



वर्गीय आवश्यकताओं के लिए मानक  
टीईसी

STANDARD FOR GENERIC REQUIREMENTS

TEC 71130:2023 (Draft)

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रेडियो ओवर फाइबर सिस्टम  
Radio Over Fibre Systems

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ISO9001:2015

दूरसंचार अभियांत्रिकी केंद्र

दूरसंचार विभाग, संचार मंत्रालय

खुर्शीदलाल भवन, जनपथ, नईदिल्ली-110001, भारत

TELECOMMUNICATION ENGINEERING CENTRE

DEPARTMENT OF TELECOMMUNICATIONS, MINISTRY OF COMMUNICATIONS

KHURSHIDLAL BHAWAN, JANPATH, NEW DELHI-110001, INDIA

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**Release 1: 2023**

## FOREWORD

Telecommunication Engineering Centre (TEC) is the technical arm of Department of Telecommunications (DOT), Government of India. Its activities include:

- Framing of TEC Standards for Generic Requirements for a Product/Equipment, Standards for Interface Requirements for a Product/Equipment, Standards for Service Requirements & Standard document of TEC for Telecom Products and Services
- Formulation of Essential Requirements (ERs) under Mandatory Testing and Certification of Telecom Equipment (MTCTE)
- Field evaluation of Telecom Products and Systems
- Designation of Conformity Assessment Bodies (CABs)/Testing facilities
- Testing & Certification of Telecom products
- Adoption of Standards
- Support to DoT on technical/technology issues

For the purpose of testing, four Regional Telecom Engineering Centers (RTECs) have been established which are located at New Delhi, Bangalore, Mumbai, and Kolkata.

## ABSTRACT

This document describes the generic requirements and specifications for Radio over fibre systems for local and access networks, as per, ITU-T G.9803 Recommendations for use in Indian telecom network.

## CONTENTS

<i>Sl.No.</i>	<i>Particulars</i>	<i>Page No.</i>
	History Sheet	8
	References	9
<b>Chapter 1:- Technical Requirements</b>		11
1.0	Introduction	11
2.0	ROF system reference points	12
2.1	System Architecture	12
2.1.1	Analogue RoF system	13
2.1.1.1	Subcarrier signal(s) transmission	13
2.1.1.2	Equivalent low-pass signal(s) transmission	14
2.1.2	Digital RoF system	15
2.1.2.1	Digital radio signal(s) transmission	15
2.1.2.2	Digitized radio signal(s) transmission	15
2.2	Reference Architecture for IMT system	17
2.3	Reference Architecture for FOD system	18
2.4	Network Architecture	19
2.5	Equipment interfaces	19
2.5.1	Service node interfaces	19
2.5.2	User network interfaces	20
2.6	Physical layer requirements	20
2.6.1	Transmission medium	20
2.6.2	Frequency band	20
2.6.3	Optical link loss	21
2.7	System requirements	21
2.7.1	Operation, administration and management function	21
2.7.2	Environmental Requirements	21
2.7.3	Eye Safety	21
2.8	Coexistence with PON	21
2.9	Optical wavelength	22
2.10	Latency	22
2.11	Use Cases	22
<b>Chapter 2:- General Requirements</b>		

1.0	Reference documents	24
2.0	Engineering requirements	24
3.0	Operational requirements	25
4.0	Quality requirements	25
5.0	Maintenance requirements	26
6.0	Power supply	27
7.0	Energy Consumption Rating	27
8.0	Accessories	27
9.0	Documentation	28
10.0	Mechanical standards	28
11.0	Operating personnel safety requirements	30
12.0	Minimum equipment requirements	31
13.0	Field trial	31
14.0	Applicable tests(for TAC purpose):	31
<b>Chapter 3:-EMC Requirements</b>		32
1.0	Electromagnetic Interference	32
<b>Chapter 4 (Part-I):- EMS Requirements</b>		38
1.0	General operational and functional requirements	38
2.0	EMS Architecture and Server Hardware Specifications	42
2.1	Architecture	42
2.2	Scalability aspects	43
2.3	EMS server specifications	43
2.4	Application server specifications	44
2.5	Database server specifications	44
2.6	Firewall server [optional to purchaser's requirements]	46
2.7	Specifications for local craft terminal/work station	46
<b>Chapter 4 (Part-II):- FCAPS Requirements</b>		48
1.0	Network management functions	48
1.1	General functions	48
1.1.1	Configuration management	48
1.1.2	Fault management	49
1.1.3	Performance management	50
1.1.4	Security management	51
1.1.5	Inventory management	53
1.1.6	Software management	53

1.1.7	Software download	54
1.1.8	Management interface details	54
1.1.9	Southbound management interface	55
1.1.10	Northbound management interface	55
1.1.11	Local management interface	56
1.1.12	User interface	56
1.2	Additional functional requirements	56
<b>Appendix-I :- Example system interface specifications</b>		58
<b>Appendix-II :- ROF system service support</b>		60
<b>Abbreviations</b>		63

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## TABLE OF FIGURE

Figure 1:Fundamental architecture.....	12
Figure 2:Configuration examples for transmitting subcarrier signal(s).....	193
Figure 3:Configuration examples for transmitting equivalent low-pass signal(s) .....	14
Figure 4:Configuration examples for transmitting digital signal(s) .....	15
Figure 5:Configuration examples for transmitting digitized signal(s).....	16
Figure 6:Typical IMT system supported by RoF system.....	17
Figure 7:Reference architecture of RoF supporting an FOD detection system .....	18
Figure 8:Typical block diagram of RoF link for FOD system .....	18
Figure 9:Network architecture .....	19
Figure 10:Wavelength plans of optical access network systems.....	22
Figure 11:Multiservice RoF system architecture in single RoF OLT.....	23

## HISTORY SHEET

Sl. No.	Standard / document No.	Title	Remarks
1)	TEC 71130:2023 (Draft)	Radio Over Fiber Systems	First Release

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**REFERENCES**

<b>S. No.</b>	<b>Standard No.</b>	<b>Designation</b>
1.	ITU-R M.1224	Vocabulary of terms for International Mobile Telecommunications (IMT)
2.	ITU-R M.2150	Detailed specifications of the terrestrial radio interfaces of IMT-2020
3.	ITU-T G.652	Characteristics of a single-mode optical fiber and cable.
4.	ITU-T G Suppl. 55	Radio-over-fibre (RoF) technologies and their applications
5.	ITU-T G.664	Optical safety procedures and requirements for optical transmission systems
6.	ITU-T G.784	Management aspects of synchronous digital hierarchy (SDH) transport network elements
7.	ITU-T G.989.2	40-Gigabit-capable passive optical networks (NG-PON2): Physical media dependent (PMD) layer specification
8.	ITU-T G.8262	Timing characteristics of a synchronous equipment slave clock
9.	ITU-T J.186	Transmission equipment for multi-channel television signals over optical access networks by sub-carrier multiplexing (SCM)
10.	IS 13252 part 1	Information Technology Equipment -- Safety, Part 1: General Requirements
11.	IEEE 802.3	IEEE Standard for Ethernet
12.	IEC 60950-1	Information technology equipment –Safety –Part 1:General requirements
13.	IEC-60825-1	Safety of laser products – Part 1: Equipment classification, requirements and user's guide
14.	IEC Publication 61000-4-2	Testing and measurement techniques of Electrostatic discharge immunity test
15.	IEC Publication 61000-4-3	Radiated RF electromagnetic field immunity test
16.	IEC Publication 61000-4-	Testing and measurement techniques of

	4	electrical fast transients/burst immunity test
17.	IEC Publication 61000-4-5	Test & Measurement techniques for surge immunity tests
18.	IEC Publication 61000-4-6	Immunity to conducted disturbances
19.	TEC 11016:2016	Electromagnetic Compatibility Standard for telecommunication Equipment
20.	TEC 14016:2010	QM-333 - Specification for environmental testing of electronic equipment for transmission and switching use
21.	TEC 49090:2014	Firewall System
22.	TEC 74046:2020	TEC Standard for Energy Consumption Rating and Energy Passport for Telecommunications Products, Equipment and Network/ Services

**Note:**

Unless otherwise explicitly stated, the latest approved issue of the standard, with all amendments in force, listed in references, on the issuance date of this standard applicable”

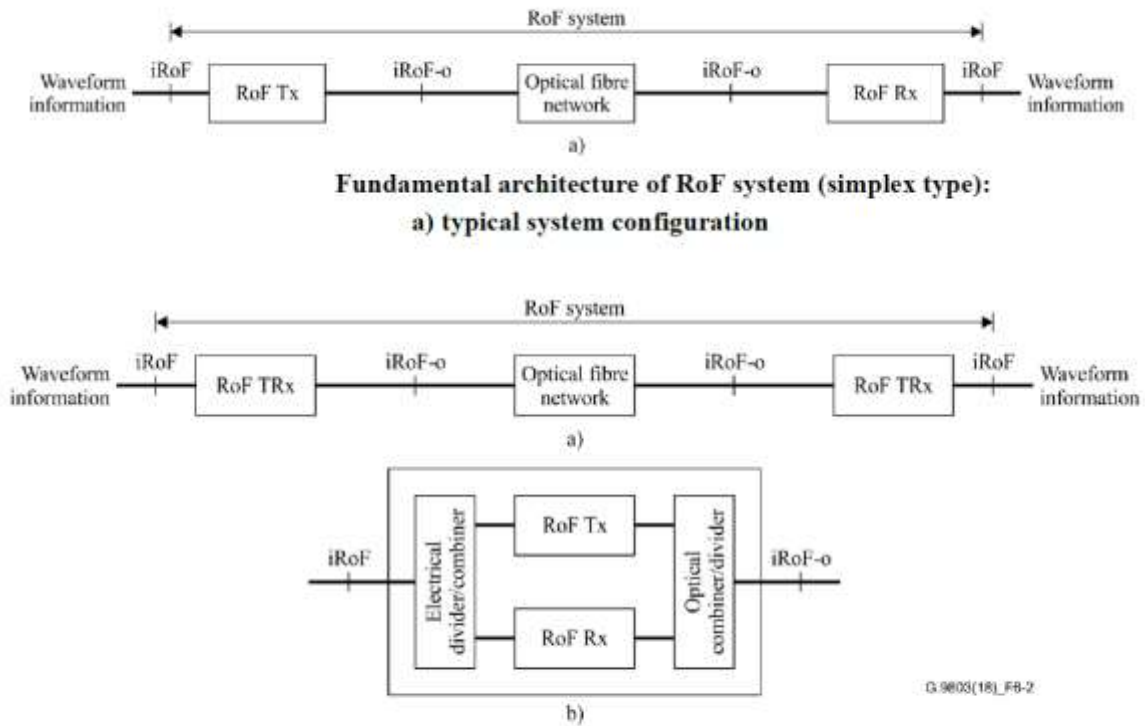
## CHAPTER-1

### Technical Requirements

#### 1.0. Introduction

- 1.1. This document describes a fundamental architecture and requirements for RoF systems as per ITU-T G.9803 Recommendations for use in Indian telecom network.
- 1.2. A radio-over-fibre (RoF) system must have the capability to transmit waveform information over an optical fibre network for radio communication services.
- 1.3. The RoF ONUs must be remotely manageable and support configuration functions. The RoF system must provide full fault, configuration, accounting, performance, and security (FCAPS) management capability for the RoF ONUs.
- 1.4. The general characteristics and architecture of ROF shall be compliant to ITU-T G.9803 as specified in the Standard.
- 1.5. The standard specifies the system overview, physical layer requirements, system requirements and co-existence with passive optical network (PON) for analogue RoF systems supporting the international mobile telecommunication (IMT) system over optical distribution network (ODN). However, specific implementation shall be subject to networking requirements of the Service Providers.

## 2.0 ROF system reference points



**Fundamental architecture of RoF system (duplex type):  
a) typical system configuration; and b) typical RoF TRx**

**Figure 1: Fundamental architecture**

Here, iRoF represents points just before and just after the RoF system, and iRoF-o represents points just before and just after the optical fibre network.

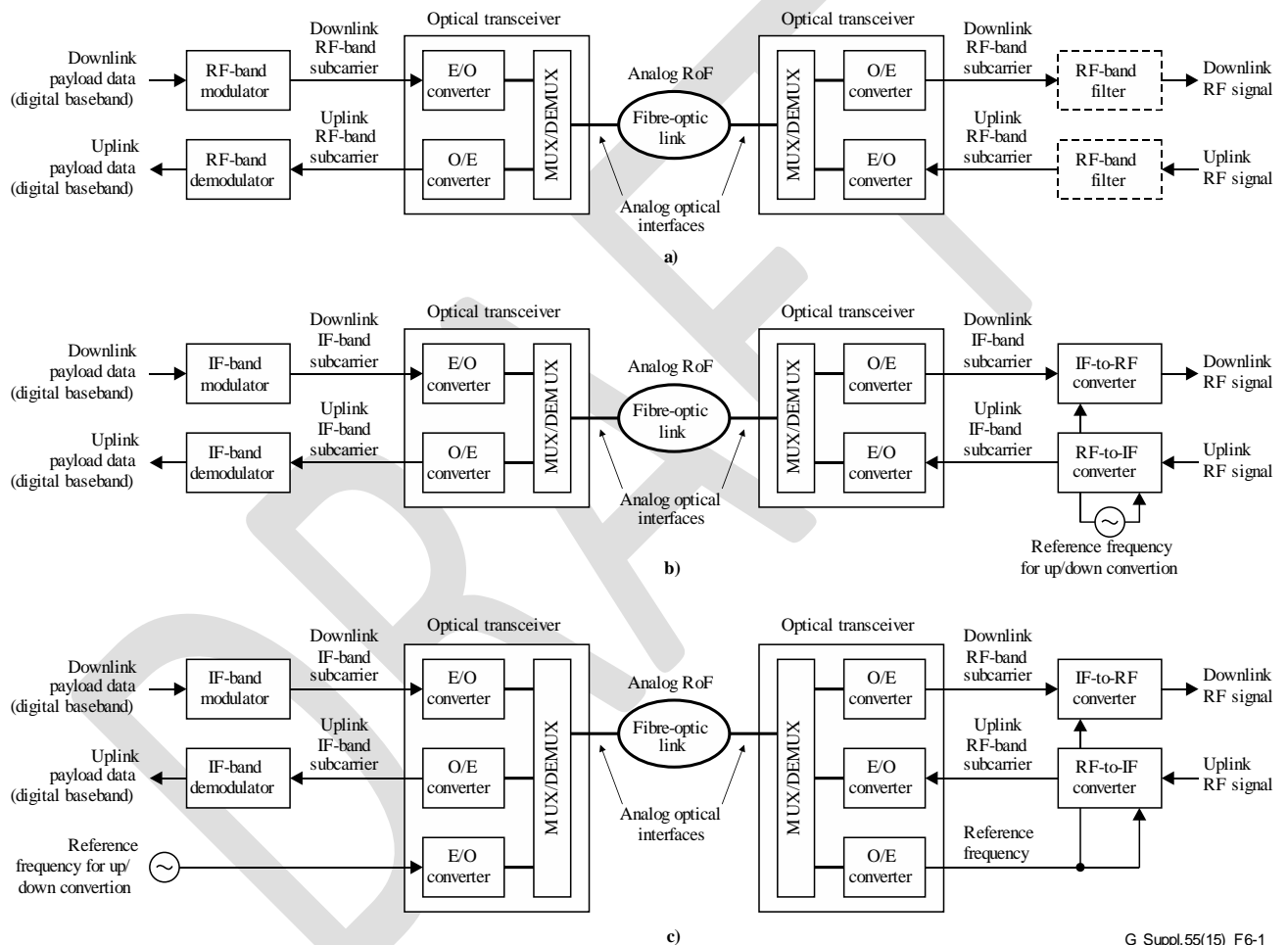
### 2.1 System Architecture

When a system consisting of one base station (BS) and many remote antenna sites, which is a typical model of RoF systems, is considered, it falls into one of two categories that differ in the types of the signal transmitted over the fibre-optic link. One is a system for transmitting subcarrier signal(s), and the other is a system for transmitting equivalent low-pass signal(s). The system architectures and their features are explained here in detail. The system architectures shown in this clause are typical examples and other system architectures are also conceivable.

## 2.1.1 Analogue RoF system

### 2.1.1.1 Subcarrier signal(s) transmission

Figure below illustrates general and fundamental architectures for transmitting subcarrier signal(s), such as RF-band subcarrier, intermediate-frequency-band (IF-band) subcarrier, and reference frequency signals. In Figure 6-1, it is assumed that the equipment on the left side of the fibre-optic link is located in the local office and the equipment on the right side is located at the remote antenna.



G Suppl.55(15)\_F6-1

**Figure 2: Configuration examples for transmitting subcarrier signal(s):  
a) RF-band, b) only IF-band signal, and c) IF-band signal and  
reference frequency**

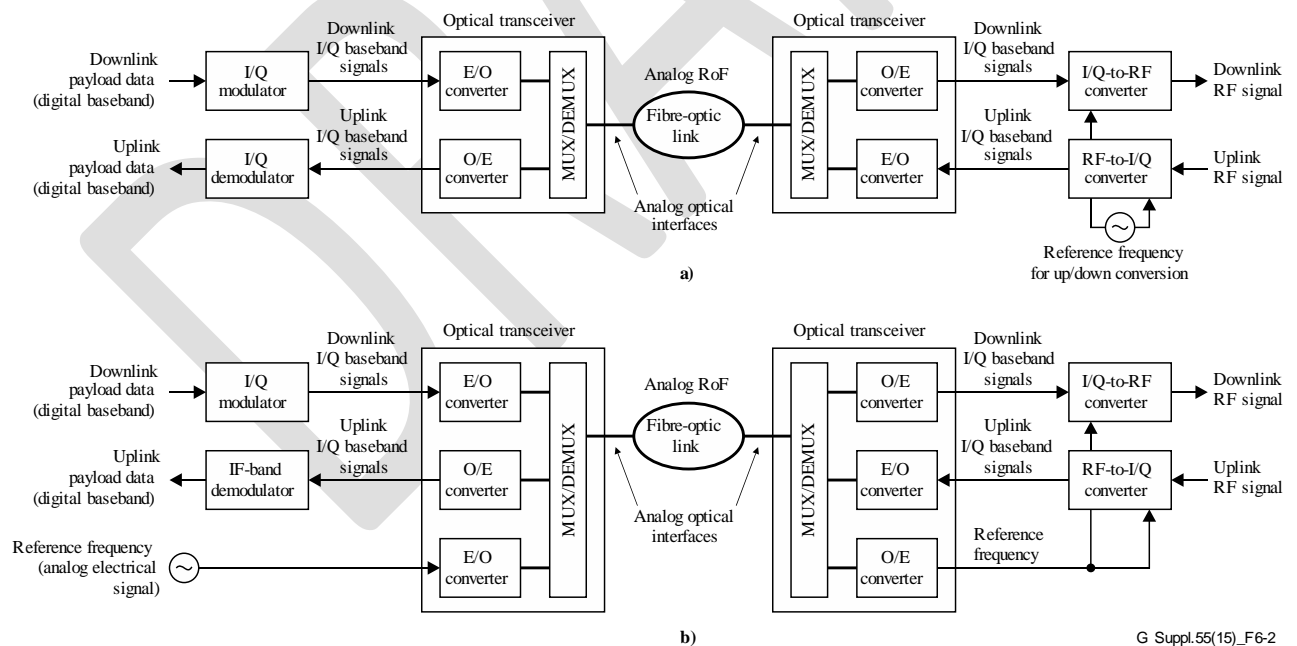
In an RF-band RoF transmission scheme as shown in Figure 2-a, the system consists of an RF-band modulator, an RF-band demodulator, a pair of optical transceivers, a fibre-optic link, and two RF-band filters. The RF-band filters may be used if the need arises to obey the radio regulation.

In an IF-band RoF transmission scheme as shown in Figure 2-b, the system consists of an IF-band modulator, an IF-band demodulator, a pair of optical transceivers, a fibre-optic link, an IF-to-RF up-converter, an RF-to-IF down-converter and a reference frequency generator. Since the IF is typically much lower than the RF, the IF-band RoF transmission scheme offers a much improved optical bandwidth efficiency compared to the RF-band RoF transmission scheme.

In an IF-band RoF and reference frequency transmission scheme, as shown in Figure 2-c, the system configuration is the same as the IF-band RoF transmission scheme shown in Figure 2-b, except the reference frequency is provided from the local office end and is delivered to the remote antenna site.

In the configurations shown in Figures 2-a and 2-c, no reference frequency generator is required at the remote end, resulting in a simpler configuration of remote equipment.

### 2.1.1.2 Equivalent low-pass signal(s) transmission



**Figure 3: Configuration examples for transmitting equivalent low-pass signal(s): a) only I/Q baseband signals, and b) I/Q baseband signals and reference frequency**

Figure 3 above illustrates general and fundamental architectures for transmitting orthogonal equivalent low-pass (equivalent baseband) signals,

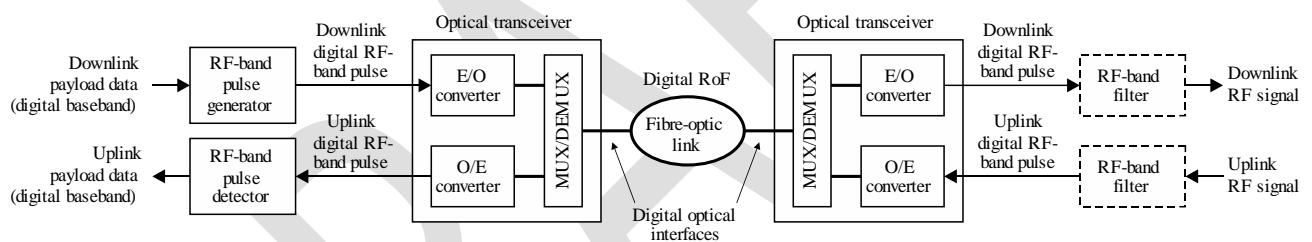
such as (non-binary) in-phase and quadrature-phase (I/Q) baseband signals. It is assumed that the equipment on the left side of the fibre-optic link is located in the local office and the equipment on the right side is located at the remote antenna.

In an I/Q baseband signals transmission scheme as shown in Figure 3-a, the system consists of an I/Q modulator, I/Q demodulator, a pair of optical transceivers, fibre-optic link, I/Q-to-RF up-converter, an RF-to-I/Q down-converter and a reference frequency generator.

In an I/Q baseband signal and reference frequency transmission scheme, shown in Figure 3-b, the system configuration is the same as the I/Q baseband RoF signal transmission scheme shown in Figure 3-a, except the reference frequency is provided from the local office end and is delivered to the antenna site.

## 2.1.2 Digital RoF system

### 2.1.2.1 Digital radio signal(s) transmission



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**Figure 4: Configuration examples for transmitting digital signal(s): RF-band pulse**

Figure 4 illustrates general and fundamental architectures for transmitting digital radio signals. RF-band pulse(s), such as impulse radio signal(s), is a typical example of digital radio signal(s). It is assumed that the equipment on the left side of the fibre-optic link is located in the local office and the equipment on the right side is located at the remote antenna.

In an RF-band pulse transmission scheme, as shown in Figure 4, the system consists of an RF-band pulse generator, RF-band pulse detector, pair of optical transceivers, fibre-optic link and two RF-band filters. The RF-band filters may be used if the need arises in order to obey the radio regulation.

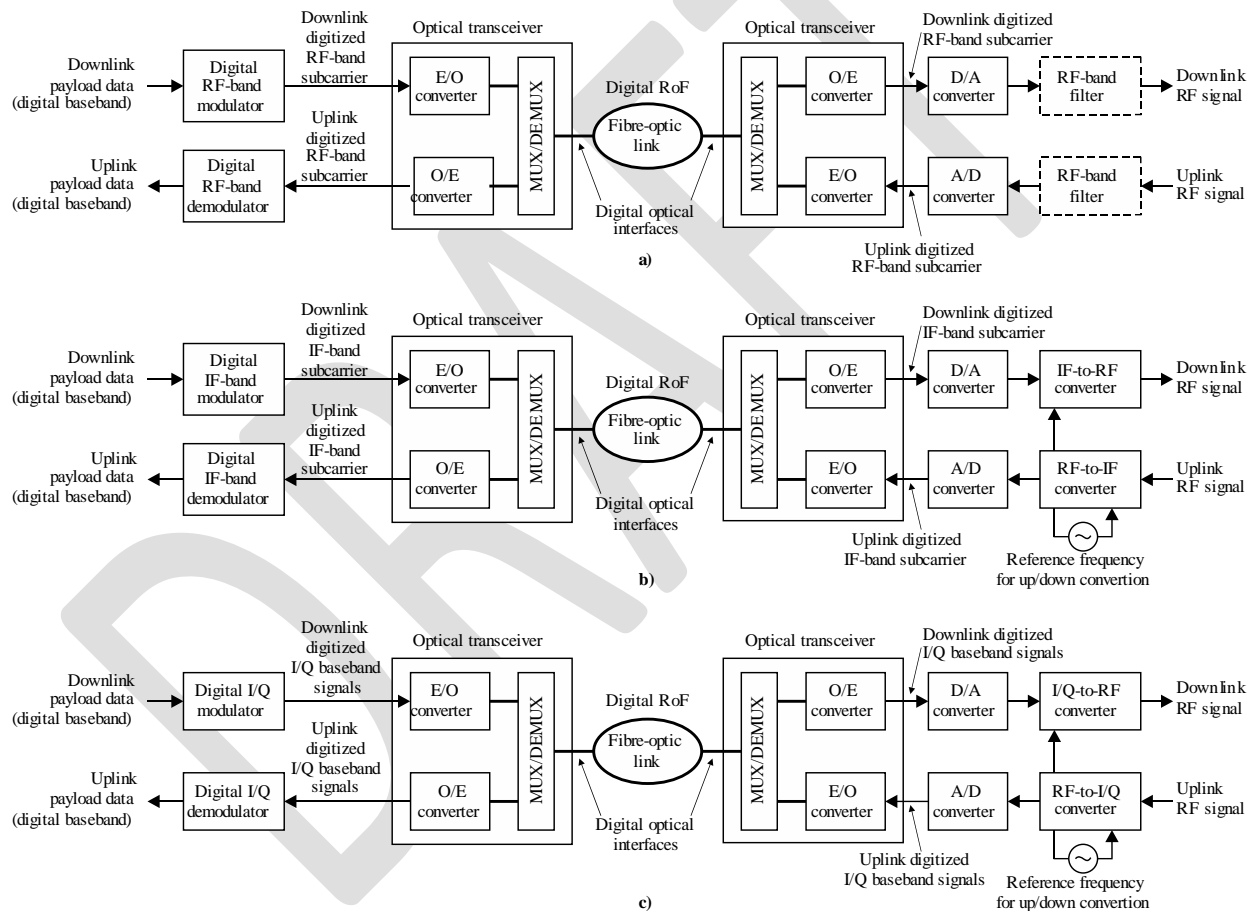
### 2.1.2.2 Digitized radio signal(s) transmission

In a digitized RF-band RoF transmission scheme as shown in Figure 5-a, the system consists of a digital RF-band modulator, digital RF-band

demodulator, pair of optical transceivers, fibre-optic link, DAC, ADC and two RF-band filters. The RF-band filters may be used if the need arises in order to obey the radio regulation.

In a digitized IF-band RoF transmission scheme as shown in Figure 5-b, the system consists of a digital IF-band modulator, digital IF-band demodulator, pair of optical transceivers, fibre-optic link, DAC, ADC, IF-to-RF up-converter, RF-to-IF down-converter and a reference frequency generator.

In a digitized I/Q baseband signals transmission scheme as shown in Figure 5-c, the system consists of a digital I/Q modulator, digital I/Q demodulator, pair of optical transceivers, fibre-optic link, DAC, ADC, I/Q-to-RF up-converter, RF-to-I/Q down-converter and a reference frequency generator.



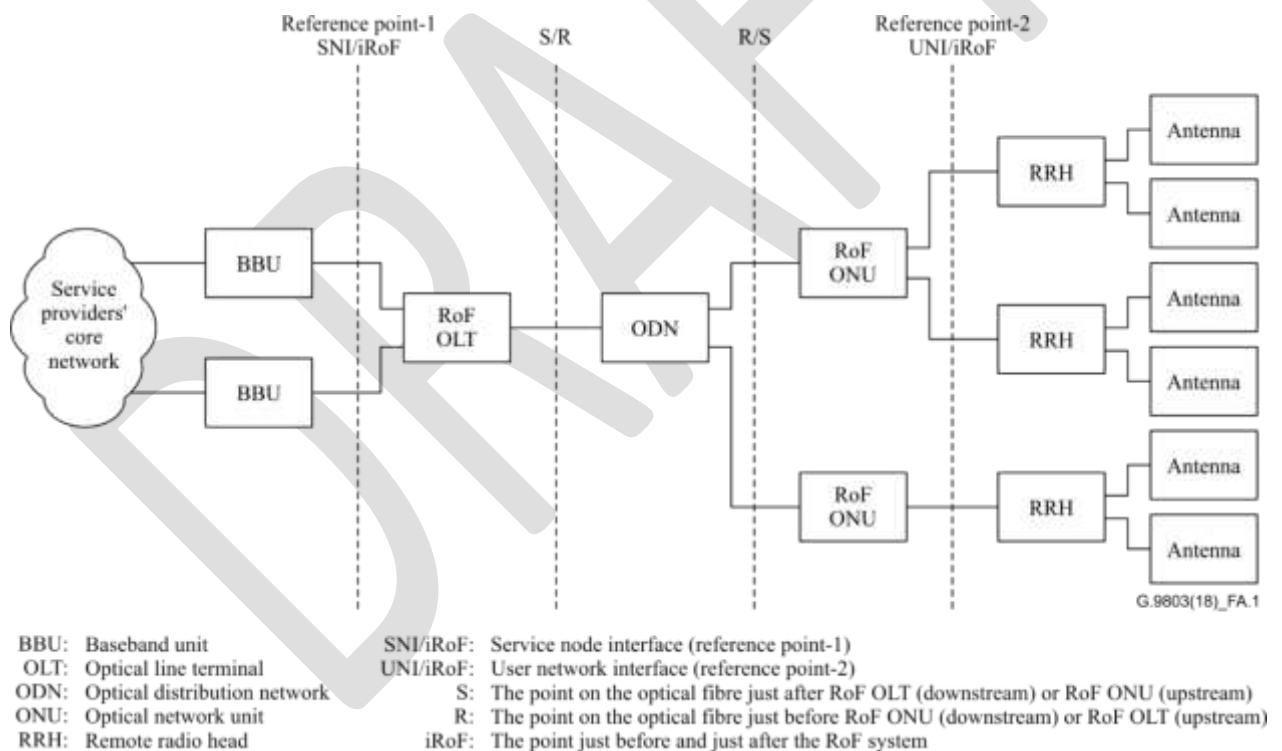
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**Figure 5: Configuration examples for transmitting digitized signal(s): a) digitized RF-band signal(s), b) digitized IF-band signal(s), and c) digitized I/Q baseband signal(s)**



## 2.2 Reference Architecture for IMT system

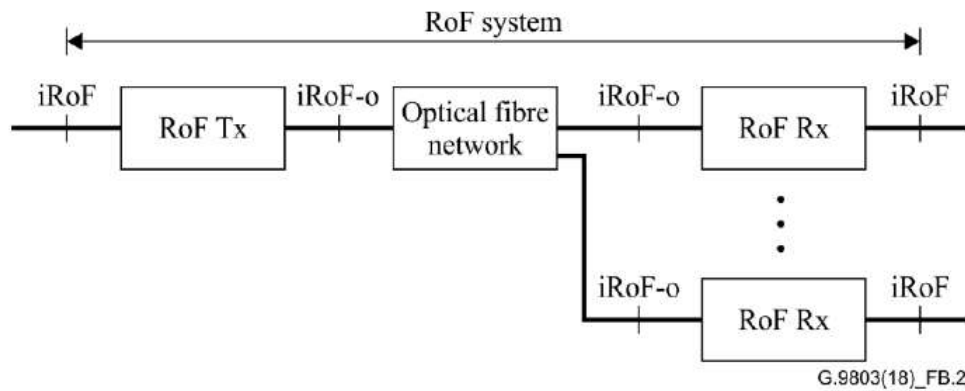
Figure 6 below shows an Analogue RoF system supporting international mobile telecommunication system over optical distribution network. This mainly consists of the RoF OLT, ODN, and the RoF optical network unit (ONU). The RoF OLT is commonly located in the network site and directly connected to one or more baseband units (BBUs). The basic function of the RoF OLT is to convert radio signals to optical signals and vice versa. In particular, a single RoF OLT is able to accommodate multiple BBUs to make efficient use of the ODN. The BBUs are linked with a service provider's core network to offer various mobile Internet services to users. The ODN is an optical fibre network consisting of optical fibres as a transmission media and optical splitters to provide connections between the RoF OLT and the RoF ONUs. The RoF ONUs are usually placed in remote sites and linked with one or more RRHs.



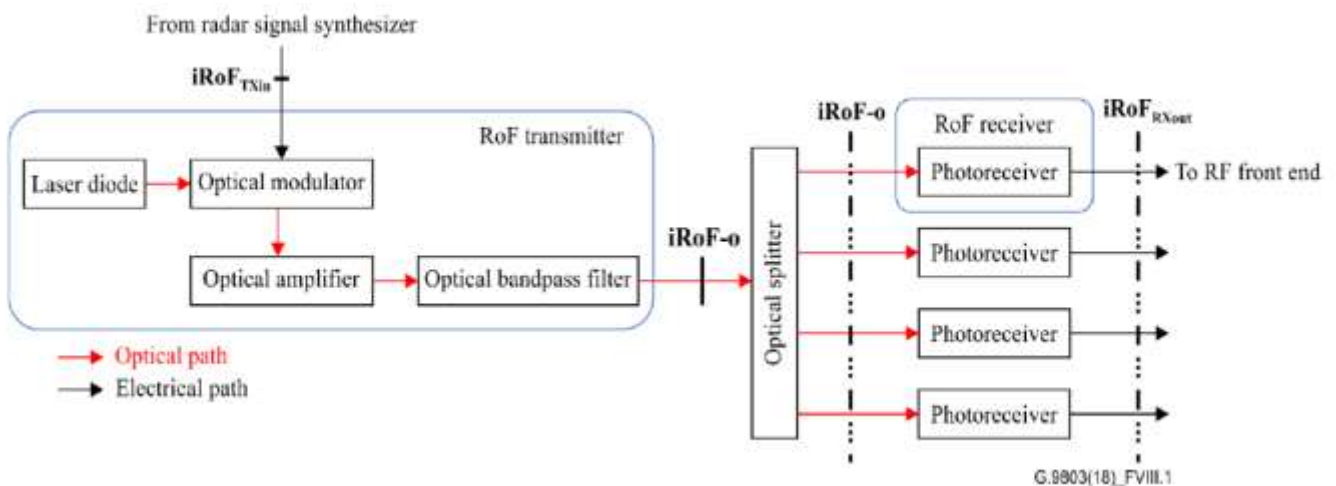
**Figure 6: Typical IMT system supported by RoF system**

### 2.3 Reference architecture for FOD (Foreign Object Debris) system

RoF system requirements include support for point-to-multi-point topology as shown below.



**Figure 7: Reference architecture of RoF system supporting an FOD detection system**



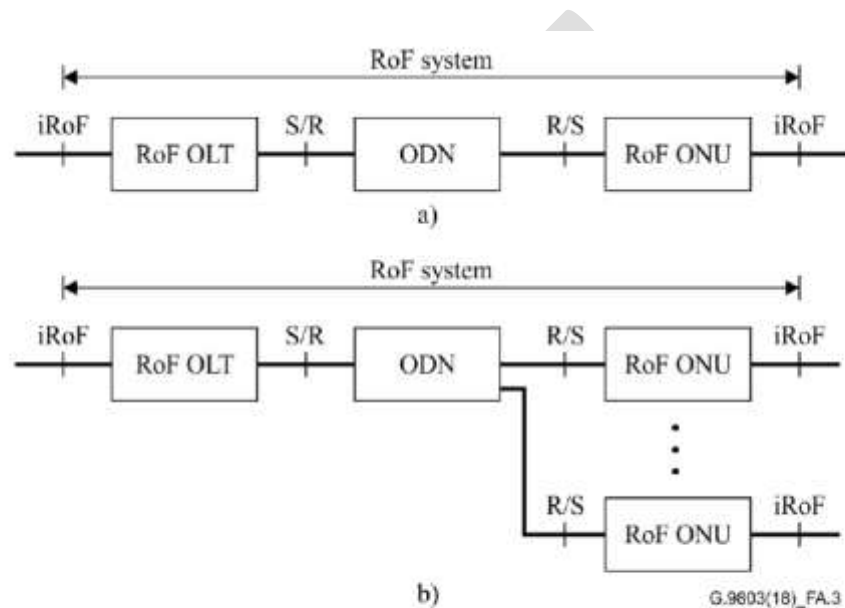
**Figure 8: Typical block diagram of RoF link for FOD system**

The RoF system consists of a RoF transmitter and multiple RoF receivers. They are connected by an optical fibre network including an optical splitter. The RoF transmitter typically consists of a laser diode, an optical modulator, an optical amplifier, and an optical bandpass filter. In the RoF transmitter, a driving signal from a radar signal synthesizer is put into the optical modulator and an FM-CW (frequency-modulation continuous-wave) RoF signal is generated as an output of the optical bandpass filter. The RoF receiver typically consists of a photoreceiver, where a received FM-CW RoF signal is converted to an electrical FM-CW signal, and put into an RF front end. Here, when the RF front end has a frequency multiplier

function, the output of RoF receiver may be a frequency-divided FM-CW signal.

## 2.4 Network Architecture

Figure 9 below shows point-to-point and point-to-multipoint configuration. Point-to-point configuration is composed of an RoF OLT, an RoF ONU, and an ODN connected together. In point-to-multi point configuration, a RoF OLT accommodates multiple RoF ONUs via a single ODN.



**Reference configurations of RoF system:**

**a) point-to-point configuration; and b) point-to-multi-point configuration**

**Figure 9: Network Architecture**

## 2.5 Equipment interfaces

### 2.5.1 Service node interfaces

SNI interconnects BBU and ROF-based access network. It should include a physical layer aspect and should be described by a well-known standard.

**Table A.1 – Examples of SNI and services supported by RoF systems**

SNI (Note 1)	Physical interface (Note 2)	Service (Note 3)
1GigE/10GigE/40GigE/100GigE [b-IEEE 802.3]	1000BASE/10GBASE/40GBASE /100GBASE	Ethernet
[b-ITU-T G.8261], [b-ITU-T G.8262]	–	Synchronous Ethernet
Common public radio interface (CPRI)/(open base station architecture initiative(OBSAI)/ open radio Interface (ORI)	–	IMT-2000 and IMT-Advanced

[b-ITU-R M.1457], [b-ITU-R M.2012]	[b-IEC 60169] based Analogue IF and RF interface	IMT-2000 and IMT-Advanced
NOTE 1 – There are many other services accommodated in RoF systems, but those services do not have specified SNIs.		
NOTE 2 – Each item in column "Physical interface" is illustrated by the corresponding entry in column "SNI".		
NOTE 3 – Column "Service" shows services supported by the physical interface.		

## 2.5.2 User network interfaces

UNI interconnects RRH and ROF-based access network . It should include a physical layer aspect and should be described by a well-known standard.

**Table A.2 – Examples of UNI and services supported by RoF systems**

UNI (Note 1)	Physical interface (Note 2)	Service (Note 3)
100 Mbit/s/1 Gbit/s Ethernet [b-IEEE 802.3]	100/1000BASE	Ethernet
[b-ITU-T G.8261], [b-ITU-T G.8262]	–	Synchronous Ethernet
CPRI/OBSAI/ORI	–	IMT-2000 and IMT-Advanced
[b-ITU-R M.1457], [b- ITU-R M.2012]	[b-IEC 60169] based Analogue IF and RF interface	IMT-2000 and IMT-Advanced
NOTE 1 – There are many other services accommodated in RoF systems, but those services do not have specified UNIs.		
NOTE 2 – Each item in column "Physical interface" is illustrated by the corresponding entry in column "UNI".		
NOTE 3 – Column "Service" shows services supported by the physical interface.		

## 2.6 Physical layer requirements

### 2.6.1 Transmission medium

This Recommendation is based on the fibre described in [ITU-T G.652]. Other fibre types compatible with this Recommendation, e.g., [ITU-T G.657], may be used for indoor cabling and/or drop section.

### 2.6.2 Frequency band

For IMT applications, see "Input carrier frequency" and "Output carrier frequency" in Appendix I for frequency band.

### 2.6.3 Optical link loss

For IMT applications, see "Optical Link Loss" in Appendix I for optical link loss.

For IMT (International Mobile Telecommunication) applications

## 2.7 System requirements

### 2.7.1 Operation, administration and management function

The RoF ONUs must be remotely manageable and support configuration functions. The RoF system must provide full fault, configuration, accounting, performance, and security (FCAPS) management capability for the RoF ONUs.

In traditional optical access systems, ONU management and control based on ONU management and control interface (OMCI) defined in [b-ITU-T G.988] may be used in the RoF system for RoF ONU management. Appendix I describes the operation, administration and management (OAM) channel frequency information. OAM parameters are described in chapter 4 part ii clause 1.1.2 .

### 2.7.2 Environmental requirements

For indoor use, the RoF system should operate in the operating temperature range defined in [b-IEC 62149-10]. For outdoor use, RoF ONUs should operate in the outdoor temperature range defined in [b-ATIS-0600010.01.2008], [b-Telcordia GR-487], or [b-ETSI ETS 300 019-1-4]. Optionally, the RoF OLT may be able to operate over the extended outside temperature range.

### 2.7.3 Eye safety

Taking coexistence with other PON systems into account, the total optical power at the point S just after the RoF OLT and RoF ONU should satisfy Class 1M and Class 1 shown in [b-IEC 60825-2], respectively. GR-487], or [b-ETSI ETS 300 019-1-4].

## 2.8 Coexistence with PON

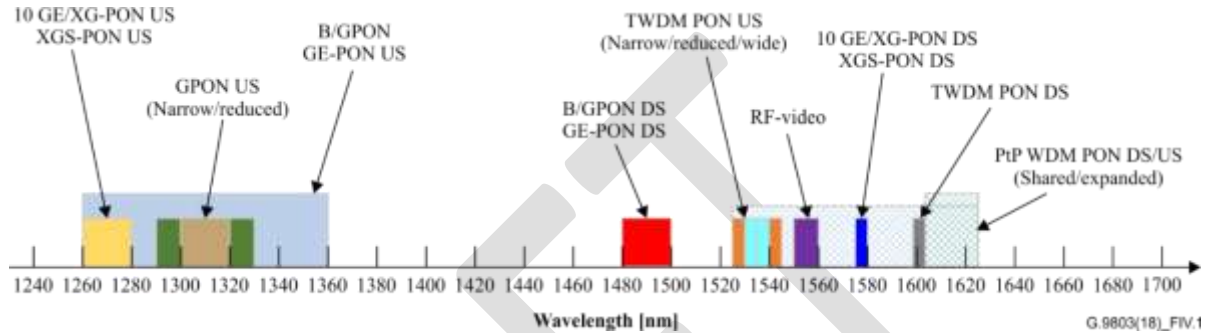
Possible PONs coexisting with RoF are

- (1) Gigabit-capable passive optical network (GPON)
- (2) 10-Gigabit-capable (symmetric) passive optical network (XG(S)-PON);
- (3) 40-Gigabit-capable passive optical network (NG-PON2).

WDM would be a reasonable method to support the coexistence.

## 2.9 Optical wavelength

Wavelength plans of standardized optical access network systems is shown below.



**Figure 10: Wavelength plans of optical access network systems**

Wavelength plan of the RoF system should be carefully designed by taking into account coexistence requirements with the deployed access networks. It would be possible to use the unoccupied wavelength region as the RoF system operating wavelength. It is also desirable to use a coarse wavelength division multiplexing (CWDM)-based wavelength plan.

## 2.10 Latency

Since most radio communication services have requirements related to latency, the RoF system should be designed to satisfy the required latency of each radio communication service. Therefore, in general, maximum fibre distance of the optical fibre network in the RoF should be limited to meet the demand.

## 2.11 Use Cases

Figure below shows a multiservice RoF system. This system consists of a multiservice RoF OLT, an ODN, and multiple RoF ONUs. The multiservice RoF OLT is located at the central office with connections to multiple BBUs corresponding to the number of services employed. Multiple BBUs correspond to the service provider’s various core networks for different services. RRHs connect RoF ONUs and antennas.

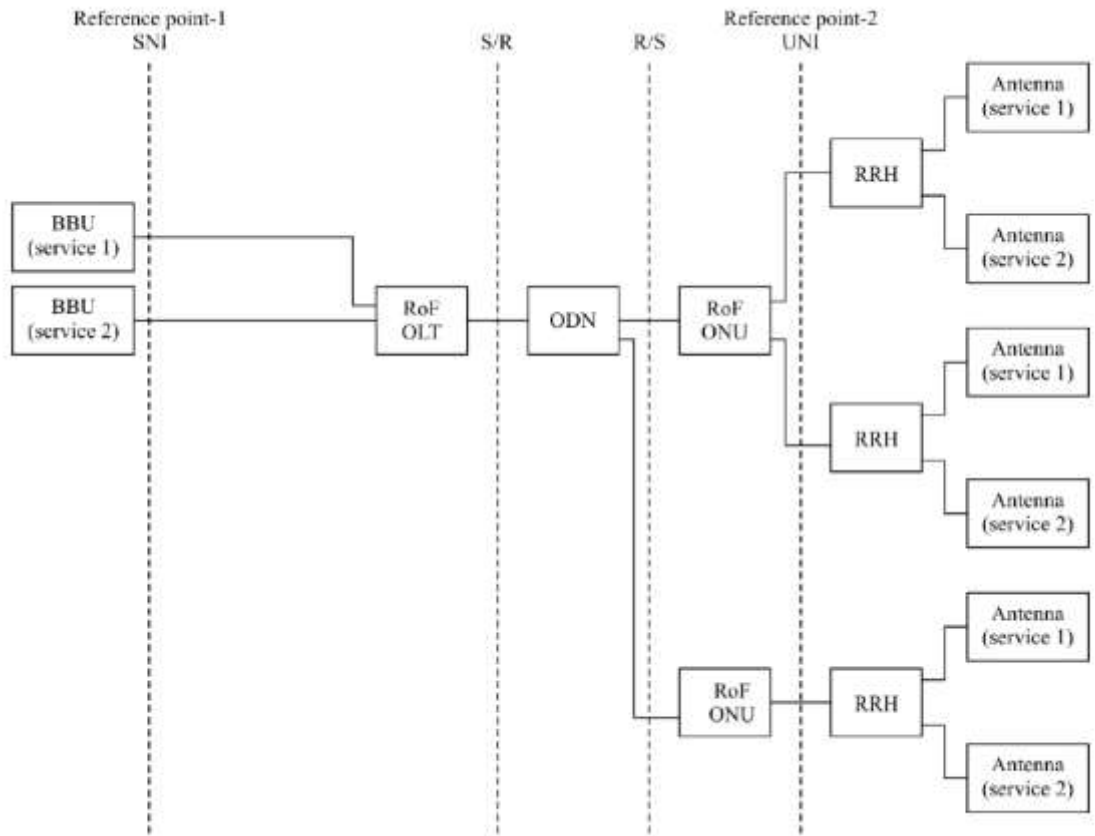


Figure 11: Multiservice RoF system architecture in single RoF OLT configuration

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## CHAPTER 2

### General Requirements

#### 1.0 Reference documents

- 1.1 Whatever that has not been specifically stated in this document, shall be deemed to be as per relevant latest ITU-T Recommendations.
- 1.2 Relevant ITU-T/IEEE Recommendations & other specifications are given in the GR.
- 1.3 All references to TEC standards & other Recommendations imply for their latest issues.

#### 2.0 Engineering requirements

- 2.1 The equipment shall be fully solid state and adopt state-of-the-art technology.
- 2.2 The equipment shall be compact and composite in construction and light-weight. The manufacturers shall furnish the actual dimensions and weight of the equipment.
- 2.3 All connectors shall be reliable and of standard type (CACT approved) to ensure failure free operation over long periods and under specified environmental conditions.
- 2.4 All connectors and the cable used shall be of low loss type and suitably shielded (CACT approved).
- 2.5 The equipment shall provide natural cooling arrangements. But the purchaser may allow use of fans if the natural cooling arrangement is not found adequate provided:
  - a. Fan failure is reported through LCT/EMS.
  - b. Fans are DC operated.
  - c. MTBF is better than 80,000 hours.
- 2.6 The plug-in units shall be of suitable type to allow their removal/insertion while the equipment is in energized condition.
- 2.7 The mechanical design and construction of each card/unit shall be inherently robust and rigid under all conditions of operation, adjustment,



replacement, storage and transport and conforming to TEC standard TEC 14016:2010 – “Standard For Environmental Testing of Telecommunication Equipment”.

- 2.8 Each sub-assembly shall be clearly marked with schematic reference to show its function, so that it is identifiable from the layout diagram in the handbook.
- 2.9 Each terminal block and individual tags shall be numbered suitably with clear identification code and shall correspond to the associated wiring drawings.
- 2.10 All controls, switches, indicators etc., shall be clearly marked to show their circuit diagrams and functions.
- 2.11 Facility to mount fixed-attenuator, if required, shall be provided in the receive-chain of the system.

### **3.0 Operational requirements**

- 3.1 The equipment shall be designed for continuous operation.
- 3.2 The equipment shall be able to perform satisfactorily without any degradation at an altitude up to 4000 meters above mean-sea-level. A test certificate from the manufacturer will be acceptable.
- 3.3 The equipment shall be able to work without any degradation in saline atmosphere near coastal areas and should be protected against corrosion.
- 3.4 Visual indication to show power ON/OFF status shall be provided.
- 3.5 Wherever the visual indications are provided, Green colour for healthy and Red colour unhealthy conditions would be provided. Some colour may be used for non-urgent alarms.
- 3.6 The equipment shall support Dual stack IP addresses (IPv4 &IPv6) for management and services.

### **4.0 Quality requirements**

- 4.1 The equipment shall be manufactured in accordance with international quality standards such as ISO 9001:2015 to meet the quality requirement.
- 4.2 The equipment shall conform to the requirements for environment as specified in TEC standard TEC 14016:2010– “Standard for Environmental

Testing of Telecommunication Equipment”. The applicable tests shall be conducted for respective environmental categories as follows:

#### **4.3 Environmental requirements for various ROF constituents**

##### **a. ONU/OLT**

(i) QM-333 ‘B2 or D’ category as offered by manufacturer for ONU

(ii) OLT shall provide compliance to QM-333 ‘B2’ category.

#### **5.0 Maintenance requirements**

**5.1** Maintenance philosophy is to replace faulty units/subsystems after quick on-line analysis through monitoring sockets, alarm indications and Built-in Test Equipment. The actual repair will be undertaken at centralized repair centers. The corrective measures at site shall involve replacement of faulty units/sub-systems.

**5.2** The equipment shall have easy access for servicing and maintenance.

**5.3** Suitable alarms shall be provided for identification of faults in the system and faulty units.

**5.4** Ratings and types of fuses used are to be indicated by the supplier.

**5.5** The manufacturer/supplier shall furnish the list of recommended spares for three years maintenance.

**5.6** The supplier shall have maintenance/repair facility in India.

**5.7** Supplier should guarantee the spares so long as the equipment is in service, at least for 10 years from the date of supply. The purchaser would like to stock spares as and when the supplier decides to close down the production of the offered equipment. In such an event, supplier shall give a two years notice to the purchaser so as to stock the life-time spares.

## 6.0 Power supply

### 6.1 Power supply requirements for various ROF system constituents:

- i. The primary power source shall be 230V+10%/-15%Vac, 50+/-2Hz for ONU. The ONU shall be designed to have protection of power transient, power-surge and power blowouts. In case of DC operation, the adaptor for AC↔DC may be external to ONU. The power rating shall be clearly marked on the device. The power backup requirement for ONU is left to the purchaser's discretion. The system shall be equipped to test, monitor and report (through EMS and LCT) the following (Note: applicable in case of presence of battery backup as requested by purchaser)::
  - A. Battery present or not (assessed by voltage of the battery)
  - B. Battery useful or not (assessed by a short periodic discharge/charge test)
  - C. Battery voltage
  - D. Charging current
  - E. Low capacity (means going to shut down soon).
- i. Nominal power supply is -48V DC for OLT with a variation in the range from -40V to -60V. The equipment shall operate over this range without any degradation in performance. The equipment shall be adequately protected in case of voltage variation beyond the range as specified above and also against input reverse polarity. The actual power rating/ consumption to be furnished by the manufacturer on the equipment. The OLT system shall be provided with at least two power feeds - centralized power supply with 1+1 redundancy.

**7.0 Energy Consumption Rating:** Energy Consumption Rating and Energy Passport of equipment shall be calculated as per TEC standard TEC 74046:2020 (or latest version).

## 8.0 Accessories

The supplier shall provide complete set of:

- a) All the necessary connectors, connecting cables and accessories required for satisfactory and convenient operation of the equipment. Types of connectors, adapters to be used and the accessories of the approved quality shall be clearly indicated in the operating manuals which should be in conformity with the detailed list in the standard

- b) Software and the arrangement to load the software at site.  
**Note.** *The quantity shall be as ordered by purchaser.*
- c) Special tools, extender-boards, extender-cables and accessories essential for installation, operation and maintenance of the equipment shall be clearly indicated and supplied along with the equipment.

## 9.0 Documentation

Technical literature in English language only shall be accepted.

### 9.1 Installation, operation and maintenance manual

It should cover the following:

- i. Safety measures to be observed in handling the equipment;
- ii. Precautions for installation, operation and maintenance;
- iii. Test jigs and fixtures required and procedures for routine maintenance, preventive maintenance, troubleshooting and sub-assembly replacement;
- iv. Illustration of internal and external mechanical parts.

### 9.2 Repair manual

It should cover the following:

- i. List of replaceable parts used including their sources and the approving authority.
- ii. Detailed ordering information for all the replaceable parts shall be listed in the manual to facilitate recording of spares.
- iii. Procedure for trouble-shooting and sub-assembly replacement shall be provided. Test fixture and accessories required for repair shall also be indicated. Systematic trouble shooting chart (fault-tree) shall be given for the probable faults with their remedial actions.

## 10.0 Mechanical standards

- a. As the ONU is located in customer premises, it should be designed to support wall-mounting as primary mounting.
- b. The OLT and ONU shall be housed in the standard sub-racks preferably 19" width. The OLT Card shall be fitted with motherboard duly masked to avoid short-circuiting. The sub-rack shall have protruded impressions on the top and base-plate of sub-rack assembly to act as built-in guides known as "CNC guide forming" for holding the PCBs in the sub-rack. The back and forth movement of PCBs shall be very smooth without any significant play towards the sideways.

- c. The guides in the sub-rack shall be made with CNC machines/tools. In case of CNC tool being used to make guides, in order to maintain the accuracy, the technique adopted shall use a single DIE punching. The plastic guides shall not be permitted.
- d. In order to avoid bending/sagging of top and base-plates during transportation, installation and maintenance process, the metal-sheet used for these plates shall be minimum 1.2 mm in thickness for mild-steel material, 1.5 mm for Aluminum material and in case of stainless-steel material; the thickness of metal-sheet shall be 1.0 mm.
- e. The connectors used on the PCB and their mating connectors on the mother-board shall have tight grip to avoid jacking problems. The connectors used shall be professional grade telecom connectors of international industry standards. (Euro-type or better).
- f. The slots for interfaces in the sub-rack shall be universal, supporting any type of PCBs in any position except for common control, matrix and line cards. No damage shall take place to PCBs when loaded in the wrong slot except in power-supply unit slots. The PCBs shall have the provision of locking/screwing to the sub-rack.
- g. The input/output terminations of tributary signals shall either follow extended mother-board using connectorised connections or directly from proper connectors at the mother-board.
- h. The height of main-rack shall be strictly as per this document till specified otherwise. The main-rack shall be made from metal-sheet of minimum 2.0 mm thickness and shall be covered from three-side minimum, with top and base covers. The thickness of the back-covers shall be 1.0 mm minimum. The base-plate of the main-rack shall be 2.0 mm minimum.
- i. The main-rack shall have adequate provision of holding/fixing the sub-racks in their positions. It shall be ensured that there is no lateral movement of sub-racks when fitted in main-rack. The main-rack shall have the proper fixing arrangements on floor, preferably with a base-plate and expansion-bolts etc. The thickness of base-plate shall be minimum 2.0 mm. The main-rack supplied with equipment shall be uniform in size irrespective of the loading of the equipment for all consignments by the manufacturer.

- j. The manufacturer shall specify the mechanical standard of racks and sub-racks in their manual and shall maintain the size and standard of racks, sub-racks, connectors etc., during supply of the equipment. The main-rack shall have sufficient space preferably in the sideways for running the input out cabling etc. This shall specifically be ensured during the testing, field trial and QA of the equipment.
- k. The permanent wiring such as distribution of power-supply etc. shall be pre-wired. During the testing and supply of the equipment the racks and sub-racks quality supplied by the manufacturer shall be ensured.
- l. The front/back opening of the sub-rack/main-rack is envisaged. No side-way opening shall be permitted. The access to data terminations shall be from the front/back side. However, with both the options available, the purchaser may specify specific requirements.

#### **11.0 Operating personnel safety requirements**

- 11.1 The equipment shall conform to IS 13252 part 1: 2010+Amd 2013+Amd 2015 “Information Technology Equipment – Safety- Part 1: General Requirements” [equivalent to IEC 60950-1:2005+A1:2009+A2:2013 “Information Technology Equipment – Safety- Part 1: General Requirements”]. The manufacturer/supplier shall submit a certificate in respect of compliance to these requirements.
- 11.2 The laser product shall meet the optical safety requirement as per IEC-60825-1. The equipment shall meet the optical safety requirement as per ALSD/ APR procedure of ITU-T Rec. G.664 (latest edition) on Class B laser. The equipment shall have visual warning and controls ensuring danger-free operation.
- 11.3 The equipment shall follow proper construction practice to minimize unintended radiation due to leakage from any gap or monitoring points. All unused ports and monitoring points should be terminated.
- 11.4 Protection against short circuit/open circuit in the accessible points shall be provided. All switches/controls on front panel shall have suitable safeguards against accidental operations.
- 11.5 The optical access ports should be designed to protect themselves against the entry of dust when they are not occupied by an external fiber-

optic connection. The optical access port shall be so positioned on the card as to be easy- to- clean by the user as well as for operation/handling purposes.

## 12.0 Minimum equipment requirements

Fully loaded pre-wired equipment for specific 'category/type' with input and output ports as specified in this standard. EMS and LCT shall also be offered. All test jigs, test instruments etc., shall be arranged by the manufacturer.

ONU	4 nos.
OLT	1 no.
EMS/LCT	1 no.

## 13.0 Field trial

The purchaser may conduct field trial for a minimum of 4 weeks. The manufacturer shall ensure that the equipment meets the field requirements of the purchaser.

## 14.0 Applicable tests(for TAC purpose):

### At OLT:

- a) **Mandatory interface and services**
- b) **PON ports**
- c) **All equipped interfaces & offered services**

### For ONU:

- a) **Mandatory interface and services:**
  - i. PON Port

---End of Chapter 2---

## Chapter 3

### EMC Requirements

#### 1.0 Electromagnetic Interference

The equipment shall conform to the following EMC requirements:

**General Electromagnetic Compatibility (EMC) Requirements:** - The equipment shall conform to the EMC requirements as per the following standards and limits indicated therein. A test certificate and test report shall be furnished from an accredited test agency.

a) **Conducted and radiated emission (applicable to telecom equipment):**

**Name of EMC Standard:** "As per CISPR 32 (2015) - Electromagnetic compatibility of multimedia equipment – Emission requirements "

- i. ONU and Mini/Desktop OLT shall comply with **Class B** and Chassis based OLT to comply with **Class A** of CISPR 32 (2015).
- ii. The values of limits shall be as per TEC Standard No. TEC 11016:2016.
- iii. For Radiated Emission tests, limits below 1 GHz for measuring distance of 3m.

**OR**

**Conducted and radiated emission (applicable to telecom equipment):**

**Name of EMC Standard:** "As per CISPR 11 {2015} Electromagnetic compatibility of multimedia equipment- Emission requirements"

**Limits:-**

- i. To comply with class B of CISPR 32 (2015).
- ii. The values of limits shall be as per clause No. 8.5.2 of TEC Standard No. TEC 11016:2016

b) **Immunity to Electrostatic discharge:**



**Name of EMC Standard:** As per IEC 61000-4-2 {2008} "Testing and measurement techniques of Electrostatic discharge immunity test" for the following.

**Limits: -**

- i. Contact discharge level 2 { $\pm 4$  kV} or higher voltage;
- ii. Air discharge level 3 { $\pm 8$  kV} or higher voltage;

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

**c) Immunity to radiated RF:**

**Name of EMC Standard:** As per IEC 61000-4-3 (2010) "Testing and measurement techniques-Radiated RF Electromagnetic Field Immunity test" for the following

**Limits:-**

**For Telecom Equipment and Telecom Terminal Equipment with Voice interface (s)**

- i. Under test level 2 {Test field strength of 3 V/m} for general purposes in frequency range 80 MHz to 1000 MHz and
- ii. Under test level 3 (10 V/m) for protection against digital radio telephones and other RF devices in frequency ranges 800 MHz to 960 MHz and 1.4 GHz to 6.0 GHz.

**For Telecom Terminal Equipment without Voice interface (s)**

Under test level 2 {Test field strength of 3 V/m} for general purposes in frequency range 80 MHz to 1000 MHz and for protection against digital radio telephones and other RF devices in frequency ranges 800 MHz to 960 MHz and 1.4 GHz to 6.0 GHz.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

**d) Immunity to fast transients (burst):**

**Name of EMC Standard:** As per IEC 61000-4-4 (2012) "Testing and measurement techniques of electrical fast transients / burst immunity test" for the following.

**Limits:-**

Test Level 2 i.e. a) 1 kV for AC/DC power lines; b) 0.5 kV for signal / control / data / telecom lines;

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

**e) Immunity to surges:**

**Name of EMC Standard:** As per IEC 61000-4-5 (2014) "Testing & Measurement techniques for Surge immunity test" for the following.

**Limits:-**

i) For mains power input ports:

- (a) 1.0 kV peak open circuit voltage for line to ground coupling
- (b) 0.5 kV peak open circuit voltage for line to line coupling
- (c) 4.0 kV peak open circuit voltage for line to ground coupling
- (d) 2.0 kV peak open circuit voltage for line to line coupling

ii) For telecom ports:

- (a) 1.0 kV peak open circuit voltage for line to ground
- (b) 0.5 kV peak open circuit voltage for line to line coupling.
- (c) 4.0 kV peak open circuit voltage for line to ground
- (d) 2.0 kV peak open circuit voltage for line to line coupling.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

**f) Immunity to conducted disturbance induced by Radio frequency fields:**

**Name of EMC Standard:** As per IEC 61000-4-6 (2013) "Testing & measurement techniques-Immunity to conducted disturbances induced by radio- frequency fields" for the following.

**Limits:-**

Under the test level 2 {3 V r.m.s.}in the frequency range 150 kHz-80 MHz for AC / DC lines and Signal /Control/telecom lines.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

**g) Immunity to voltage dips & short interruptions (applicable to only ac mains power input ports, if any):**

**Name of EMC Standard:** As per IEC 61000-4-11 (2004) "Testing & measurement techniques- voltage dips, short interruptions and voltage variations immunity tests" for the following.

**Limits:-**

- i. a voltage dip corresponding to a reduction of the supply voltage of 30% for 500ms (i.e. 70 % supply voltage for 500ms)
- ii. a voltage dip corresponding to a reduction of the supply voltage of 60% for 200ms; (i.e. 40% supply voltage for 200ms)
- iii. a voltage interruption corresponding to a reduction of supply voltage of > 95% for 5s.
- iv. a voltage interruption corresponding to a reduction of supply voltage of >95% for 10ms.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

**h) Immunity to voltage dips & short interruptions (applicable to only DC power input ports, if any):**

Name of EMC Standard: IEC 61000-4- 29:2000: Electromagnetic compatibility (EMC) - Part 4-29: "Testing & measurement techniques- voltage dips, short interruptions and voltage variations on DC input power port immunity tests" for the following.

**Limits:-**

- i. Voltage Interruption with 0% of supply for 10ms. Applicable Performance Criteria shall be B.
- ii. Voltage Interruption with 0% of supply for 30ms, 100ms, 300ms and 1000ms. Applicable Performance Criteria shall be C.
- iii. Voltage dip corresponding to 40% & 70% of supply for 10ms, 30 ms. Applicable Performance Criteria shall be B.
- iv. Voltage dip corresponding to 40% & 70% of supply for 100ms, 300ms and 1000ms. Applicable Performance Criteria shall be C
- v. Voltage variations corresponding to 80% and 120%of supply for 100ms to 10s as per Table 1c of IEC 61000-4-29. Applicable Performance Criteria shall be B.

**Note 1: Classification of the equipment:**

Class B: Class B is a category of apparatus which satisfies the class B disturbance limits. Class B is intended primarily for use in the domestic environment and may include:

- Equipment with no fixed place of use; for example, portable equipment powered by built in batteries;
- Telecommunication terminal equipment powered by the telecommunication networks
- Personal computers and auxiliary connected equipment.

Please note that the domestic environment is an environment where the use of broadcast radio and television receivers may be expected within a distance of 10 m of the apparatus connected.

**Class A:** Class A is a category of all other equipment, which satisfies the class A limits but not the class B limits.

**Note 2:** The test agency for EMC tests shall be an accredited agency and details of accreditation shall be submitted.

**Note 3:** For checking compliance with the above EMC requirements, the method of measurements shall be in accordance with TEC Standard No. TEC 11016:2016 and the references mentioned therein unless otherwise specified specifically. Alternatively, corresponding relevant Euro Norms of the above IEC/CISPR standards are also acceptable subject to the condition that frequency range and test level are met as per above mentioned sub clauses (a) to (g). The details of IEC/CISPR and their corresponding Euro Norms are as follows:

<b>IEC/CISPR</b>	<b>Euro Norm</b>
CISPR 11	EN 55011
CISPR 22	EN 55022
IEC 61000-4-2	EN 61000-4-2
IEC 61000-4-3	EN 61000-4-3
IEC 61000-4-4	EN 61000-4-4
IEC 61000-4-5	EN 61000-4-5
IEC 61000-4-6	EN 61000-4-6
IEC 61000-4-11	EN 61000-4-11

---End of Chapter 3---

## Chapter 4

### Element Management System and Local Craft Terminal

#### Part I: EMS Requirements

#### 1.0 General operational and functional requirements

An EMS shall be provided along with the ROF system for centralized management and control of the access network. The EMS shall be multi-user system and based on Graphical User Interface (GUI).

- 1.1 The management system shall comply with ITU-T G.9803 recommendation.
- 1.2 The access network management system shall be able to execute and configure the following.
- 1.3 The management menu selections should include the following functionality:
  - i. Alarm monitoring
  - ii. Customized EML functions as per the purchaser's requirement
  - iii. Remote view on ONT/ONU
  - iv. PON Management
  - v. IP management
  - vi. Alarm management
  - vii. Equipment management
  - viii. Service management
  - ix. Log management
  - x. Loopback Management
  - xi. Operational state
  - xii. Profile management
  - xiii. Performance monitoring
  - xiv. User security
- 1.4 Configuration of overall equipment with modules (ONUs, OLT and all related equipment modules).
  - i. EMS shall be able to display Graphical network topology
  - ii. All alarms and messages of the entire network to be displayed by EMS and for the local node by the LCT
  - iii. EMS/LCT shall be able to display Color coded graphical fault display
  - iv. Each individual site shall have the facility to be managed by Local craft terminal in the remote sites.

- v. The operator should be able to check system status, alarm information, alarm logging, performance data and performance system diagnostic from GUI. The EMS shall access and security control for multiple classes access.
- 1.5 The EMS shall provide:
- i. Security management (NE access control, EMS security control, and management privilege control)
  - ii. Configuration management (NE equipment provisioning, connection provisioning, and NE software download)
  - iii. Database management (system data, software version, and database backup).
- 1.6 It should be possible to generate customized reports for various types of faults, performance history, security management etc. It should also be possible to generate up time-reports to facilitate monitoring of performance statistics in a pre-defined/customized format. It shall be possible to generate and define the formats at any time, based on network needs.
- 1.7 It should be possible to have a view of selected network controlled by the Element Management System as per requirement. By zooming-in, it shall be possible to drill-down up to module-level in each NE for configuration and fault management. The same shall be provided through user-friendly GUI commands.
- 1.8 The EMS shall be able to diagnose its own faults by running diagnostic software.
- 1.9 The Element Manager shall provide the complete view of the network elements and the interconnecting links. The EMS shall have the ability to include the network elements and the links in the visual/graphical map of the domain. The visual maps shall display the elements and the links in different color depending upon the status of the links. It is preferable that green color for healthy and amber/yellow color for degraded condition and red for unhealthy condition is used.
- 1.10 It shall provide the ability to drill down to the individual element, then to subsystem, then to card and then to port level configuration template from the domain-map by clicking on the icon of the network element.
- 1.11 The Element Manager shall have suitable system level backup mechanism for taking backup of EMS data of at least one month. There shall be no magnetic

- tapes used for the objective, only DVD, CD-ROM, SSDs or any other suitable backup device with purchaser consent shall be provided.
- 1.12 The information model shall be as per specified standards. The EMS shall support correlation (filtering and suppression) to avoid multiple alarms from a single source of failure within the sub-network. Single Alarm shall be provided for the events that are correlated and are due to a common cause.
  - 1.13 The EMS shall provide the visual presentation of the Network Element's status and the alarms. It shall also present the complete map of the network domain with suitable icons and in suitable color like green for healthy, red for non-operational, yellow for degraded mode of operation etc.
  - 1.14 It shall be possible to take any Network Element out-of-service & in-service from the EMS. It shall be possible to restart the Network Element from EMS.
  - 1.15 The EMS shall carry out the systematic Health Monitoring of the elements of the Network. Check on the health of the card of any element of the Network shall be possible through command with settable periodicity - @ 24 hrs, 1 week, and 1 month.
  - 1.16 It shall be possible to log recent commands and be re-displayed, and re-issued on request through GUI if the southbound interface supported is TL.
  - 1.17 The configuration of the various network elements like creating or discovering, viewing, and editing shall be possible from the EMS. The configurations of the network elements shall also be stored at suitable place in EMS from where it can be retrieved in case of failure.
  - 1.18 It shall provide the graphical layout of the network elements with modules drawn using different colors to indicate their status.
  - 1.19 Manufacturer shall provide soft copy of EMS on a CD on per-ink or per-ring basis (or as asked for by the purchaser). The setup/procedure to download the software shall be clearly mentioned in the system manual of the equipment
  - 1.20 **Calendar Management:** It shall be possible to execute any schedulable administrative command i.e.- NE backup, software download, performance, operator log-in/ log-out etc., at any time by attaching a time tag to the command and it shall be executed when the Network real time matches the time tag. It shall be possible to define both time and date. If no date is mentioned, the command shall be executed daily at the time indicated.
  - 1.21 **Messaging system:** The EMS shall have a messaging system which will generate and send alert messages in the form of e-mail or SMS to the designated personnel depending upon the location of NE, on generation of



alarms.(Infrastructure required to support e-mail (ie, SMTP server) & SMS (ie; SMSC Server) shall be provided by the purchaser.

- 1.22 It is recommended that the response time for query/command on any operator terminal, local or remote shall be 10 seconds or better on GUI. For updation on topological information on the terminals, the response time shall be better than 20 seconds under all conditions. The response time shall however, be reviewed depending upon network conditions, total NE load and topology by purchaser during testing of EMS.
- 1.23 The supplier shall provide all necessary interface details (with the documents) for integration of its EMS with existing or proposed NMS (irrespective of its brand/make) and also provide time bound support for its integration, under obligation of a Non-Disclosure Agreement (NDA).
- 1.24 The supplier shall provide infrastructure requirements to the purchasers for setting up the EMS. Purchaser shall provide all the items of infrastructure include A/C power, Air conditioning load, space etc.
- 1.25 All critical components and units of the EMS i.e. – LAN interfaces, hard-disk, processor etc., shall be fault resilient.
- 1.26 It shall be possible to produce customized reports. The purchaser shall be free to ask for customization of reports based on the data available in the database from time to time in line with contractual agreement between the EMS Solution supplier and the purchaser.
- 1.27 It shall be desirable to interconnect a Disaster Recovery EMS with an existing EMS, in future, with possible manual switchover between them. The issues regarding hardware and software compatibility with regards to existing server platform shall be subject to a mutual understanding on the issue between purchaser and manufacturer. The expected downtime should be mentioned by the purchaser. Depending upon the expected downtime, deployment scenario, software and supporting hardware requirement may change. Purchaser should provide the required infrastructure to support automatic disaster recovery (if required).
- 1.28 Installation & commissioning of the EMS shall include supply & installation of cables, distribution frames, electrical switches etc. [Depends upon the decision taken by Purchaser as mentioned in point (x)].
- 1.29 Format for creation of database of network elements, circuits, ODN/OLT etc., and their numbering scheme, details of built up points across various rings other commissioning details, supplementary information, order reference,

dates etc. shall be define by the supplier to meet the requirement prescribed by purchaser at the time of validation of EMS and agreement.

- 1.30 The purchaser shall validate all the components of EMS and features of EMS as part of Acceptance Testing (AT).

## **2.0 EMS Architecture and Server Hardware Specifications**

### **2.1 Architecture**

- i. It shall be ensured that EMS connectivity to sub-network is not disrupted and there is no loss of EMS performance and fault data from the sub-network. To ensure EMS connectivity to the sub-network under control-card failure, there shall be provision to support control card redundancy. In case of total loss of EMS connectivity, the sub-network shall continue to provide the services without any deterioration.
- ii. In case of total loss of EMS connectivity, it is recommended that the performance data of the NE shall be stored in the controller card and shall be sent to central EMS server upon restoration of EMS connectivity. It is recommended that 15 minutes performance data for one day and 24 hour summary performance data for two days and fault data messages containing a minimum of last 100 alarms shall be stored by the system. The response time shall however, be reviewed depending upon total NE load and topology by purchaser during testing of EMS.
- iii. In case of loss of EMS connectivity, the LCT privilege shall remain for managing the local equipment, as privileged by EMS administrator.
- iv. The centralized EMS may consist of standalone application server, database server and firewall server or it can be a standalone EMS server subject to scaling requirements. Any other server required for meeting the purchase requirements shall be quoted separately by the bidder.
- v. Local Client connectivity to EMS for privileged operation shall be through a log-in password.
- vi. As a cost-effective measure, two display units are adequate for all the servers (application, database, and firewall servers). Purchaser is at discretion to convey any additional requirements. It shall be possible to access any server from any of the display.
- vii. The purchaser shall communicate requirements for (1+1) server backup or internal constituents of server.

## 2.2 Scalability aspects

- i. The EMS should be able to support at least 500 OLTs on a prescribed deployment setup (like Bare Metal, Virtual Machine, Containers) with appropriate deployment specifications. The EMS application shall also be scalable to 15000 ONT/ONUs subject to deployment setup scalability. Any more requirements may be communicated by purchaser. The maximum number of NE to be monitored by EMS should be informed to EMS solution provider. EMS solution may put software based restriction to avoid inclusion of extra NE by the purchaser.
- ii. The operating system and applications for EMS including database server shall be multi-user with minimum 25 concurrent users (including local terminals at EMS site and remote terminals i.e. LCTs). Any more requirements may be communicated by purchaser.
- iii. A minimum of four operator terminals will be provided at the EMS site. The EMS shall be equipped to connect to at least 5 local terminals at EMS site. It shall be upgradeable to 15 local terminals. The operator terminals at the EMS site are recommended to be PC i3, 1TB HDD, 21" LCD/TFT video display, DVD or better configuration, Ethernet interface (10/100G) with industry standard operating system UNIX/Linux/Windows but having GUI. Any other requirements shall be communicated by purchaser to supplier.
- iv. The EMS shall provide SNMP or TL1 options for southbound interfaces. The options for northbound interface shall be SOAP or XML or JSON or CORBA or better configuration.

## 2.3 EMS server specifications

- i. EMS software solution can be deployed on a bare metal standalone system or on bare metal clustered systems setup or on Virtual Machines or on Containers. It is mandatory for the EMS solution provider to elicit the deployment setup requirements for a purchaser prescribed deployment type, purchaser prescribed level of performance for a purchaser prescribed load levels. It is the prerogative of the purchaser to mention the type of deployment that they require and it is the prerogative of the purchaser to decide if the setup is to be provided by the EMS solution supplier or purchaser shall make the deployment setup available to the supplier to deploy the EMS software

solution. Procurement of the required setup depends upon the contractual agreement between the EMS solution supplier and the purchaser.

- ii. A sample deployment setup for EMS Software solution can be as mentioned below.
- iii. A 'Telecom Grade Enterprise Server' from a reputed national/international vendor with broad specifications, as below, shall be provided.
- iv. The multi-process EMS design is recommended which shall enable distribution of functions over multiple processors. In addition, the RMI inter-process communication enables distribution of functions over multiple servers. Consequently, increasing system capability can be achieved by upgrading the existing platform (e.g. adding CPUs) or adding new servers into the cluster. The manufacturer shall indicate limitations regarding processing requests, notifications, updates, Network-map view refreshing etc., in the supplied system.
- v. Both Application and Database servers shall have UNIX based operating system.
- vi. The EMS shall be supplied with a Work Station offering Graphical User Interface (GUI) using 17" colour screen with key board and mouse etc. the Work Station shall be of latest type of machine with very high processing speed as available on the date of procurement of equipment. The Work Station shall support Ethernet ports as 10BaseT, 100BaseT and 1000BaseT. The operating system shall be Windows 10 or latest, Linux or Unix. The specifications are given in clause 2.7 of Chapter-4 (Part-I).

## **2.4 Application server specifications**

Deployment setup related details mentioned in the above section 2.3 are applicable here as well. The EMS application server shall be multi-processor with minimum 4 processor with each processor having at least 8 cores, RISC/CISC based 64 bit system with at least 1.9 GHz clock, 32GB RAM, 1GB cache memory, 160GB HDD/500GB HDD with CD-ROM/DVD-ROM or any suitable back-up device (with purchaser consent), multiple Ethernet LAN interfaces and the server shall operate in high availability cluster mode.

## **2.5 Database server specifications**

- i. Deployment setup related details mentioned in the above section 2.3 are applicable here as well. The database server shall be multi-processor with

- minimum 4 processors with each processor having at least 8 cores, RISC/CISC based 64 bit system with at least 1.9 GHz clock, 32GB RAM, 1GB cache memory. However, the purchaser may choose single server as per network needs. The system shall support at least 6xDVD for loading of software configuration. The system shall have Hard-disk storage implemented on RAID 0, RAID 1, T+RAID 0+1 and RAID 5 architecture of disk storage which shall be configurable. The RAID system shall be hardware based and shall have redundant fibre based RAID controller. The hard-disk storage shall provide for no single point of failure. The server will operate in high availability cluster mode, on load sharing basis. Exact specifications may be issued by purchaser.
- ii. Database hard-disk memory shall be sufficient to store all the information as indicated in the document and any other necessary system for at least one month duration.
  - iii. Each of the server i.e. EMS server and database server as well as firewall server shall have redundancy for control module, disk, power supply and LAN interface.
  - iv. Industry standard relational database (RDBMS) for storing all the data related to the network and the system shall be used.
  - v. The database interface shall be open so that a centralized EMS at a future date is able to retrieve information from the EMS database using TCP/IP stack and do post processing. The data base structure for all the databases used in the system shall be provided. [This point violates the IPR of the solution provider. It's the ingenuity of the solution provider how efficiently he designs the database and hence cannot be revealed. What can be made available are the APIs of interest w.r.t FCAPS functionalities (adhering to NG-PON2 standard Data Models - if any) through which data can be accessed by any third party solution with applicable performance matrices namely (a) allowed periodicity/frequency of access of specific APIs (b) allowed extent of data accessed per request (c) allowed format of data access etc.
  - vi. The memory of the Database server shall be sufficient to store the data of 500 full loaded OLTs and 15000 ONT/ONUs (as per respective type/category of equipment) at a minimum. It shall be capable of storing performance/fault history of 30 days of the network under its domain. This shall be ensured during the testing of the equipment. EMS may delete data older than 30 days to maintain enough storage for new data. The purchaser shall inform EMS

supplier in advance if the limit of data maintenance has to be more than 30 days.

## 2.6 Firewall server [optional to purchaser's requirements]

- i. In order to provide security to EMS from public networks, a dual redundant hardware based Firewall system may be provided at each of the NMS locations for providing security to the various servers at the EMS. The Firewall system shall be as per TEC GR No.: TEC 49090:2014. The FWS shall have a capability of handling a concurrent sessions of around 20,000. The Firewall system shall support 4 ports of 10/100/1000BaseT expandable to 12 ports.
- ii. There shall be a common Firewall system. The Firewall system shall be used for providing the security cover to the Web-based Customer-care system from the internet. The same Firewall system shall also provide the security to the EMS database from the Internet and the Web-based Customer-care users & the systems.
- iii. The Firewall shall be based on stateful connection-oriented fire-walling and shall be appliance/hardware based. The Firewall shall track the following parameters of each packet-source and destination address, Transmission Control Protocol (TCP) sequence numbers, port numbers and TCP flags.

**Note: All the above servers can be standalone or house on one machine.**

## 2.7 Specifications for local craft terminal/work station

The LCT desktop configuration as a PC or laptop shall be as given below at a minimum-

- i. i7 processor or better
- ii. 21" TFT/ LCD monitor
- iii. 1TB HDD/ 8GB RAM or better
- iv. DVD Drive or any suitable back-up device (with purchaser consent)
- v. Dual Ethernet LAN port
- vi. Min 2 nos. USB ports
- vii. USB Keyboard port
- viii. Licensed operating software preloaded/recovery CDs / recovery license key.

The Desktop/Laptop shall be supplied with the LCT software installed in it.  
The PC shall be from a reputed international/national PC manufacturer.

**Note 1:** No QM-333 environmental tests shall be conducted on the EMS server/LCT PC.

**Note 2:** Actual server sizing defined is left to purchaser requirements.

*--End of Chapter 4 (Part - I) --*

DRAFT

## Part II: FCAPS requirements

### 1.0 Network management functions

#### 1.1 General functions

The equipment shall provide a centralized element management system (EMS) as well as shall provide local management capability through an LCT, which shall be capable of managing the required functions and shall also be used for carrying out supervisory, maintenance, fault localization & performance functions (FCAPS) as described in ITU-T Rec.9803 for ROF system. It shall be possible to manage various constituent of the system through local management interface) as well as through remote management interface.

The equipment EMS shall provide general management functions described in ITU-T Rec. G.784. The filters for performance and fault management shall also be as per ITU-T Rec. G.784. The other management functions as defined in ITU-T Rec. G.784 shall be as under:

1. Configuration management
2. Fault management
3. Performance management
4. Security management
5. Software management
6. Inventory management.

##### 1.1.1 Configuration management

The equipment EMS shall support configuration and provisioning capabilities as per IEEE 802.3av. The system shall support 'point & click' provisioning in a vendor's sub-network, subject to clearance by Inventory management, shall be supported as per the following configuration provisioning:

- 1.1.1.1 Network Element creation in the NE management domain.
- 1.1.1.2 Programming of a multiple interface units.
- 1.1.1.3 To create, update, delete and retrieve the managed network topology data.



1.1.1.4 Assigning the equipment protection to a unit/interface.

1.1.1.5 Error detection thresholds.

1.1.1.6 Network Element configuration.

1.1.1.7 Software download (local & remote).

1.1.1.8 Protection switching.

1.1.1.9 Ethernet interface bandwidth.

1.1.1.10 The layer-2 control protocol between ONU and OLT shall be MPCP  
Multipoint Control Protocol

### 1.1.2 Fault management

The equipment management system shall support OAM parameter in table shown below

Physical layer OAM parameters and their appropriate ranges for RoF OLT & RoF ONU				
Parameter	Function	Ranges	Unit	Comment
System input level (total RF power) control	control	0~30	dB	electrical attenuation level
System output level (total RF power) control	control	0~30	dB	electrical attenuation level
System input level (total RF power) monitor	monitor	-30~0	dBm	electrical power monitor
System output level (total RF power) monitor	monitor	-30~0	dBm	electrical power monitor
Optical output power/channel control	control	+3~+7	dBm	optical power control
Optical output power/channel monitor	monitor	-3~+7	dBm	optical power monitor
Optical output power/channel alarm	alarm	<+3	dBm	optical power alarm
Optical input power/channel monitor	monitor	-3~-13	dBm	optical power monitor
Optical input power/channel alarm	alarm	<-5	dBm	optical power alarm
LD enable	control	-	-	enable/disable
PD enable	control	-	-	enable/disable
DC power failure	alarm	-	-	failure alarm
FSK modem enable	control	-	-	enable/disable
FSK modem alarm	alarm	below received signal strength indication (RSSI) threshold value	V	failure alarm

The EMS Network Element shall perform a persistency check on the fault-cause, before it declares a fault causing failure.

The equipment shall do surveillance of alarms & their detection, reporting of relevant events and conditions that lead to the generation of alarm after filtering. Further, the element management system shall support the following:

- 1.1.2.1 Path alarm notification to be generated and recorded, the alarm notification shall include: type, occurrence, severity, probable cause and clearing.
- 1.1.2.2 Path alarm shall be graphically shown by the EMS-.
- 1.1.2.3 Alarm and status display.
- 1.1.2.4 Fault localization.
- 1.1.2.5 Fault correlation control.
- 1.1.2.6 Storing and processing of current alarm information, up to module/unit level.
- 1.1.2.7 Storing and processing of historical alarm information for 30 days minimum. The EMS/LCT shall provide on-line logging capability for historical alarms and events with sufficient information such as managed resources, alarm/event type, alarm severity, day and time of occurrence etc. The retrieving functions with filtering capabilities for historical alarms and events shall be provided as well.
- 1.1.2.8 Assigning alarm severity i.e., Critical, Major, Minor & Deferred.

### **1.1.3 Performance management**

The performance management shall consist of set of functions that evaluate and report on the behavior of network element and their effectiveness relating to the communication taking place on the network. The performance management shall deal with definitions, evaluation and reporting of equipment performance.

It shall be possible to store all the performance and traffic statistics for a month. It shall also be possible to generate daily, weekly, monthly reports for the individual element as well as complete domain. The report generation shall be supported for text and graphic reports.

If the management protocol is based on SNMP then the performance monitoring will be based on RFC 2558. Performance history for minimum 30 days shall be supported with configurable launch-time and performance evaluation/integration period. The main performance functionality to be provided shall be as under:

- 1.1.3.1 Configuration of threshold concerning the error counters.
- 1.1.3.2 Performance history (data logging).
- 1.1.3.3 The EMS shall store the performance data of the sub-network in terms of configured circuits. In addition to, the following shall also be some of the different parameters that shall be stored
- 1.1.3.4 The collection of the performance counters shall be performed at pre-assigned rate.
- 1.1.3.5 The EMS shall support configurable scheduling of the performance measurement, collection, storage and transfer of the performance statistics. It shall also support presentation of the performance statistics in graphical and text mode as and when requested and at repeated interval automatically.

#### **1.1.4 Security management**

The management system shall provide adequate security to the data and for the access to the management system as per the following details:

- 1.1.4.1 The EMS shall have the capability of supporting the management of Network through local and remote operators. The authorizations and the privileges of the operators (remote and local) shall depend upon the Login and Password.
  - a. Low-level protection for read only access to faults and performance information.
  - b. Medium-level protection for access to configuration status and features.
  - c. High-level protection for control of access to change in the configuration and control parameters.
- 1.1.4.2 Network management security features shall include operator authentication, command, menu-restriction and operator privileges. The EMS shall support multi-level passwords as below-
  - a. EMS shall allow the System Administrator to define the level of access to the network capabilities or feature for each assigned password. It shall be desirable that the EMS shall block the access to the operator in case of unauthorized commands being tried for five consecutive times. Also it is desirable that the EMS shall also not allow the entry

- into the EMS in case wrong password is provided more than five consecutive times during the login.
- b. The system administrator shall be able to monitor and log all operator activities in the EMS and Local Craft Terminal.
  - c. The dynamic password facility shall be provided in which the operator may change his password at any time.
- 1.1.4.3 All log-in and log-out attempts shall be logged in the security log file of the EMS system.
- 1.1.4.4 The network and the management system shall be protected against intentional or accidental abuse, unauthorized access and loss of communication.
- 1.1.4.5 The man-machine communication programs shall have the facility of restricting the use of certain commands or procedures to certain passwords and terminals.
- 1.1.4.6 The Equipment shall normally operate through the centralized EMS. Only in case of failure of link between the Equipment location and the EMS, the LCT should be able to manage the local assigned to it.
- 1.1.4.7 It should be mandatory for the system to have a record of all log-ins for a period of at least six months after which a back up should be possible under system administrator command.
- 1.1.4.8 It shall be possible to connect EMS and the network elements to the IP-MPLS network. The EMS and components of the existing/proposed Network Management Layer (NML)/Service Management Layer (SML) of a purchaser shall be part of the common MPLS-VPN providing the inherent security required for the management information in addition to the login and password based authorization for the operators of the Network Manager.
- 1.1.4.9 Back up for programmes and data.
- 1.1.4.10 The EMS shall be able to back up and restore the data base to and from external storage media.
- 1.1.4.11 External security measures (optional to purchaser's requirements)**
- Network security may require deployment of external devices/machines/firm-ware at the network operation centre [NOC], like-
- a. Firewalls
  - b. Access control servers
  - c. Data encryption devices/use of PKI keys

- d. Anti-virus packages.
- e. In the data communication network (DCN) for management system, VLAN tags/MPLS labels may be used for security to information flows from NEs to DCN Gateways with IPSec, PKI security options.

The purchaser may communicate requirements as per his network security needs.

### **1.1.5 Inventory management**

- 1.1.5.1 It shall indicate the absence or presence of any physical module in hardware elements. It shall also indicate the usage of module i.e., how many ports are in use, which interface is in use and which are free to be used etc.
- 1.1.5.2 The EMS shall be able to discover and keep the device information
- 1.1.5.3 The EMS shall be able to keep track on any change in the network inventory reported chronologically.
- 1.1.5.4 The EMS shall provide the inventory information to the Network Management Layer (NML)/Service Management Layer (SML) so that SML is able to create and activate a service to the customer automatically. This shall also assist SML in providing the network inventory to which the SML shall add the customer identification and maintain this information in its database.
- 1.1.5.5 The EMS shall be able to show inventory based on the available device inventory in terms of circuits' utilization.
- 1.1.5.6 The EMS shall provide the complete view of the network elements and the interconnecting links.

### **1.1.6 Software management**

It shall be possible to carry out the following tasks under the software management function

- 1.1.6.1 Loading of new system software.
- 1.1.6.2 Manage different versions of software.
- 1.1.6.3 Shall have the capability of managing multiple versions of software for individual elements. In this case, one software version shall remain active and other versions shall be passive.
- 1.1.6.4 Installation of software patches.

- 1.1.6.5 Examine contents of all system memory and disk memory.
- 1.1.6.6 At the time of downloading the software, the message shall be displayed that the software has been downloaded successfully or failed and at what stage.
- 1.1.6.7 The EMS shall support FTP/TFTP for downloading of Software, configuration, patches etc., to the Network Element.
- 1.1.6.8 The operator terminals (local & remote) shall not allow loading of any software without the terminal administrator's authorization.
- 1.1.6.9 The EMS shall enable operations like changing the system configuration, reconfiguration of input and output devices, loading a new software package, etc. Both automatic and manual reconfiguration capabilities shall be available.
- 1.1.6.10 All commands which are executed over the EMS program or data shall be logged in a file (read only) and it shall be possible to retrieve the same on demand whenever required, using man-machine commands. The file usage of up to 50%, 75% and 90% shall generate alerts in the server platform, of suitable category prompting the operator to initiate the backup operation. This is applicable only if the south bound interface is TL-1.
- 1.1.6.11 It shall be possible through a single man-machine command to obtain a list and the total number of equipment of a particular domain in a state (e.g. in-service, blocked etc.).
- 1.1.6.12 While working on system level commands, it shall be possible to store at least the last 20 commands on the screen and by scrolling and editing any command shall be re-executable. This is applicable only if the south bound interface is TL-1.

### **1.1.7 Software download**

Local & remote software download via management system to NEs and LCT shall be possible, including the means of identification of software module versions. No loss of data/traffic & connection-map shall take place during the software down-loading process.

### **1.1.8 Management interface details**

The complete details of the management interface and the protocols, as pertaining to each layer of the protocol-stack implemented in the

management system, shall be made available, for the purpose of integrating the local management capabilities with the centralized NMS at a later date. The requirements, in brief, shall be:

- i. Protocol details at all layers of TCP/IP stack.
- ii. PHY I/F at each layer.
- iii. Database structures.
- iv. Number formats.
- v. Node addressing system.
- vi. Complete application software details etc.
- vii. EMS software check-sum.

### 1.1.9 Southbound management interface

The system shall provide at least one remote management interface and one Local Management Interface (LMI) at each Network

The system shall provide an SNMP version2c [or later interface] with standard MIBs Browser. It shall be implemented on UDP/IP stack at all Gateway NEs (GNEs) to interact with a centralized Element Management System (EMS). Or else ITU-T specified Qx or Bellcore specified TL1 interface implemented on TCP/IP, remote management interface shall also be acceptable.

**Note 1.** The equipment shall provide an Ethernet port for Work Station/Network Server connectivity with standard RJ-45 connector.

**Note 2.** The purchaser may validate vendor's claim for management functions as well as protocol compliance for Qx or SNMPv2c interface (or later interface) through NMS Protocol Analyzer etc.

### 1.1.10 Northbound management interface

For remote management purposes, the equipment shall provide remote and local management interfaces at NEs as outlined in the GR. The northbound interface of the EMS towards NMS layer shall be TMF 814 CORBA [version 3.0] or SOAP or XML. And the southbound interface towards NEs shall be SNMPv2c [or later interface] implemented on UDP/IP stack. The purchaser may verify SNMP MIBs and CORBA IDLs during their testing.

### **1.1.11 Local management interface**

The manufacturer shall provide a Work Station/Network Server, which shall act as a manager of management activities, i.e. monitoring and controlling NEs within its management domain. The Local Craft Terminal i.e., a Personal Computer shall support the local management of NEs. The Local Craft Terminal and Network Server shall be operating simultaneously.

The inter-office communication shall be facilitated through in-band management channels or dedicated data-link. The equipment shall provide V.24/V.28/RS232/RS-485/RJ-45 for connecting a PC-server as a Local Craft Terminal.

### **1.1.12 User interface**

The management system shall be provided with user-friendly interfaces based on Windows/UNIX icons & menus and mouse to accomplish management function that needs user interventions. The EMS start-up and shut-down shall be user friendly, and shall provide on-line help. The EMS shall be able to provide an on-screen nested geographical view of the managed network in the management domain of the manufacturer. It shall be possible to access any managed node within the whole network in the managed domain. The EMS shall be able to depict the failure state of each link and node in the displayed network.

Further, it shall also be possible from the EMS system to get the details of status of an individual managed NE, such as equipment presence, settings, alarm status etc.

## **1.2 Additional functional requirements**

### **1.2.1 ONU requirements**

1.2.1.1 ONU shall perform following tests/monitor relative to the battery to be reported through EMS and LCT:

- i. Battery present or not (assessed by voltage of the battery)
- ii. Battery useful or not (assessed by a short periodic discharge/charge test)



- iii. Battery voltage
- iv. Charging current
- v. Low capacity (means going to shutdown soon).

#### 1.2.1.2 Status reporting

- i. ONU ID
- ii. PON port link status
- iii. Power supply status
- iv. Vendor code
- v. Model number.

#### 1.2.1.3 ONU shall also support the following:

- i. Vendor code and model number in EEPROM.
- ii. Remote download firmware upgrade.
- iii. **LED status indication**
  - A. **Power.** Indicates power on/off status
  - a. **Operation.** Indicates PON fiber link is normal and OAM channel is operational

#### 1.2.2 OLT requirements.

- 1.2.2.1 The OLT shall provide one craft port for local configuration access.
- 1.2.2.2 The OLT shall provide in-band management connection to the EMS through GigE from the network.
- 1.2.2.3 The OLT shall provide out-band management connection to the EMS through 10/100/1000BaseT Ethernet interface.
- 1.2.2.4 The OLT shall support alarm output and control
  - A. Critical alarm output
  - B. Major alarm output
  - C. Minor alarm output
- 1.2.2.5 Line rate, security, and performance requirements
- 1.2.2.6 Network diagnostic and healthy check.

---End of Chapter 4 (Part-II)---

## APPENDIX-I

### Example system interface specifications

Figure below illustrates the RoF system configuration supporting international mobile telecommunication (IMT) system ODN. This configuration is based on the Reference architecture described in clause 2.2

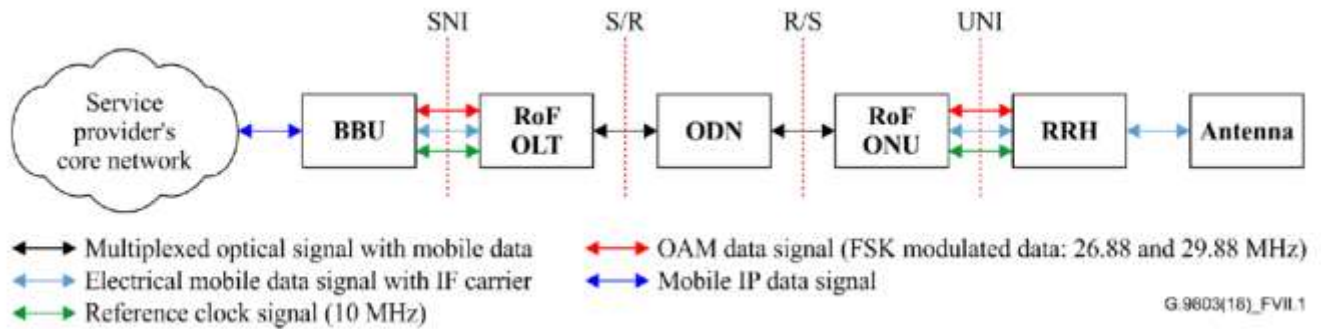


Figure 8: ROF system supporting IMT system over ODN

Table VII.1 – Example system interface specification

Items	Specifications	
	Downlink	Uplink
Input carrier frequency @ SNI & UNI (intermediate frequency)	150,170,270,290,390,410,510,530,630,650,750,770 MHz (12IF)	
Output carrier frequency @ SNI & UNI (intermediate frequency)	150,170,270,290,390,410,510,530,630,650,750,770 MHz (12IF)	
Each carrier bandwidth @ SNI & UNI	1.4, 3, 5, 10, 20 MHz	
Reference frequency for up/down conversion @ SNI & UNI	10 MHz	
OAM channel frequency @ SNI & UNI	Below 100 MHz (ex: 26.88 MHz downlink frequency-shift keying (FSK), 29.88 MHz uplink FSK)	
System input level (total power) @ SNI & UNI	-10 dBm	-10 dBm
System output level (total power) @ SNI & UNI	-10 dBm	-10 dBm
Gain (from SNI to UNI or vice versa)	0 dB	0 dB
Optical modulation index (OMI) per channel @ S/R or R/S	~ 0.1 (typ.)	
Ripple @ SNI & UNI	±1.0 dB Max.	
	DL0	1550 nm ±7.5 nm
	DL1	1570 nm ±7.5 nm
	UL0	1510 nm ±7.5 nm

**Table VII.1 – Example system interface specification**

Items		Specifications	
		Downlink	Uplink
Optic wavelength @ S/R or R/S (support for multi operator or multi service)	UL1	1530 nm $\pm$ 7.5 nm	
Optic link loss between S/R and R/S		0 ~ 10 dB	
Operating temp		-20 ~ +60°C	
Gain variation with temp @ SNI & UNI		3 dBp-p@-20~+60°C	
Optical power/channel @ S/R or R/S		+5 dBm $\pm$ 1.5dB (Typ)	
TX $\leftrightarrow$ RX isolation @ SNI & UNI		Above 50 dBc/max gain	
Noise floor @ SNI & UNI		-130 dBm/Hz	
Transmission medium		Optical fibre described in [ITU-T G.989.2]	

## APPENDIX-II

### RoF system Service Support

RoF systems have the potential to support various services for mobile users, residential subscribers, business customers, mobile and fixed backhauling, and other applications. Mobile services defined in ITU-R recommendations on IMT-2000 and IMT-Advanced are basically supported by RoF systems. Table below summarizes examples of current and future mobile services supported by RoF systems.

#### Examples of current and future mobile services supported by RoF systems

No.	Service	Remarks
1	Messaging	Messaging services (e.g., SMS, MMS, e-mail) exchange messages between user terminals. Video messaging service is comparable to voicemail with a video accompanying the voice message.
2	Voice telephony	Voice communication involving two or more parties that includes features such as call waiting, conference calling, voicemail, message waiting indication, caller ID and calling name ID. Voice over IP (VoIP) is a form of voice telephony service. See [b-ITU-T H.323].
3	High-quality video telephony	High-quality video telephony is full-duplex, realtime audiovisual communication between or among end users. It may be provided as a complement of traditional voice telephony service. See [b-ITU-T H.100], [b-ITU-T F.703], [b-ITU-T F.724].
4	Video conference	Video conference is full-duplex, realtime audiovisual communication between or among end users. See [b-ITU-T H.140], [b-ITU-T F.702], [b-ITU-T F.733].
5	Internet browsing	Internet browsing is accessing Internet pages to get information. It mainly involves communication between UE and an information server/content provider.
6	Interactive gaming	Interactive gaming services mainly involve data transferred between multiple users that are connected to a server, or directly between the equipment of multiple users. Realtime communication with low delay and low jitter may be required for interactive gaming.
7	File transfer/download	File transfer/download is the act of transferring a file electronically from one network element to another.
8	Multimedia	Multimedia is media that uses multiple forms of information content and information processing (e.g., text, audio, graphics, animation, video, interactivity) to inform or entertain the audience (user). Multimedia communication is an essential element of various application services described in this section which are to be supported by IMT. See [b-ITU-T F.700], [b-ITU-T F.701], [b-ITU-T F.741].

**Examples of current and future mobile services supported by RoF systems**

No.	Service	Remarks
9	Mobile broadcasting/multicasting	Mobile broadcasting is one to many transmission of multimedia content (e.g., text, audio and video) over the mobile networks. This includes mobile instant and interactive content/TV is the ability to interact with an audio/video programme by exchanging multimedia information.
10	IoT (Internet of Things)	Every object is being and will be connected through wired or wireless internet technologies. These connected "things" can be smart phones, sensors, actuators, cameras, vehicles, etc., ranging from low-complexity devices to highly complex and advanced devices. A significant number of connected devices are expected to use IMT systems. Smart energy distribution grid system, agriculture, healthcare, vehicle-to-vehicle and vehicle-to-road infrastructure communication are generally viewed as potential fields for further growth of the IoT.
11	Mobile commerce	Mobile commerce is buying and selling of goods and services through wireless handheld devices, such as cellular telephone and personal digital assistants. It mainly involves data transferred between UE and financial servers connected with secured databases. This service also enables the realtime sharing and management of information on products, inventory, availability, etc. This service requires a high level of reliability.
12	Public alerting	Public alerting enables emergency management officers to quickly notify all residents and emergency response teams, within a defined area of hazardous situations, such as chemical spills, power outages, weather warnings and other potential life-threatening events. Location, device screen characteristics and a feedback mechanism may be required as an enhanced public alerting service.
13	Priority service	Priority service provides qualified users with priority access to radio resources and network resources to help increase call completion rates, especially during periods of congestion or emergency.
14	Location-based services	Location-based services, which depend on the present location of a user, enable users to find other people, vehicles, resources, services or machines.

RoF systems also have the potential to support various fixed network services to provide compatibility with existing PON systems such as GPON, 10-Gigabit-capable passive optical network (XG-PON) and NG-PON2. Table below summarizes examples of fixed network services supported by RoF systems.

**Examples of fixed network services supported by RoF systems**

No.	Service		Remarks
1	Telephony	VoIP	
2		Plain old telephone service (POTS)	<p>Mean signal transfer delay time between T-V (or (a)-V) should be less than 1.5 ms. If echo cancellation is used in the network, the mean signal transfer delay time between T-V (or (a)-V) on the PON-based system may be longer, provided end-to-end transfer delay requirements are met. 8 kHz reference has to be provided.</p> <p>Signal on the T reference point and V reference point must be continuous.</p> <p>Emulation and/or simulation, as defined in [b-ITU-T Y.2201], is assumed.</p> <p>E.g., packetized voice at ONU.</p>
3	TV (realtime)	Internet protocol TV (IPTV)	To be transported using IP multicast/unicast
		Digital TV broadcasting	Transported using RF-video overlay. See [b-ITU-T G.983.3], [b-ITU-T J.185] and [b-ITU-T J.186].
4	Leased line	T1	<p>Bearer rate is 1.544 Mbit/s.</p> <p>Mean signal transfer delay time between T-V (or (a)-V) should be less than 1.5 ms.</p> <p>Emulation is assumed primarily.</p>
5		E1	<p>Bearer rate is 2.048 Mbit/s.</p> <p>Mean signal transfer delay time between T-V (or (a)-V) should be less than 1.5 ms.</p> <p>Emulation is assumed primarily.</p>
6	High speed Internet access		UNI is typically Gigabit Ethernet. See [b-IEEE 802.3].
7	Mobile backhaul		Accurate frequency/phase/time synchronization should be supported. See [b-ITU-T G.810], [b-ITU-T G.813], [b-ITU-T G.8261], [b-ITU-T G.703], and [b-ITU-T G.8262].
8	L2 virtual private network (VPN) services		Services such as Ethernet services, with latest metro Ethernet forum (MEF) carrier Ethernet 2.0 extension, etc. See [b-MEF 6.1].
9	IP services		Services such as L3 VPN, and VoIP, etc.

## ABBREVIATIONS

CISPR	Special International Committee on Radio Interference
CPRI	Common Public Radio Interface
CORBA	Common Object Request Broker Architecture
CPU	Computer Processing Unit
EMC	Electro Magnetic Compatibility
EMS	Element Management System
FWS	Firewall Server
GPON	Gigabit Passive Optical Network
IEEE	International electronic and Electrical Engineering
IP	Internet Protocol
ISO	international Standard Organisation
LCT	Local Craft Terminal
LED	Light Emitting Diode
MTBF	Mean Time Between Failure
NE	Network Element
NMS	Network Management System
OBSAI	Open Base Station Architecture Initiative
ODN	Optical Distribution Network
OLT	Optical Line Terminal
ONU	Optical Network Unit
PON	Passive Optical Network
POTS	Plain Old Telephone System
QA	Quality Assurance
SDH	Synchronous Digital Hierarchy
SNI	Service Network Interface
SNMP	Simple Network Management Protocol
TCP	Transmission Control Protocol
TEC	Telecommunication Engineering Centre
UNI	User Network Interface
VLAN	Virtual LAN
VoIP	Voice over Internet Protocol

WDM	Wavelength Division Multiplexing
XG-PON	10 Gigabit-capable Passive Optical Network
XGS-PON	10 Gigabit-capable Symmetric-Passive Optical Network
XML	Extensible Markup Language

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