (G.704) and unframed (G.703) signals. It shall also support termination and cross connection of VC-12 and VC-4. Equipment protection and various protection schemes shall be supported.

7.12.0 Teleprotection and telecommunication requirements an integrated Teleprotection interface (distance, differential & IEC 61850 GOOSE based protection) shall be offered / supported with SDH and MPLS-TP functionality. For external Teleprotection equipment is only accepted in stations, wherein existing equipment has to be integrated for extending the teleprotection application. External Teleprotection equipment must be offered with Ethernet interface for communication on MPLS-TP and E1 2 Mbps for SDH functionality and it should also comply requirement of Teleprotection as per IEC 60834-1. i.e. security, dependability.

7.13.0 The proposed 19" rack Hybrid FOTE equipment should have minimum 18 slots for application cards. Each network element shall be manageable locally as well as from an operation center.

With Hybrid FOTE equipment with SDH and MPLS-TP functionality / Future upgradability for direct connection to following user signals shall be available on hot pluggable plug-in modules for the equipment:

- Ethernet interface module with 10/100/1000BaseT, electrical, RJ-45 or SFP based or integral part of Control System or TDM interface.
- Ethernet Interface 100BaseFX and 1000BaseLX/SX, optical, SFP based
- Support of L2 switching functions
- Support of L3 routing functions
- Support of Power over Ethernet
- Ethernet interface supporting Ethernet over SDH (EoSDH, GFP ITU-T G.7041 and LCAS ITU-T G.G.7042 functions)
- Alarm collection interface
- Distance Teleprotection integrated interface module with 4 tripping signals common for both SDH and MPLS-TP functionality as per IEC 60834-1
- Differential Teleprotection integrated Optical interface module for up to 4 protection relays common for both SDH and MPLS-TP functionality compliant to IEEE C37.94
- IEC 61850 GOOSE based protection interface
- Binary signal (status and control) interface
- 2 Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704
- Circuit emulation function for E1, serial and telephony interfaces
- n x 2 Mbit/s electrical SHDSL ports for TDM services supporting copper pair bonding

7.14.0 On TRANSPORT LEVEL the equipment shall support / future upgradable to the following connection ports:

- Up to 8 x STM-16 SDH optical ports

- Up to 16 x STM-4 SDH optical ports
- Up to 8 x STM-1 SDH optical / electrical ports
- Up to 8 x MPLS-TP capable transport ports
- Up to 8 x 10 Gbit/s Ethernet (MPLS-TP) ports
- N x 2 Mbit/s electrical E1 ports
- N x 2 Mbit/s SHDSL ports
- Up to 200 x electrical/ optical 1 Gbit/s Ethernet ports

7.15.0 All optical MPLS-TP, SDH and Ethernet ports shall support SFP or SFP + modules (small-factor pluggable unit) for short, medium, long and extra-long optical communication. ALS (Automatic Laser Shutdown) shall be fully supported.

7.16.0 The bidder must supply the FOTE from the Original Equipment Manufacturer (who has service centre in INDIA) of proposed FOTE MPLS-TP, Teleprotection interface/Coupler for Distance, Differential and IEC 61850 goose based teleprotection solution desired for intertripping application. The OEM shall have necessary valid evidence such as Certificate of Registration, ISO, License, previous supply / delivery references in State Power Utilities/ IPPs/ CPPs /PGCIL substations, performance certificate etc.

7.17.0 **Equipment Life Span:** All equipment supplied under this specification shall have a minimum expected life of ten (10) years from the date of operational acceptance by GIPCL. FOTE and it cards, accessories shall be selected that no items shall be in end-of-life cycle/phase-out product. O.E.M shall provide certificate/letter for support of spares and services for 10 years from the date of operational acceptance by GIPCL.

7.18.0 The FOTE shall support minimum functionality, namely: -

- high speed bundled n x E1 support including ethernet, gigabit ethernet (GbE);
- high speed E1 channel support.
- 64 kilobits per second (kbps) and n x 64 kilobits per second (kbps) data and Protection channel support.
- low speed (300 -1200 bits per second) data channel support.
- voice (2 wires, 4 wires) channel support.
- data transport supporting network management channels; and
- Institute of Electrical and Electronics Engineers (IEEE)-C37.94 interface card for teleprotection of lines.
- The relevant standards and code of practice as specified in the Bureau of Indian Standards (BIS), the International Telecommunications Union Telecommunication (ITU-T) and the IEC shall be followed.

8.0.0 Multiservice Platform Requirements

8.1.0 General Requirements

The equipment shall be capable of operating as a Label Edge Router (LER) and Label Switch Router (LSR) in MPLS-TP networks. It shall support packet switched point-to-point, point-to-multipoint and multipoint-to-multipoint topologies. The proposed FOTE equipment shall as well support hybrid operation where MPLS-TP and SDH is operational at the same time.

Ethernet over SDH as well as circuit emulation functionality shall be provided to link the TDM with the PSN domain. In SDH networks the equipment shall operate as a terminal, as an add-drop multiplexer and in transit mode as a regenerator/repeater. First order (2 Mbps), low order (VC-12) and high order (VC-4) multiplexing shall be integrated. Conference for voice channels and point-multipoint functions for data signals shall be supported. The equipment shall be of modular design.

8.2.0 Packet Switched Capacity

The design of the backplane shall provide wire-speed 10 Gigabit Ethernet (GbE) connectivity between the different slots and the central (redundant) Ethernet switching matrix slots. Between uplink slot positions a backplane capacity of n x 10 GbE shall be available ($n \geq 2$). For future upgrade purposes a 10 GbE backplane connection from the central Ethernet switching matrix to x different slots shall be available ($x \geq 6$). The central switching matrix shall at least support 62 Gbit/s in full duplex wire-speed switching capacity in a lower scale version and at least 146 Gbit/s in a higher scale version. IPv4 routing shall be as an option with a capacity of at least 10 Gbit/s wired speed routing. The combination of MPLS-TP and integrated IP routing interface card shall allow to offer L3 VPN services with fast L2.5 based transport functionality and IP routing at defined locations. This also supports VPWS (Point to Point) & VPLS (Point to Multipoint) services, to send the Ethernet traffic over MPLS-TP Link.

8.3.0 Circuit Switched Capacity

The cross-connection functions shall be implemented in such a way that no single point of failure exists. Each SDH interface card shall offer a high-order SDH cross-connect capacity of up to VC-4 and VC-12 in the same SDH interface card with a capacity of up to VC-12.

VC-4 & VC-12 SDH cross connect capacity shall be upgradable by adding additional SDH interface units.

8.4.0 Redundancy Capabilities

The equipment shall provide enhanced redundancy features in order to ensure highest availability of the communication network. The following redundancy schemes shall be supported:

- Redundant or distributed cross connect
- Redundant power feeding
- Redundant CPU functionality
- HW redundancy of SDH aggregate interfaces
- HW redundancy of 1 Gbit/s and 10 Gbit/s MPLS-TP aggregate interfaces
- HW redundancy of voice and data conferencing
- HW redundancy of central Ethernet switching matrix
- HW redundancy of routing function
- Enhanced TDM traffic protection schemes
- SNCP/ MSP/ VCAT/ LCAS over redundant TDM aggregate modules
- Enhanced PSN traffic protection schemes
    - 1:1 LSP protection switching
    - Hitless redundancy for protection data channels using MPLS-TP

- xSTP and ERPS loop prevention
- VRRP for routing function

8.5.0 Traffic Protection Scheme

A. 1:1 Path protection

1:1 protection of MPLS LSPs shall be supported. Switching from main to backup path shall be automatic, bidirectional and symmetrical. Configuration options shall exist for reversible or non-reversible operation.

B. 1+1 Path Protection

The equipment shall provide means to protect 64kbit/s channels. The protection shall be end to end from one interface (telephone, data, protection signaling) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm. The switching shall be done within the multiplexer without using the Network Management System.

SNCP protection on VC-12 and VC-4 level shall be supported. Switching from main to backup path shall be automatically. Configuration options shall exist for reversible or non-reversible switching. Switchover time shall be less than 50 ms.

For utility critical applications symmetrical switching of TX and RX on VC-12 and 64Kbps level shall be supported.

C. 1+1 Selection Protection

The equipment shall provide means to protect SDH STM-n sections (MSP). It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed. MSP shall be configurable as intra- and inter-card feature to provide aggregate interface as well as module protection. The switching shall be done within the multiplexer without using the Network Management System.

D. Hitless protection for teleprotection data channels

Critical teleprotection data shall not use any LSP 1:1 protection but rather be implemented using a hitless redundancy scheme where critical teleprotection data is duplicated at the teleprotection interface card itself and transmitted via two diverse non-redundant Label Switch Path.

8.6.0 Teleprotection

The offered Hybrid FOTE (SDH and MPLS-TP) equipment shall support integrated teleprotection coupler by adding necessary hardware in the same equipment. The communication system has to ensure simple, reliable and secure operation. The module shall support the following features related to the protection commands.

- Security and Dependability according to IEC 60834-1 shall be fulfilled
- Accept protection command signals in the range of 40VDC to 250VDC

- All inputs and outputs shall be isolated and with EMC immunity for harsh environment (see also table of compliance, emission and immunity)
- Transmit up to 4 protection commands bi-directionally

It shall also be able to drop and insert commands, transfer commands as a transit station and to realize AND- and OR-combinations between commands. The module shall support T-node configurations.

The Integrated teleprotection module shall provide

- An integrated non-volatile event-recorder, which shall be synchronized to either the PTP information available in the MPLS-TP based WAN, to the node local clock or via local connection to the Global Positioning System (GPS) using the IRIG-B inputs
- IRIG-B time of day outputs to pass on time of day information to end devices
- Robust and fast transmission of teleprotection commands by means of direct packetization of teleprotection signals in case of MPLS-TP WAN shall be supported.

The teleprotection module shall further support

- 1+1 path protection. Switching shall be done within less than 4 ms (typical value) for TDM line interfaces and hitless for MPLS-TP networks
- Periodical automatically initiated loop-tests
- Delay measurement and supervision of the Teleprotection channel including a warning if a configured threshold is exceeded
- Input de bouncing functionality shall be provided
- Input/ output command prolongation functionality shall be provided
- Command addressing: this function shall be used to prevent tripping if the signal is wrongly routed through the telecommunication network

Under no circumstances the module shall cause false trip-commands in case of power supply failure or when equipment is put into or taken out of service.

Distance and differential protection functions shall also be made available for MPLS-TP/ TDM based transport (networks) complying with the established, standard TDM/PSN performance parameters.

8.7.0 IEC 61850 GOOSE protection interface

Specific integrated interface for IEC 61850 based protection applications shall be available. The same shall be part of the IEC 61850 configuration of the substation and act as a gateway IED subscribing to the relevant messages for line distance protection. At least the following functionality shall be provided:

- 4 x FE/ GbE interfaces (SFP based) for direct connection with the station bus of IEC 61850 substations
- Representation of remote IED for inter substation IEC 61850 GOOSE signal transmission

- Filtering capabilities for GOOSE messages
- Translation capabilities of GOOSE messages to resolve potential addressing/ naming conflicts between substations
- Redbox functionality for connection to PRP redundant station bus (one card/ two card solution)
- L2 firewall for access restriction from the WAN to the substation station bus
- Hitless redundancy for GOOSE protection communication channels
- Guaranteed data integrity thanks to authentication of data streams
- 6 electrical IRIG-B outputs for synchronization of end devices to GPS Grandmaster clock
- Optical IRIG-B output for synchronization of end devices to GPS Grandmaster clock
- SNTP master functionality for providing time of day information to IEDs
- SNTP client functionality for full IEC 61850 compliance
- MMS status reporting to substation automation system for full IEC 61850 compliance
- Enhanced traffic supervision features providing full visibility of the communication channel performance
- Full integration in network management system (such as FOXMAN-UN or, equivalent) and configuration tool (such as FOXCST or, equivalent)
- Providing all optical interconnections from relay to relay through multiplexer without any converter boxes
- Processing time of IEC 61850 GOOSE Gateway shall be less than 200 µs.
- It shall be possible to connect to up to 8 different remote ends with 1 interface card (or 1 PRP redundant interface card couple).

8.8.0 Synchronization

It shall be possible to synchronize the equipment using an external clock source, derived from a network or from an internal oscillator. The synchronization shall be configurable, and it shall be possible to distribute the synchronization to other equipment as well. The system shall have the means of switching to select the synchronization source as well as a means of preventing the system from creating synchronization loops.

The equipment shall support synchronous Ethernet and a synchronization selection process based on ESMC (Ethernet Synchronization Message Channel).

The precision time protocol (PTP) as defined by IEEE/ IEC shall be supported for frequency and time of day synchronization.

For teleprotection event recording it shall be possible to synchronize the event recorder of teleprotection interfaces to a GPS. The GPS time shall be available for the Network Element time as well.

Configuration support for SyncE and PTP synchronization shall be available e.g. by means of wizards or guided configuration.

For TDM synchronization the equipment shall be capable of selecting the source of synchronization by means of SSM (Synchronization Status Messaging) on 2 Mbit/s PDH or SDH port or by means of a priority-based sequence.

8.9.0 Telephony

The equipment shall support interconnection of telephony subscribers as well as digital solutions shall be supported:

- Digital VoIP subscriber and gateway functionality (SIP)
- Power over Ethernet solutions
- Hotline services

8.10.0 Cyber Security

The equipment shall support integration into a cyber-security architecture enabling cyber secure operation of a communication network.

- Authentication, Authorization and Accounting (AAA)
  - Local management port disabling
  - User roles (privilege-levels)
  - Radius based authentication
  - Security relevant local event logging (audit log)
  - Syslog
- Secured management communication
  - SNMPv3
  - IPSec
  - SSH
- Denial of service (DoS) prevention for device functions and user traffic
  - Rate limiters for different traffic types
  - Firewall towards device management
- Traffic authentication and encryption
- Access Control Lists (ACL)

The equipment shall be of robust design and hardening shall be done considering cyber security aspects.

8.11.0 Quality of Service

Hardware support to ensure device internal and user traffic quality of service shall be provided:

- ≥ 8 hardware queues per physical port
- Configurable scheduling profiles
- Priority mapping tables (DSCP, PCP, EXP, PHB, TC)
- Priority configuration for individual protocols (e.g. PSC, MCC, …)
- Port and service-based rate limiting (at least single rate two color markers (SR2CM))
- Configurable storm control for unicast, unknown unicast, multicast and broadcast per port.

9.0.0 Aggregation / Transport Interface Requirement

9.1.0 MPLS-TP Functionality

The following MPLS-TP functionality shall be supported:

- Static configuration of MPLS-TP tunnels via configuration tool or network management system
- Bidirectional MPLS-TP tunnels
- Priority handling using L2 or L3 class of service information
- Mission critical services & guaranteed performance parameters for teleprotection applications.
- Port based MPLS assignment
- VLAN based MPLS assignment
- The following topologies shall be supported
    - Point to point virtual private wire services (VPWS)
    - Tree structures
    - Virtual private LAN structures (VPLS)
    - Hierarchical VPLS structures (H-VPLS)
- End to end Operation Administration and Maintenance (OAM) channel with at least the following functionality
    - Continuity check messages (CCM)
    - Remote defect indication (RDI)
    - Route tracing (LSP ping/ trace route)
- 1:1 traffic protection with < 50 ms switchover time
- Management functionality using dedicated MPLS channel
- Circuit emulation of legacy services via MPLS-TP shall be supported.

9.2.0 SDH functionality

The interface shall be designed for use on single mode fiber (conforming to ITU-T G.652 or G.655). The interface card shall be based on SFP technology and use LC/PC connectors.

The following main functions shall be supported:

- Prepared for STM-1/4/16 SFP's (small-factor pluggable units) for short, medium, long and extra-long optical communications (1310nm, 1550nm or xWDM)
- Prepared for electrical STM-1 (155Mbit/s) SFPs
- Termination of the OS-, RS-, MS- and VC-4 layer

- Extraction and insertion of the SOH communications information
- Through connections of VC-12, VC-3 and VC-4
- Support of MSP (Multiplex Section Protection)
- Support of SNCP (Subnetwork Connection Protection)
- Ethernet over SDH (EoS) functionality based on GFP / VCAT / LCAS
- 1+1 SETS timing protection
- 1+1 hardware protection

The following maintenance functions shall be supported:

- Status indications
- Loops
- Restart after ALS
- Trail Trace Identifier (TTI) monitoring
- SFP inventory and diagnostics

At least the following number of ports shall be available per module. Twice the amount shall be available in hardware redundant configuration.

9.3.0 SHDSL Interface

The 2 Mbit/s SHDSL interface shall provide means to interconnect the multiplexer over one or two pairs of copper wire up to 10 km using G.SHDSL modulations. At least 8 x SHDSL interfaces shall be available on the module. The ports shall be available for the synchronization source selection process. Clock quality level transmission/ reception shall be supported.

9.4.0 Access / user Interface

This Equipment shall be offered with following user application interfaces:

- Voice over IP subscriber media gateway
- Party line Telephone System (Engineering Order Wire)
- Ethernet electrical connection: 10/100/1000BaseT
- Ethernet optical connection: 100Base-FX and 1000Base-LX/-SX/-EX/-ZX
- Circuit Emulation Interface
- Distance Teleprotection integrated interface module with 4 tripping signals common for both SDH and MPLS-TP functionality as per IEC 60834-1
- Differential Teleprotection integrated Optical interface module for up to 4 protection relays common for both SDH and MPLS-TP functionality compliant to IEEE C37.94
- IEC 61850 GOOSE based protection interface

9.5.0 Alarm Interface

The module shall provide means to collect at least 12 external alarms, which shall be displayed on the Network Management System. It shall be used to supervise external equipment by the Network Management System. Minimum of 2 Outputs shall be available.

It shall be possible to label an alarm. The label-text shall be read from the interface module and visible on Network Management System as well as on the local craft terminal.

9.6.0 Optical Teleprotection Interface

This module shall have at least 4 optical ports each of them allowing direct connection to protection relays with interfaces complying with ANSI/IEEE C37.94. Each interface shall support all 12 time slots (64 kbit/s – 768 kbit/s) in accordance with ANSI/IEEE C37.94.

Symmetry as well as jitter and wander values shall be guaranteed in order to meet application requirements regardless of the transport technology (TDM or MPLS-TP). IRIG-B outputs (optical and electrical) shall be available to pass on time of day information to end devices in case WAN supports transmission of accurate Time of Day information.

Redundant communication channels in line with application requirements shall be supported.

9.7.0 Management Interfaces

The equipment shall be equipped with an Ethernet port (henceforth called "local management interface") that allows access only to the local management agent (i.e. to the management agent running on the equipment itself but not to management agents running on remote equipment).

The equipment shall have required interface(s) that allow access to the management agent from a remote site through an IP network (henceforth called "routed management interface(s)").

The equipment shall have VLAN dedicated exclusively to the traffic to/from the management agent (out-of-band management). The VLAN identification must be configurable.

The priority of the traffic flowing through the routed management interfaces shall be configurable (i.e. capability to assign a Class of Service to the management traffic). It shall be possible to enable/disable the local management interface by configuration. It shall be possible to enable/disable the routed management interface(s) by configuration. The IP address of the local management interface shall be configurable. The IP address/addresses of the routed management interface(s) shall be configurable.

The local management interface shall not participate in dynamic routing protocol (i.e. the local interface and its IP address are not propagated outside the local equipment). It shall be possible for a routed management interface to participate in a dynamic routing protocol. The participation shall be configurable.

The equipment shall support the following protocols for the communication between the management agent and the network management system (NMS)/craft terminal (CT):

1. Telnet
2. SSH
3. IPsec (tunnels between the NMS and the equipment management agent)
4. SNMPv3

10.0.0 SYSLOG

The equipment shall support the capability of sending event messages to up to ten different remote syslog servers. Each server is identified by its IPv4 address.

11.0.0 OSPF Authentication

The equipment shall provide the capability to authenticate Open Shortest Path First (OSPF) messages (e.g. MD5). This capability shall be provided for both DCN and user traffic OSPF capable routers.

12.0.0 Encryption

The equipment shall provide the capability to encrypt MPLS-TP traffic (end-to-end tunnel encryption). The encryption shall be provided by a plug-in self-contained unit (henceforth designated as "encryption unit") offering the following features:

- Eight (8x) SFP/SFP+ cages for electrical or optical 1 or 10 Gbit/s Ethernet
- AES-256 GCM encryption
- Four dedicated and independent (i.e. not shared) encryption engines for each one of four pairs of Encrypted/Unencrypted ports (i.e. the 8x ports are grouped into 4x pairs, for each pair one unencrypted port connects to the trusted zone whereas one encrypted port connects to the untrusted zone – henceforth such a port pair will be designated as "E/U ports-pair").
- The 4x E/U ports-pairs shall be in turn grouped into 2x fully independent functional sub-units (2x E/U ports-pairs on each functional unit). Independent means that if one of the two functional sub-units is compromised it shall be possible to continue operation on the remaining sub-unit.
- 1 or 10 Gbit/s wire-speed encryption capability for each encryption engine
- Management port dedicated exclusively to the management of the encryption unit
- MPLS outer label dependent encryption
- Up to 1024x keys to encrypt 1024x LSPs to arbitrary endpoints for each one of the four E/U ports-pairs (total 4x E/U ports-pairs X 1024 = 4096 encrypted LSPs)
- Encryption of layer 2 frames (e.g. PTP, ESMC) shall be configurable
- Encryption of OAM message shall be configurable

13.0.0 Power Supply

The supply voltage to **FOTE panel shall be Dual 48/110 VDC of station battery or 230 V AC UPS supply**. The equipment shall work satisfactorily over battery voltage variations of +20% to –15%.

The equipment shall support dual power feed (1+1 hardware protection) with 100% redundancy and auto changeover i.e. that two power sources can be connected directly to the equipment (two connection points).

The equipment shall supervise the power source and provide corresponding alarming in case of loss of either power source. The alarm shall be integrated to SAS.

Power supply modules directly connected to mother board is preferred. However, in event of non-availability of directly connected power supply modules to mother board, then rack mounted DC/DC converter of required specifications shall be provided as an integral part of FOTE panel. Make of DC/DC converter shall be that of OEM of FOTE panel with required input and output switchgears and protections.

14.0.0 Safety

14.1.0 Electromagnetic Compatibility (EMC)

The equipment shall comply with the EN 55022 class A, EN 61000-6-2, EN 61850-3, and shall be in conformance with Circuit Emulation (CE).

14.2.0 Mechanical Construction

The equipment shall be available as a 19" shelf to be mounted in a 19" rack or 19" cabinet. It shall be of robust design. All modules shall be integrated in the same shelf. All connectors shall be accessible from the front and comply with international specifications.

15.0.0 Network Management System (NMS)

The network management system (NMS) shall have facilities to supervise, monitor, control and configure each equipment and the whole network. It shall have capabilities of fault, configuration, performance and security management. It shall provide various graphical views to the network such as, logical network structure, and hierarchical view. The network management system shall allow to define different user profiles.

The NMS shall support end-to-end service for MPLS-TP as well as for TDM based services. For MPLS-TP based services, all service types (VPWS, Tree, VPLS) shall be supported by the end-to-end service functionality. The NMS shall perform channel calculations based on various parameters such as available bandwidth, number of hops, provisioned bandwidth/services and channel diversity requirements.

A comprehensive alarm management shall show current alarms such that icons of the network elements change their colors according to the alarm level. The alarms shall be categorized as critical, major, minor alarms and warnings. A summary shall indicate the total number of alarms and warnings in the entire network. An alarm list shall list all alarms of the entire network according to the time of their occurrence. It shall be possible to filter alarms with various filter criteria. Operators shall be able to add comments to the alarms.

16.0.0 Table of compliance

Sl. No.	DESCRIPTION		REQUIRED
A	**GENERAL**		
i.	Make		GE T & D (INDIA) LIMITED
ii.	Model & Type		eDXC (STM-4) & AMPLIFIER & DIP

Sl. No.	DESCRIPTION		REQUIRED
iii.	Type of multiplexer		Hybrid, MPLS-TP and SDH
iv.	Complying to IEC/ ITU-T/ IETF recommendations		YES
v.	Transmission Capacity	Gbit/s Gbit/s Mbit/s Mbit/s	1/10 Gbit/s MPLS-TP STM-16: 2.5 STM-4: 622 STM-1: 155
vi.	Packet switching capacity low density version	Gbit/s FD	≥ 62 Gbit/s
vii.	Packet switching capacity high density version	Gbit/s FD	≥146 Gbit/s
viii.	Hardware supported QoS scheduling		YES
ix.	SNMP northbound interface supported		YES
x.	Integrated cyber security features		YES
xi.	PDH access capacity on 64kbit/s	Channels	≥ 200
xii.	PDH access capacity on 2Mbit/s	Channels	≥ 40
xiii.	SDH high density 2Mbit/s access interface	Amount	≥ 48 per module
xiv.	Digital PDH/ SDH cross connect function		Fully non-blocking
xv.	PDH cross connect capacity		≥ 128 x 2Mbit/s
xvi.	SDH cross connect capacity, high order		≥ 128 x VC-4
xvii.	SDH cross connect capacity, low order		≥ 945 x VC-12 + 48 x VC-3
xviii	Fan less operation at full PDH/ SDH and MPLS-TP transmission capacity		YES
xix.	Hardware redundant central processor, switching matrix, SDH cross connect and power supply		YES
xx.	Offered Equipment used in global / Indian substation environment		List of 10 reference substation projects
xxi.	The equipment is type tested by an independent, accredited test laboratory (e.g. VDE, DNV/KEMA)		YES
xxii.	Integrated distance teleprotection interface		YES

Sl. No.	DESCRIPTION		REQUIRED
xxiii	Integrated optical teleprotection interface		YES
xxiv	Integrated interface card for IEC 61850 based protection		YES
xxv	Hitless redundancy of protection signal transmission over MPLS-TP		YES
xxvi	Enhanced traffic monitoring of protection signal data channels		YES
xxvi	Authentication of protection signal data channels (distance, differential and GOOSE based)		YES
B	**PACKET SWITCHING FEATURES**		
i.	Maximum Number of transits LSPs		600
ii.	Number of terminating (protected) tunnels in LER.		250
iii.	Maximum Number of VPLS instances		50
iv.	Number of VPWS instances		≥ 300
v.	Support of MPLS-TP P2MP tree service		YES
vi.	Number of fast BFD sessions (≤ 10ms)		≤ 100
vii.	Number of medium BFD sessions (≤ 50ms)		≤ 200
viii.	Number of slow BFD sessions (≥ 100ms)		≤ 500
ix.	1:1 bidirectional, symmetrical LSP protection		YES
x.	Support of L2GP protocol		YES
xi.	L2GP dual homing support		YES
xii.	Support of RSTP protocol		YES
xiii.	Support of ERPS protocol		YES
xiv.	Number of supported VLANs	Amount	≥ 4000
xv.	VLAN tag stacking support		YES

Sl. No.	DESCRIPTION		REQUIRED
xvi.	MAC address table size	Amount	≥ 16'000
xvii.	Support of Synchronous Ethernet		YES
xviii	Support of IEEE 1588 v2 PTP ordinary clock		YES
xix.	Support of IEEE 1588 v2 PTP boundary clock		YES
xx.	Support of IEEE 1588 v2 PTP transparent clock		YES
xxi.	Support of a ITU-T 8275.1/ 8275.2 telecom profile compatible PTP profiles		YES
xxii.	Accuracy of PTP time of day information per node	µs	≤ 1,5 µs
C	**PACKET TRANSPORT INTERFACES**		
i.	Optical 10 Gbit/s MPLS-TP interface	Amount	≥ 4
ii.	Optical 1 Gbit/s MPLS-TP interface	Amount	Up to 8
D	**TDM TRANSPORT INTERFACES**		
i.	SFP based STM-N transport interfaces		YES
ii.	Optical STM-16 interface	Amount	≥ 8
iii.	Optical STM-4 interface	Amount	≥ 16
iv.	Optical STM-1 interface	Amount	≥ 8
v.	Electrical STM-1 interface	Amount	≥ 8
vi.	E1, 2Mbit/s interface	Amount	≥ 8
vii.	SHDSL interface	Amount	≥ 8
E	**ACCESS/ USER INTERFACES**		
E.1	**2/ 4-wire voice interface module**		
i.	Analogue, 4wire with E&M: Input level Output level	dBr	+9.5 to –16.0 +7.0 to –16.5

Sl. No.	DESCRIPTION		REQUIRED
ii.	Analogue, 2wire with E&M: Input level Output level	dBr	+9.5 to – 12.5 –1.0 to – 20.0
iii.	Digital, 2Mbit/s CAS or PRI		YES
iv.	Number of interfaces per module	Amount	≥ 8
v.	1+1 path protection on TDM circuits		YES
vi.	1:1 hardware redundancy for Conferencing		YES
E.2	**FXS/ FXO subscriber / exchange interface module**		
i.	2-wire, subscriber side	dBr	-4 … +4 / -10 ... 0
ii.	Minimum number of subscribers per module	Amount	≥ 10
iii.	2-wire, PABX side	dBr	-5 … +4 / -7.5 ... -3
iv.	Minimum number of PABX interfaces per module	Amount	≥ 10
E.3	**Voice over IP subscriber media gateway module**		
i.	SIP protocol support		YES
ii.	Redundant registrar		YES
iii.	Local call routing		YES
iv.	ITU-T G.711/ G.729A codec and RFC 3550 RTP compliance		YES
v.	Minimum number of subscribers per module	Amount	≥ 500
vi.	1:1 hardware redundancy		YES
E.4	**Distance Protection Commands module**		
i.	Number of interfaces per module	Amount	≥ 4
ii.	Maximum trip transmission time	ms	≤ 5
iii.	Input contact voltage range	VDC	24 … 250

Sl. No.	DESCRIPTION		REQUIRED
iv.	Channel addressing for trip commands		YES
v.	Channel loop delay measurement		YES
vi.	1+1 hitless path redundancy		YES
vii.	IRIG-B inputs/ outputs		YES
E.5	**Line Differential Protection module**		
i.	Optical interface IEC 60870-5-1	Kbit/s	Minimum 64
ii.	Optical interface C37.94	Mbit/s	2.048
iii.	Payload for protection relay	Kbit/s	64 – 768
iv.	4-wire voice channel transmission		YES
v.	V.11/ X.21 Channel transmission		YES
vi.	ITU-T G.703.1 CODIR Channel transmission		YES
vii.	ITU-T G.703/ G.704 E1 Channel transmission		YES
viii.	Number of interfaces/ channels per module	Amount	≥ 4
ix.	Maximum channel transmission time	ms	≤ 10
x.	Maximum channel asymmetry for C37.94 interfaces over SDH & MPLS-TP.	µs	≤ 150
xi.	1+1 hitless path redundancy		Yes
xii.	IRIG-B outputs		YES
E.6	**IEC61850 GOOSE based Protection module**		
i.	PRP support		YES
ii.	Integration in IEC 61850 substation configuration file		YES
iii.	Capability for wire speed GOOSE signal translation		YES

Sl. No.	DESCRIPTION		REQUIRED
iv.	Capability for GOOSE filtering		YES
v.	Translation of GOOSE fields		YES
vi.	Trip countersx for GOOSE signals		YES
vii.	Back-to-back latency of IEC 61850 GOOSE-based protection interface data channels		≤ 200 µs
viii.	Number of interfaces per module	Amount	≥ 4
ix.	IRIG-B outputs	Amount	≥ 6
x.	SNTP client and server functionality		YES
xi.	Status supervision		Telecom NMS and IEC 61850 MMS
E.7	**Serial data interface module**		
i.	V.24/ V.28 (RS-232)	Amount	≥ 4 ports / module
ii.	V.11/ X.24/ X.21 (RS-422)	Amount	≥ 4 ports / module
iii.	V.35	Amount	≥ 4 ports / module
iv.	RS-485 2/ 4-wire	Amount	≥ 4 ports / module
v.	Serial protocol configurable per port		YES
vi.	Integrated Ethernet port (EoPDH)		YES
vii.	Point-to-Multipoint/ Multipoint-to-Multipoint conferencing		YES
viii.	1+1 path redundancy on TDM circuits		YES
ix.	1:1 hardware redundancy for conferencing		YES
E.8	**E1 module**		
i.	Complying to ITU-T G.703/ G.704, configurable		YES
ii.	Number of E1 interfaces per module	Amount	≥ 8

Sl. No.	DESCRIPTION		REQUIRED
iii.	HDB3 line code support		YES
iv.	1+1 path protection on TDM circuits		YES
E.9	**Circuit emulation module**		
i.	Number of physical E1 interfaces per module	Amount	≥ 8
ii.	Complying to ITU-T G.703/ G.704, configurable		YES
iii.	HDB3 line code support		YES
iv.	Number of CES PW interfaces per module	Amount	≥ 8
v.	CES PW IF available for serial and telephony access interfaces		YES
vi.	SAToP (RFC 4553) method support		YES
vii.	CESoPSN (RFC 5086) method support		YES
viii.	CESoETH (MEF8) method support		YES
E.10	**Ethernet switched/ MPLS attachment circuit module**		
i.	Number of optical/ electrical 1GbE interfaces	Amount	≥ 100/ chassis
ii.	PoE/ PoE+ support		YES
iii.	Number of PoE/ PoE+ interfaces	Amount	≥ 12/ module
iv.	Port and VLAN based rate limiting support		YES
v.	Hard QoS (8 queues per physical port)		YES
vi.	Port based access (all traffic is mapped into MPLS-TP services)		YES
vii.	VLAN based access (separation of VLANs into different MPLS-TP services)		YES
viii.	Mix of port and VLAN based access and mapping into VPWS/ VPLS on the same physical port		YES
E.11	**Low-capacity Ethernet routing module**		

Sl. No.	DESCRIPTION		REQUIRED
i.	Number of electrical 10/ 100BaseT interfaces		≥ 4
ii.	Support of OSPF v2, RIP v2 routing protocols		YES
iii.	PPP and MLPPP WAN protocol support		YES
iv.	WAN capacity	Mbit/s	≥ 16 Mbit/s
v.	Number of WAN ports	Amount	≥ 30
vi.	Port-based rate limiting		YES
vii.	Soft QoS (software queueing)		YES
viii.	Support of VRRP		YES
ix.	1:1 hardware redundancy		YES
E.12	**High-capacity Ethernet routing module**		
i.	Number of FE/ GbE optical/ electrical SFP based front interfaces	Amount	≥ 12
ii.	Number of virtual routing functions (VRF/ VPRN)	Amount	≥ 4
iii.	Number of VLAN interfaces	Amount	≥ 128
iv.	Wire speed forwarding on all ports (physical and logical, 1/ 10GbE)		YES
v.	OSPFv2 (RFC 2328)/ static routing support		YES
vi.	OSPF authentication (Simple/ MD5) support		YES
vii.	VRRPv3 (RFC 5798) support		YES
viii.	Number of VRRP instances	Amount	≥ 128/ module
ix.	Number of VRRP link tracking instances	Amount	≥ 32/ module
x.	1:1 NAT support		YES
xi.	Basic firewalling support (ACL rules/ DoS protection/ port and VLAN based rate limiting)		YES

Sl. No.	DESCRIPTION		REQUIRED
xii.	Hard QoS support (DSCP/ 8 queues per physical port)		YES
xiii.	1:1 hardware redundancy		YES
E.13	**Ethernet over SDH functionality**		
i.	Accessible from any port within the chassis (electrical and optical)		YES
ii.	Switched and point-to-point configuration		YES
iii.	RSTP or ERPS protection for switched services		YES
iv.	ITU-T G.7041 GFP, G.707 VCAT and G.7042 LCAS compliance		YES
v.	Number of logical EoS WAN ports	Amount	≥ 12
vi.	EoS WAN capacity	Gbit/s	≥ 2
F	**POWER SUPPLY**		
i.	Operation	VDC	48/110V DC (-15/+20%) or 230V UPS
ii.	Dual power feeding		YES (100% redundant)
G	**CONFIGURATION TOOL**		
i.	Local / remote operation		YES / YES
ii.	Data communication network (DCN)		Ethernet / IP
iii.	Integrated management of teleprotection modules		YES
H	**NETWORK MANAGEMENT SYSTEM**		
i.	Fault management		YES
ii.	Configuration management		YES
iii.	Alarm management		YES
iv.	Inventory management		YES

Sl. No.	DESCRIPTION		REQUIRED
v.	Security management		YES
vi.	Synchronization management		YES
vii.	Ethernet service and QoS management		YES
viii.	Data communication network (DCN)		Ethernet / IP
ix.	Management of integrated teleprotection modules		YES
I	**AMBIENT CONDITIONS**		
i.	Storage: ETS 300 019-1-1, class 1.2	°C / % hum	As per site / project design conditions
ii.	Transport: ETS 300 019-1-2, class 2.2	°C / % hum	As per site / project design conditions
iii.	Operation: ETS 300 019-1-3, class 3.1E	°C / % hum	As per site / project design conditions
iv.	Operation fan less: ETS 300 019-1-3, class 3.1E	°C / % hum	As per site / project design conditions

17.0.0 Emission of the equipment (substation environment)

Sl. No.	Test Name	Description	Basic standard	Class	Comply
a	Radiated radio frequency interference	30 MHz to 1 GHz 1 GHz to 6 GHz	EN 55022	A	
b	Conducted radio frequency interference AC/DC Power supply	150 kHz to 30 MHz	EN 55022	A	

17.1.0 Immunity of the equipment (substation environment)

Sl. No.	Test Name	Description*	Basic standard	Level	Comply
a.	ESD test	Contact/air discharge	IEC 61000-4-2	8 / 15 kV	
b.	Radiated electromagnetic field	80 to 1000 MHz, 80% AM, 1 kHz modulated	IEC 61000-4-3	20 V/m	
c.		1 to 3.8 GHz, 80% AM, 1 kHz modulated		10 V/m	
d.		3.8 to 6 GHz, 80% AM, 1 kHz modulated		1 V/m	

Sl. No.	Test Name	Description*	Basic standard	Level	Comply
e.	Fast transient test	DC power supply:	IEC 61000-4-4	4 kV	
f.		Local interfaces:		1 kV	
g.		Field interfaces:		2 kV	
h.		High voltage interfaces:		4 kV	
i.		Telecommunication IFs:		4 kV	
j.	Surge test (1.2/50 μs)	DC power supply: Common mode Differential mode	IEC 61000-4-5	 2.0 kV 1.0 kV	
k.		Local interfaces: Common mode Differential mode		 1.0 kV 0.5 kV	
l.		Field interfaces : Common mode Differential mode		 2.0 kV 1.0 kV	
m.		High voltage interfaces : Common mode Differential mode		 4.0 kV 2.0 kV	
n.		Telecommunication IFs: Common mode Differential mode		 4.0 kV 2.0 kV	
o.	Conducted radio frequency interference	0.15 to 80 MHz, 80% AM, 1kHz modulated	IEC 61000-4-6	10 V	
p.	Power frequency magnetic field	Continuous Short (1 to 3 s)	IEC 61000-4-8	100 A/m 1000 A/m	
q.	Conducted common mode disturbance	Frequency 50 Hz, continuous mode	IEC 61000-4-16	30 / 300 Vrms	
r.	Damped oscillatory waves	DC power supply: Common mode Differential mode	IEC 61000-4-18	 2.5 kV 1.25 kV	
s.		Field interfaces : Common mode Differential mode		 1.0 kV 0.5 kV	
t.		High voltage interfaces : Common mode Differential mode		 2.5 kV 1.25 k	
u.		Telecommunication IFs: Common mode Differential mode		 2.5 kV 1.25 kV	

* Description of interface names according to IEC 61850-3.

18.0.0 DRAWINGS, DATA AND MANUAL

18.1.0 To Be Submitted After Award of Contract:

- Technical data sheet
- Bill of Material
- Dimensional general arrangement drawing
- System Layout
- Optical Power Budget Calculation
- Quality plan
- Test certificates
- O&M manual

19.0.0 TESTS

The equipment offered shall be of type tested and proven type. Type test reports shall be submitted for review. The bidder shall submit the type tests reports for the tests conducted on equipment similar to those to be supplied under this contract and the test(s) should have been conducted at an independent laboratory not earlier than five (5) years prior to date of supply. All routine and acceptance tests in accordance with the latest version of applicable standard shall be conducted. The minimum tests / test reports are mentioned below but not limited to:

19.1.0 Type Test

A) Temperature and Humidity Tests

- Low temperature test – Operation to Specifications and Operation without Damage
- Dry Heat test – Operation to Specifications and Operation without Damage
- Damp Heat test – Temperature and Humidity
- Temperature variation test

All the above tests shall be as per IEC 60068-2

B) Immunity Tests

- Power supply and EMI/EMC tests
    - Voltage Fluctuations
    - Voltage dips and interruptions
- 1.2/50 – 8/20 ms surges Power Supply ports as per IEC 61000-4-5
- 1.2/50 – 8/20 ms surges Signal & Control Lines as per IEC 61000-4-5
- Fast Transient Test
- Damped oscillatory waves
- 10/700 ms surges
- Electrostatic discharge
- Power frequency magnetic field
- Radiated electromagnetic field
- Damped oscillatory magnetic field
- PF voltage on control and signal lines
- DC voltage on control and signal lines

C) Emission Tests

- LF disturbance voltage
- RF disturbance voltages
- RF disturbance currents
- RF radiated field

D) Insulation Withstand Voltages

- Isolation Test
  - DC power supply
  - Control and Signal
  - Telecon Line
- 1.2/50 microseconds impulse voltage
  - DC power supply
  - Control and Signal
  - Telecon Line

E) Mechanical Tests

- Vibration Test – Response and Endurance test
- Free Fall Test

19.2.0 Factory Acceptance Tests, Routine Test, Pre-commissioning and Commissioning Tests

All the Factory Acceptance Tests, Routine Test & Pre-commissioning and Commissioning Tests shall be carried out as per relevant IEEE/IEC/ITU-T/EN guidelines of FOTE. Bidder has to follow specification and Customer approved Manufacturing Quality Plan and FAT/SAT procedures.

20.0.0 Bidder shall provide all necessary information that deems to be necessary to complete the project in all respects.

21.0.0 Equipment Availability

The calculated availability requirements are as follows:
a. The availability of each fiber optic link shall be at least 99.999%.
b. The availability of subscribers (on Ethernet interfaces) shall be at least 99.97%.

The calculated availability is defined as theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS.

The bidder shall confirm that the equipment & configuration proposed by the bidders shall be capable of demonstrating the specified availability figures. The contractor shall submit the availability analysis for the proposed equipment/ sub system. The analysis shall include the meantime- between failure (MTBF) and mean-time-to-repair (MTTR) of all the components on the link. For this analysis, an MTTR of at least 4 hours shall be assumed.

22.0.0 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable. Under NMS Control controlled sequencing of the alarm response and restoration may alter normal switch over/ switchback.

23.0.0 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by owner, prior to the completion of SAT.

All field modifications required to update the hardware, firmware and software to the latest revision level occurring after the above specified testing shall be fully disclosed, documented and presented to the Owner for their consideration. Satisfaction of this disclosure requirement does not obligate the bidder to implement the changes provided the latest revision date occurs after the above requirements are met. The intent is to provide the Owner with the documentation and opportunity to consider their implementation.

All field modifications of the hardware, firmware and software that is required to meet installation and performance specifications, shall be fully documented as part of the deliverables, both as a separate field modifications record and as corrected equipment/configuration documentation.

24.0.0 System Maintainability

Once a failure or degradation of performance is detected in the communications system, its cause shall be promptly isolated and corrected. To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control.

Preventive and problem-oriented maintenance of the communications system shall be performed using diagnostics tools such as NMS and test equipment. They shall support complete maintenance of all system elements and shall permit the diagnosis of any fault without requiring additional test equipment. For all redundant systems, disconnection and repair of any failed device shall not interrupt the operation of the system.

25.0.0 Help

All applications shall be supported by user accessible help commands that shall assist the user in the performance of its tasks. Help commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application