टी ई सी का मानक दस्तावेज
TEC XXXXX:२०२५

STANDARD DOCUMENT OF TEC No:
TEC XXXXX:2025

वाई-फाई ओवर एमएमवेव (n257, n258) प्रौद्योगिकी एक्सेस प्वाइंट (WoMT-AP) और स्टेशन (WoMT-STA) के लिए मानक

Standard for Wi-Fi over mmWave (n257, n258) Technology Access Point (WoMT-AP) and Station (WoMT-STA)

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र

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HISTORY SHEET

S. No.	Standard No.	Title	Remarks
1.	TEC XXXXX:2025	Standard for Wi-Fi over mmWave (n257, n258) Technology (WoMT)Access Point (WoMT-AP) and Station (WoMT-STA)	
2.			

REFERENCES

S.NO.	Document No.	Title/Document Name
a) TEC GRs/IRs		
1	TEC/SD/DD/EMC-221/05/OCT-16 [1]	Compatibility Standard For Telecommunication Equipment
b) IEEE Standards		
1	IEEE 802.1q	IEEE standards for local and metropolitan area networks – Virtual Bridge local Area Networks
2	IEEE 802.1x	Standards for Local and metropolitan area networks—Port-Based Network Access Control
3	IEEE 802.11 ax	IEEE Standard for Information technology-- Telecommunications and information exchange between systems—Local and metropolitan area networks-- Specific requirements--Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment Enhancements for High efficiency WLAN

4	IEEE 802.11be	IEEE Standard for Information technology—Telecommunications and information exchange between systems Local and metropolitan area networks— Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 2: Enhancements for extremely high throughput (EHT), August 2024
5	IEEE 802.11i	IEEE Standard for Information technology-Telecommunications and information exchange between system--Local and metropolitan area networks Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications-- Amendment 6: Medium Access Control (MAC) Security Enhancements
6	IEEE 802.1AE	IEEE Standard for Local and metropolitan area network-Medium Access Control (MAC) Security
7	IEEE 802.3	Telecommunications and information exchange between systems-Local and metropolitan area networks--Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.

c) IETF Standards		
1	RFC 791	Internet Protocol (IPV4)
2	RFC 8200	Internet Protocol, Version 6 (IPv6) Specification

3	RFC 2865	Remote Authentication Dial In User Service (RADIUS)
d) Other Standards		

1.	CISPR 32 (2015)	Limits and methods of measurement of radio disturbance characteristics of Information Technology equipment
2	IEC 61000-4-2 (2008)	Testing and measurement techniques of Electrostatic discharge immunity test
3	IEC 61000-4-3 (2010)	Radiated RF Electromagnetic Field Immunity test
4	IEC 61000-4-4 (2012)	Testing and measurement techniques of electrical fast transients/burst immunity test
5	IEC 61000-4-5(2014)	Test & Measurement techniques for Surge immunity tests
6	IEC 61000-4-6(2013)	Immunity to conducted disturbances, induced by radio frequency fields
7	IEC 61000-4-11 (2004)	Testing and measuring techniques – Voltage dips, short interruptions and voltage variations immunity test
8	IEC 61000-4-29 (2000)	Testing and measuring techniques – Voltage dips, short interruptions and voltage variations immunity tests'
9	TEC 10009:2024	Safety Requirements of Telecommunication Equipment
10	IS 10437{1986}	Safety requirements for radio transmitting equipment

11	IEC 60950-1 {2005}	Information Technology Equipment –Safety- Part 1: General Requirements
12	IEC 62368-1: 2018	Audio/video, information and communication technology equipment - Part 1: Safety requirements
13	IEC 60215	Safety requirements for radio transmitting equipment

2 TECHNICAL SPECIFICATIONS

2.1 Introduction

This document specifies the Standard of Wi-Fi over mmWave (n257, n258) Technology (WoMT) Access Point (WoMT-AP) and Wi-Fi over mmWave (n257, n258) Technology Station (WoMT-STA) that are used for accessing services provided by Fixed Wireless Access (FWA) networks in licensed n257, n258 bands spanning 24.25 – 29.5 GHz frequency range. The schematic of WoMT based FWA network is given in Annexure I (Section 4.1).

Definitions:

i) **Wi-Fi over mmWave (n257, n258) Technology Access Point (WoMT-AP)**: Any outdoor device that can associate with multiple WoMT-STAs and provide access to the distribution network, via the wireless medium in the n257, n258 bands for associated WoMT-STAs.

ii) **Wi-Fi over mmWave (n257, n258) Technology Station (WoMT-STA)**: Any outdoor device that contains an IEEE 802.11-ax/be conformant media access control (MAC) and physical layer (PHY) interfaces to the wireless medium in the n257, n258 bands.

WoMT-AP and WoMT-STAs in turn use Wireless Local Area Network (WLAN) standards to operate in the above mmWave frequency range. The WLAN is based on IEEE standards listed in this standard. The Wi-Fi signal waveforms are transmitted/received as-is using the mmWave frequency range with appropriate channel center frequency.

2.2 Description

1. This satndard covers Operational, Quality, Electromagnetic Compatibility, Safety and Security requirements.
2. This standard may be used for certification of the following types of WoMT devices:
    a) WoMT-AP without Router functionality, wherein the WoMT-AP acts like a Layer-2 Bridge.
    b) WoMT-STA without Router functionality, wherein the WoMT-STA acts like a Layer-2 Bridge.
3. This document covers WoMT-APs and WoMT-STAs for outdoor applications.

4. For all TEC GRs / IRs and International Standards referred to in this document, the latest issue shall be applicable unless specified otherwise.
5. Prevailing National Regulations shall apply in case of VoIP and Internet telephony.
6. The equipment shall support IPv4/IPv6 traffic. The IP addresses of WoMT-AP and WoMT-STA shall be unique in a network for accounting and tracking. The equipment shall conform to IETF RFC 8200 and IETF RFC 791.
7. Information to be mentioned on the TEC Certificate is given in Clause 3.2.

2.3 Deployment scenarios

WoMT will work both in P2P and P2MP configurations. Some of the possible deployment scenarios of WoMT technology are presented below:

1. **Outdoor Rural/Semi Urban/Urban Broadband Solutions**

   Providing broadband services in Villages, Gram Panchayat or Village Schools and other institutions are some of the examples of such solutions. Providing broadband services in cities and enterprises for applications such as internet access, e-mail, file transfer and video conferencing.

2. **Enterprise/Commercial High Bandwidth Solutions**

   Providing broadband services in homes, enterprises, commercial establishments for high bandwidth applications such as video conferencing, HD video streaming, IPTV and gaming

2.4 Functional/Operational Requirements

2.4.1 Operating Frequency Range

The operation of equipment shall be in the licensed n257, n258 bands spanning radio frequencies from 24.25 to 29.5 GHz as per the latest National Frequency Allocation Plan (NFAP).

2.4.2 Conformance to Standards

The equipment shall conform to the relevant IEEE 802.11 standard (IEEE 802.11 ax / IEEE 802.11be) with respect to physical layer PPDU packet format and MAC layer MPDU frame format.

Note: The procurer may refer to Section 2.3 of this document for the possible deployment scenarios of WoMT devices and the suitability of different IEEE 802.11 standards in them.

2.4.3 Association rates and Throughput

The WoMT devices in accordance with the technology used (IEEE 802.11 ax/be) should support the data bit rates for the different technologies in different configurations as specified in the Annexures mentioned below:

- In case of IEEE 802.11ax: Annexure II a
- In case of IEEE 802.11be: Annexure II b

The highest signal bandwidth allowed by the 802.11ax standard (160 MHz) and 802.11be standard (320 MHz) shall be used. The procurer shall specify/choose the configuration (channel bandwidth), and the technology used (IEEE 802.11 ax/be). Link budget calculations shall be submitted by Manufacturer/ Supplier.

2.4.4 Radio

The equipment shall comply with radio requirements specified in Sections 2.4.6 and 2.4.7.

2.4.5 RF Technology

WoMT-AP and WoMT-STA devices shall use Orthogonal Frequency Division Multiplexing (OFDM) as well as Orthogonal Frequency Division Multiple Access (OFDMA). Thus, the following mandatory IEEE 802.11ax / 802.11be features shall be supported in WoMT-AP and WoMT-STA devices:

i. Downlink (DL) OFDMA: The WoMT-AP shall successfully transmit DL OFDMA PPDUs (Clause 27.3.1.2 IEEE 802.11ax, Clause 36.3.2.1 IEEE 802.11be) to all WoMT-STAs in all supported bandwidths. The WoMT-AP shall support all

Resource Unit (RU) sizes (Clause 27.3.2.2 802.11ax, Clause 36.3.2.2 802.11be) for its operating bandwidth.

ii. Uplink (UL) OFDMA: The WoMT-AP shall successfully receive the corresponding data frames from all connected WoMT-STAs using OFDMA (Clause 27.3.2.6 802.11ax, Clause 36.3.2.2 802.11be) in all supported bandwidths. The WoMT-AP shall support all Resource Unit (RU) sizes for its operating bandwidth.

iii. Single User (SU) MIMO with 2 Spatial Streams: The WoMT-AP and WoMT-STA shall transmit and receive successfully with 2 spatial streams in all supported bandwidths.

iv. Single User (SU) MIMO with 4 Spatial Streams: The WoMT-AP shall transmit and receive successfully with 4 spatial streams in all supported bandwidths.

v. DL MU MIMO: DL MU MIMO feature (Clause 27.3.3.1 802.11ax, Clause 36.3.3.1 802.11be) shall be mandatory only if the WoMT-AP declares support for two or more Spatial Streams (SS) in Downlink (DL) transmission.

vi. Uplink (UL) Multiuser (MU) MIMO: The WoMT-AP shall support Uplink Multiuser MIMO (Clause 27.3.3.2 802.11ax, 36.3.3.2 802.11be) functionality.

vii. For WoMT devices supporting IEEE 802.11ax PHY packet format:

   a. HE SU PPDU format (Clause 27.3.4 IEEE 802.11ax) is to be used for communication between the WoMT-AP and a single WoMT-STA. The WoMT-AP and WoMT-STA shall successfully transmit and receive HE SU PPDUs in all supported bandwidths and number of spatial streams.

   b. HE MU PPDU format (Clause 27.3.4 IEEE 802.11ax) is to be used when the WoMT-AP intends to transmit data simultaneously to multiple WoMT-STAs. This PPDU format is designed for OFDMA and/or DL MU-MIMO transmission. The WoMT-AP shall successfully transmit HE MU PPDUs. The WoMT-STA shall successfully receive HE MU PPDUs.

   c. HE TB PPDU format (Clause 27.3.4 IEEE 802.11ax) is to be used for UL MU transmission that is a response to a Trigger frame, including UL OFDMA. The WoMT-STA shall successfully transmit HE TB PPDUs. The WoMT-AP shall successfully receive HE TB PPDUs.

viii. For WoMT devices supporting IEEE 802.11be PHY packet format:

d. EHT MU PPDU format (Clause 36.3.4 IEEE 802.11be) is to be used for communication between a WoMT-AP and one or more WoMT-STAs. When the WoMT-AP intends to transmit data simultaneously to multiple WoMT-STAs, this PPDU format is inherently designed to support OFDMA and/or DL MU-MIMO transmission modes. The WoMT-AP and WoMT-STA shall successfully transmit and receive EHT MU PPDUs in all supported bandwidths and number of spatial streams.

e. EHT TB PPDU format (Clause 36.3.4 IEEE 802.11be) is to be used for UL MU transmission that is a response to a Trigger frame, including UL OFDMA. The WoMT-STA shall successfully transmit EHT TB PPDUs. The WoMT-AP shall successfully receive EHT TB PPDUs.

ix. The WoMT-AP and WoMT-STA shall support MCSs 0-11 (Clause 27.5 IEEE 802.11ax, Clause 36.5 IEEE 802.11be) for all supported bandwidths and all supported number of spatial streams.

x. The WoMT-AP shall successfully transmit and receive BCC-coded PPDUs in all supported modes for which LDPC is not mandatory for WoMT-STAs.

xi. TWT (Target Wake Time): The WoMT-AP and WoMT-STA shall support Target Wake Time (Clause 26.8 802.11ax, Clause 35.3.24 802.11be) functionality.

xii. Spatial Reuse Operation: The WoMT-AP may set the BSS Color field in its transmitted High efficiency (HE) and/or Extra High Throughput (EHT) PPDUs (Clause 26.10 802.11ax, Clause 35.10 802.11be).

2.4.6 Transmitter parameters

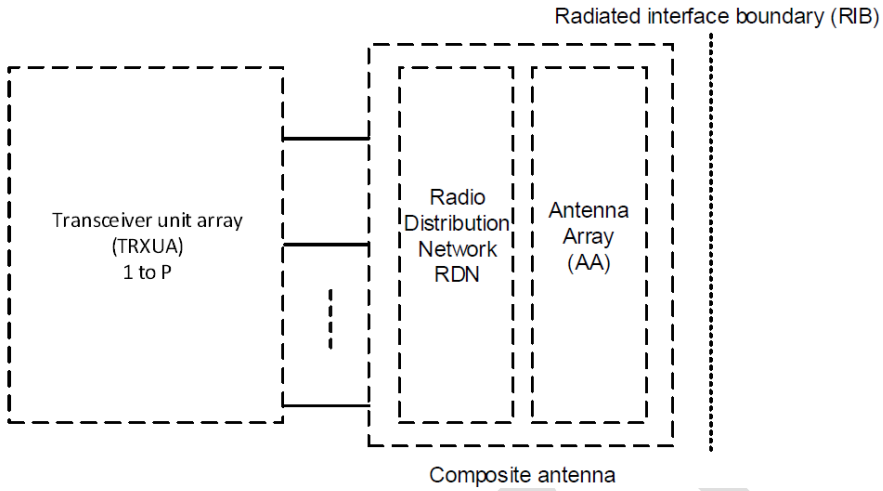

Figure 1: Front end structure of WOMT transceiver

All Transmit Parameters are referenced to the Radiated Interface boundary (RIB) in Figure 1.

2.4.6.1 *Radiated Transmit Power (EIRP)*

Radiated transmit power is defined as the Effective Isotropic Radiated Power (EIRP) level for a declared beam at a specific beam peak direction. For WoMT-AP , EIRP limit shall be up to 59 dBm, for WoMT-STA EIRP limit shall be 55 dBm.

2.4.6.2 *OTA Output Power*

Over The Air (OTA) output power is declared as the Total Radiated Power (TRP) requirement, with the output power accuracy requirement defined at the RIB during the transmitter ON period. The maximum carrier TRP output power $P_{max,c,TRP}$ shall remain within ±3 dB of the rated carrier TRP output power $P_{rated,c,TRP}$, as declared by the manufacturer.

Notation and Terminology:

$P_{max,c,TRP}$: Maximum carrier TRP measured at the RIB(s), and corresponding to the declared rated carrier

$P_{rated,c,TRP}$: Rated carrier TRP declared per RIB

2.4.6.3 *OTA Adjacent Channel Leakage Power Ratio*

OTA Adjacent Channel Leakage Power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on

an adjacent channel frequency. The measured power is TRP. The requirement shall be applied per RIB, per cell, during the *transmitter ON period*.

Table 1: ACLR limits for WoMT FWA devices

***Channel bandwidth* of lowest/highest WoMT carrier transmitted $BW_{Channel}$ (MHz)**	**Adjacent channel center frequency offset below the lowest or above the highest carrier center frequency transmitted**	**Assumed adjacent channel carrier**	**Filter on the adjacent channel frequency and corresponding filter bandwidth**	**OTA ACLR limit (dB)**
320	$BW_{Channel}$ + *offset* (Note 1)	WoMT of same BW	Square / 319 MHz	29.7 (NOTE 2)
160		WoMT of same BW	Square/ 159 MHz	29.7 (NOTE 2)
NOTE 1: Appropriate offset needs to be considered based on operator specified guard band. NOTE 2: Inclusive of 2.3dB measurement uncertainty.				

ACLR absolute limit shall be -10.3 dBm/MHz.

Note:

1. This section is referenced to the 3GPP specifications standard TS 38.141-2, V18.6.0 (6.7.3.5.2, Table 6.7.3.5.2-1)
2. The ACLR limit has been revised from 25.7 dB to 29.7dB, for interference management.

2.4.6.4 OTA Operating Band Unwanted Emissions

The OTA limits for operating band unwanted emissions (OBUE) are specified as TRP per RIB, per cell, unless otherwise stated.

Table 2: OBUE limits for WoMT FWA devices

Frequency offset of measurement filter -3 dB point, Δf	**Frequency offset of measurement filter center frequency, f_offset**	**Test limit**	**Measurement bandwidth**
Offset (Note1) + 0 MHz ≤ Δf < $0.1*BW_{contiguous}$	*Offset (Note1)* + 0.5 MHz ≤ f_offset < $0.1* BW_{contiguous}$ +0.5 MHz	Min(-2.3 dBm, Max($P_{rated,t,TRP}$ – 32.3 dB, -9.3 dBm))	1 MHz
$0.1*BW_{contiguous}$ ≤ Δf < Δf_B	$0.1* BW_{contiguous}$ +0.5 MHz ≤ f_offset < Δf_B +0.5 MHz	Min(-13 dBm, Max($P_{rated,t,TRP}$ – 43 dB, -20 dBm))	1 MHz
$\Delta f_B \leq \Delta f < \Delta f_{max}$	Δf_B +5 MHz ≤ f_offset < f_offset_{max}	Min(-5 dBm, Max($P_{rated,t,TRP}$ – 33 dB, -10 dBm))	10 MHz
NOTE 1: Appropriate offset needs to be considered based on operator specified guard band. NOTE 2: $BW_{contiguous}$ = 320 MHz, 160 MHz NOTE 3: $\Delta f_B = 2 * BW_{contiguous}$ NOTE 4: Δf_{OBUE} = 1500 MHz NOTE 5: F_offsetmax = Δf_{OBUE} ± operating band. NOTE 6: Δf_{max} = f_offsetmax -10MHz/2			

Note: This section is referenced to the 3GPP specifications standard TS 38.141-2, V18.6.0 (6.7.4.5.2.3, Table 6.7.4.5.2.3-1)

Notation and Terminology:

Δf is the separation between the contiguous transmission bandwidth edge frequency and the nominal -3dB point of the measurement filter closest to the contiguous transmission bandwidth edge.
f_offset is the separation between the contiguous transmission bandwidth edge frequency and the center of the measurement filter.
f_offsetmax is the offset to the frequency Δf_{OBUE} outside the downlink operating band, where Δf_{OBUE} is defined in Table 2.

2.4.6.5 OTA Transmitter Spurious Emissions

The general, OTA transmitter spurious emissions requirements are specified as TRP per RIB, per cell, unless otherwise stated.

The OTA transmitter spurious emission limits shall apply from 30 MHz to 2nd harmonic of the upper frequency edge of the downlink operating band, excluding the frequency range from Δf_{OBUE} below the lowest frequency of each supported downlink operating band, up to Δf_{OBUE} above the highest frequency of each supported downlink operating band, where the Δf_{OBUE} is defined in Table 2.

Table 3: Requirements for radiated Tx spurious emissions

Frequency range (Note 1)	Test limit	Measurement Bandwidth
30 MHz ↔ 1 GHz	-36 dBm	100 kHz
1 GHz ↔ 18 GHz	-30 dBm	1 MHz
18 GHz ↔ Fstep,1	-20 dBm	10 MHz
Fstep,1 ↔ Fstep,2	-15 dBm	10 MHz
Fstep,2 ↔ Fstep,3	-10 dBm	10 MHz
Fstep,4 ↔ Fstep,5	-10 dBm	10 MHz
Fstep,5 ↔ Fstep,6	-15 dBm	10 MHz
Fstep,6 ↔ min(2nd harmonic of the upper frequency edge of the DL operating band in GHz; 60 GHz)	-20 dBm	10 MHz
NOTE 1: The step frequencies $F_{step,X}$ are defined in Table 4.		

Table 4: Step frequencies for defining the radiated Tx and Rx spurious emission limits

Operating band	Fstep,1 (GHz)	Fstep, 2 (GHz)	Fstep,3 (GHz)	Fstep, 4 (GHz)	Fstep,5 (GHz)	Fstep, 6 (GHz)
n257, n258	18	21	22.75	29	30.75	40.5

Note: This section is referenced to the 3GPP specifications standard TS 38.141-2, V18.6.0 (6.7.5.2.5.2.3).

Table 5: Spurious emissions test limits for protection of Earth Exploration Satellite Service

Frequency range	Limit	*Measurement Bandwidth*	Note
23.6 – 24 GHz	-3 dBm	200 MHz	Note 1
23.6 – 24 GHz	-9 dBm	200 MHz	Note 2
NOTE 1: This limit applies to devices brought into use on or before 1 September 2027 and enters into force from January 1, 2021. NOTE 2: This limit applies to devices brought into use after 1 September 2027.			

Note: This section is referenced to the 3GPP specifications standard TS 38.141-2, V18.6.0 (6.7.5.4.5.2).

2.4.7 Receiver Parameters

2.4.7.1 OTA Receiver Sensitivity

The OTA Receiver Sensitivity requirement is a directional requirement (for each supported polarization) and is intended to ensure minimum reference sensitivity level for a reference declared boresight reference direction. The OTA reference sensitivity power level is the minimum mean power received at the RIB at which reference performance requirement shall meet for a specified reference measurement channel as specified in Table 6.

The receiver sensitivity shall meet at 10% Packet Error rate (PER).

Table 6: Minimum sensitivity requirements for WoMT FWA high bandwidth signals

Reference Measurement Channel, Modulation	Reference Measurement Channel, Rate	Reference Measurement Channel, Bandwidth 160MHz	Reference Measurement Channel, Bandwidth 320MHz
QPSK	1/2	-92 dBm	-89dBm

For 802.11be based WoMT devices with 320 MHz signal bandwidth, the receiver sensitivity and interference rejection (adjacent and nonadjacent channel) shall be tested in accordance with IEEE 802.11be Clauses 36.3.21.2 to 36.3.21.4, using the PER-based method, with the appropriate PSDU lengths and modulation schemes defined therein.

For 802.11ax based WoMT devices with 160 MHz signal bandwidth, the receiver sensitivity and interference rejection (adjacent and nonadjacent channel) shall be tested in accordance with IEEE 802.11ax Clauses 27.3.20.2 to 27.3.20.4, using the PER-based method, with the appropriate PSDU lengths and modulation schemes defined therein.

2.4.7.2 OTA Receiver Spurious Emissions

The power of any receiver spurious emission shall not exceed the limits in Table 7. The metric used to capture OTA receiver spurious emissions for WoMT devices is total radiated power (TRP), with the requirement defined at the RIB.

Table 7: Radiated Rx spurious emission requirements

Frequency range (Note 1)	**Test limit**	**Measurement Bandwidth**
30 MHz ↔ 1 GHz	-36 dBm	100 kHz
1 GHz ↔ 18 GHz	-30 dBm	1 MHz
18 GHz ↔ Fstep,1	-20 dBm	10 MHz
Fstep,1 ↔ Fstep,2	-15 dBm	10 MHz
Fstep,2 ↔ Fstep,3	-10 dBm	10 MHz
Fstep,4 ↔ Fstep,5	-10 dBm	10 MHz
Fstep,5 ↔ Fstep,6	-15 dBm	10 MHz
Fstep,6 ↔ min(2nd harmonic of the upper frequency edge of the UL operating band in GHz; 60 GHz)	-20 dBm	10 MHz
NOTE 1: The step frequencies Fstep,X are defined in Table 4.		

Table 8: Spurious emissions test limits for protection of Earth Exploration Satellite Service

Frequency range	**Limit**	***Measurement Bandwidth***	**Note**
23.6 – 24 GHz	-3 dBm	200 MHz	Note 1
23.6 – 24 GHz	-9 dBm	200 MHz	Note 2
NOTE 1: This limit applies to devices brought into use on or before 1 September 2027 and enters into force from January 1, 2021. NOTE 2: This limit applies to devices brought into use after 1 September 2027.			

2.4.7.3 Receiver Blocking

2.3.7.3.1 Adjacent channel rejection

The receiver demodulates the wanted signal at f_0 with a bandwidth of W MHz (W = 160 or 320) and power set 3 dB higher than the value of the minimum sensitivity level given in Table 6 (refer to Sec. 2.4.7.1 OTA Receiver Sensitivity). An interfering HE-compliant or EHT-compliant signal with the same bandwidth as the wanted signal is centered W MHz from the wanted signal (f_c + W MHz). The packet error rate is measured as the interferer signal power is increased. When the packet error rate reaches 10%, the delta between the interferer power and the wanted signal power is measured. This value is defined as adjacent channel rejection (Clause 27.3.20.3 IEEE 802.11ax, Clause 36.3.21.3 IEEE 802.11be). The measured value must be greater than the value provided in Table 9.

Table 9: Minimum adjacent channel rejection requirements for 160/320 MHz channel

MCS	Modulation	Coding rate (R)	Adjacent channel rejection (in dB)
1	QPSK	1/2	13

2.3.7.3.2 Nonadjacent channel rejection

Nonadjacent channel rejection (Clause 27.3.20.4 IEEE 802.11ax, Clause 36.3.21.4 IEEE 802.11be) is similar, but the interfering signal is 2W MHz from the wanted signal. The measured value must be greater than the value provided in Table 10.

Table 10: Minimum nonadjacent channel rejection requirements for 160/320 MHz channel

MCS	Modulation	Coding rate (R)	Non-Adjacent channel rejection (in dB)
1	QPSK	1/2	29

The detailed table of applicable Transmitter and Receiver characteristics test clauses as per applicable 3GPP and IEEE standards is enclosed as 4.3 Annexure-III.

2.4.8 Bit Rates

As per Annexure II, WoMT-AP and WoMT-STA shall support channel bit rates up to:

- For WoMT devices supporting IEEE 802.11ax (refer to Clause 27.5):
  - Up to 2402 Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 2 spatial streams
  - Up to 4804 Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 4 spatial streams
  - Up to 9607.8 Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 8 spatial streams
- For WoMT devices supporting IEEE 802.11be (refer to Clause 36.5):

- Up to 4804 Mbps as per IEEE 802.11be and 320MHz channel bandwidth, 2 spatial streams
- Up to 9608 Mbps as per IEEE 802.11be and 320MHz channel bandwidth, 4 spatial streams
- Up to 19215 Mbps as per IEEE 802.11be and 320MHz channel bandwidth, 8 spatial streams

2.4.9 Antenna

Antenna system shall use a programmable mmWave phased-array antenna.

2.4.10 Status indication

The WoMT-AP and WoMT-STA equipment shall have visual status indication on the unit and on EMS/ WLAN controller for

1. Activity over Radio
2. Activity over the Ethernet
3. Operating / Faulty State
4. Power Indicator

As an option, audio status indication can also be provided.

2.4.11 Power supply requirements

The equipment should be able to operate on AC/DC/PoE (Power over Ethernet). The AC power supply shall be 230 V + 10% to -15% and frequency 50 Hz ± 2 Hz. DC/PoE Supply details to be given by the supplier / manufacturer. Solar/Wind Power option may also be provided.

2.5 Interface Requirements

Radio interface shall conform to IEEE standards 802.11ax/be and the Wi-Fi signal waveforms are transmitted/received as-is using the mmWave frequency range with appropriate channel center frequency.

1. Network management shall be supported by a central NOC/EMS.
2. Interfaces: Equipment shall support electrical or optical Ethernet Interface.
3. Interface Ports: Auto sensing IEEE 802.3 2500/10000 BASE-T Ethernet.

4. IPv4 and IPv6 addressing shall be supported.

2.6 Quality Requirements

1. The manufacturer shall have a valid ISO 9001:2008 or any other equivalent ISO certificate.
2. The equipment shall meet the environmental requirements as per 'Category D' (Outdoor equipment) of QM-333 March 2010 Standard for Environmental Testing of Telecommunication Equipment.
3. The device in mounting condition should sustain 150 km/hr wind load.
4. Environmental requirement for operation in an ambient temperature range of -5°C to +55°C.
5. The MTBF (Mean Time between Failure) and MTTR (Mean Time To Restore) predicted shall be provided and the manufacturer shall furnish observed values.
6. The WoMT System should be minimum IP65 compliant. The equipment may be IP67 compliant as per user/procurer's requirement.

2.7 EMI/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 from an accredited test lab shall be furnished from a test agency.

Table 11: EMI & EMC requirements for WoMT FWA devices

Sr.No.	Parameter Name	Standard Name
1	Conducted And Radiated Emission - Class A	TEC EMI EMC Standard CISPR 32 EN550 32. Annex-B
2	Immunity to DC Voltage Dips and Short Interruptions	EN/IEC:61000-4-29. Annex-B
3	Immunity to Electrostatic Discharge	TEC EMI EMC Standard EN/IEC:61000-4-2. Annex-B
4	Immunity to Fast Transients (Burst)	TEC EMI EMC Standard EN/IEC:61000-4-4. Annex-B

5	Immunity to Radiated RF	TEC EMI EMC Standard EN/IEC:61000-4-3. Annex-B
6	Immunity to RF Field Induced Conducted Disturbance	TEC EMI EMC Standard EN/IEC:61000-4-6. Annex-B
7	Immunity to Surges	TEC EMI EMC Standard EN/IEC:61000-4-5. Annex-B

2.8 Safety Requirements

The equipment shall conform to:

1. TEC 10009: 2024 “Safety Requirements of Telecommunication Equipment”

2.9 Security Requirements

1. Equipment shall conform to WPA3 Enterprise 192-bit mode as defined in Wi-Fi Alliance WPA3 Enterprise specification [https://www.wi-fi.org/system/files/WPA3%20Specification%20v3.4.pdf].
2. Equipment shall support 802.1X for authentication with a RADIUS server supporting IETF RFC 2865 for centralized management and control.
3. EAP-TLS Protocol is to be used for authentication of the WoMT-AP and WoMT-STA, providing secure certificate-based authentication.
4. Equipment shall be fully compliant with WPA3 Enterprise 192-bit deployment guidelines as defined in Wi-Fi Alliance deployment guide [https://www.wi-fi.org/system/files/WPA3%20and%20Wi-Fi%20Enhanced%20Open%20Deployment%20Guide%20v1.1.pdf]
5. Equipment shall conform to Media Access control security based on 802.1 AE as an optional requirement.
6. Service Set Identifier (SSID) for each WoMT-AP shall be managed and configured by NMS / EMS.
7. Equipment shall provide a mechanism to identify association of each WoMT-STA with WoMT-AP by way of using a NAI.

2.10 Other Requirements

2.10.1.1 Identification of Equipment

i) Equipment shall be marked with supplier's or manufacturer's logo/name.

ii) Model No., Serial No., Month and year of manufacture shall be indicated by screen printing on the body of equipment or by tamper-proof sticker pasted on the body of equipment.

iii) Power Supply requirements shall be indicated on the body.

iv) The above markings shall be legible, indelible and easily visible.

2.10.1.2 Documentation

Detailed documentation in English shall be provided, including:

i) Self-explanatory user manual giving details of all functions, facilities and procedures

ii) Set-up and configuration parameters and procedures

iii) Trouble shooting guide including fault dictionary.

iv) Repair manual (Optional)

2.11 Optional requirements

1. Support IEEE 802.1q VLAN tagging to segregate Management traffic of WoMT-AP and WoMT-STA from end user CPE traffic depending on the deployment needs.
2. Support IEEE 802.1p priority to prioritize various traffic types in both uplink and downlink directions.
3. Spectrum sensing and reporting capability.
4. Configuration of operational parameters through secure local web interface when link to NOC/EMS/WLAN Controller is not available.
5. NavIC support on board.
6. WoMT-AP shall support Concurrent client connections per radio

2.12 Interference Mitigation

For interference mitigation, the WoMT deployments shall adhere to EIRP and ACLR limits as specified in Sections 2.4.6.1 and 2.4.6.3 respectively. Furthermore, the WoMT FWA system shall adhere to the following additional guidelines:

1. Operating Modes of WoMT System:
    a. The WoMT system should operate in TDMA mode with synchronisation signal from GPS and slot timing based on 3GPP TS 38.211. The WoMT system operating in TDMA mode shall use a time-slot structure that is synchronised to 3GPP system (for example, FR2 NR with 120 kHz sub-carrier spacing (SCS) and DDDSU TDD configuration).

    OR

    b. The WoMT system should operate in CSMA mode as specified in IEEE 802.11ax and 802.11be standards.
2. The system adjacent to WoMT may either be a 3GPP system or WoMT system (TDMA or CSMA). The following are recommendations for interference mitigation:
    a. When two WoMT systems are operating in adjacent channels, use a minimum frequency separation of 160 MHz.
    b. When a WoMT system and a 3GPP system are operating in adjacent channels:
        i. If the EIRP delta is less than 3 dB, then use a minimum frequency separation of 160 MHz.
        ii. If the EIRP delta is between 3 dB and 6 dB, then use a minimum frequency separation of 320 MHz.
3. However, the operational frequency separation between WoMT-WoMT or WoMT-3GPP shall be left to TSPs for discussion and implementation.
4. The TDMA configuration including SCS and TDD configuration shall be left to TSPs for discussion and implementation.

3 SUPPLEMENTARY INFORMATION

3.1 Information for the procurer of product

For procurement purposes, purchaser may specify the following:

i) Equipment should be compliant with which of the IEEE standards as per Clause 2.4.2.

ii) Application: Outdoor

iii) Frequency of operation: As per Clause 2.4.1

iv) MIMO Configuration (for example 2x2, 4x4 and above) in case of IEEE 802.11ax / IEEE 802.11be as per Clause 2.4.3.

v) Clause 2.4.11: Option for power supply requirements

vi) Clause 2.5: Type of Network Interface and number of interfaces required.

vii) Antenna Type and whether integrated Antenna/ Separate Antenna etc. may be specified.

viii) Requirements with respect to RADIUS client as per Clause 2.9.

ix) Requirements as per Clause 2.10.1.2

x) Validation requirements for the equipment

xiii) The requirement for IEEE 802.1AE as per Clause 2.9 may be specified by the procurer keeping in mind that this may be applicable only when devices at both end points support IEEE 802.1AE.

xiv) The requirement for IP67 compliance shall be specified by the procurer.

3.2 Specific remarks / information to be mentioned in the Certificate

1. TEC standard XXXXX-2025 Frequency of operation
2. Channel Bandwidth
3. Application: Outdoor
4. MIMO Configuration
5. Interface Ports: Type and number of Ports
6. “AC Power/DC Power/PoE/non-conventional energy sources like Solar Power/ Wind Power etc.”

3.3 Abbreviations

Table 12: Abbreviations used in this standard

Abbreviation	Full form
AC	Alternating current
ACLR	Adjacent channel leakage ratio
AP	Access point
BCC	Binary convolutional code
BPSK	Binary phase shift keying
BW	Bandwidth
CISPR	Comité International Spécial des Perturbations Radioélectriques
DC	Direct current
DCM	Dual carrier modulation
DL	Downlink
DoT	Department of Telecommunications
EAP-TLS	Extensible Authentication Protocol - Transport Layer Security
EIRP	Effective Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMS	Element Management System
ER	Essential Requirements
FWA	Fixed Wireless Access
GI	Guard Interval
GR	Generic Requirements
HD	High Definition
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IR	Interface Requirements
ISO	International Standards Organisation
LDPC	Low Density Parity Check
MAC	Medium Access Control
MIMO	Multiple Input Multiple Output
MPDU	MAC Protocol Data Unit
MTBF	Mean Time Between Faults
MTCTE	Mandatory Testing and Certification of Telecommunication Equipment
MTTR	Mean Time To Restore

MU	Multi user
NAI	Network Access Identifier
NFAP	National Frequency Allocation Plan
NOC	Network Operations Center
NR	New Radio
OBUE	Operating Band Unwanted Emission
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OTA	Over The Air
PER	Packet Error Rate
PHY	Physical layer
PoE	Power over Ethernet
PPDU	PHY Protocol Data Unit
PSDU	PHY Service Data Unit
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RADIUS	Remote Authentication Dial In User Service
RFC	Request For Comment
RIB	Radiated Interface Boundary
RTEC	Regional Telecom Engineering Center
RU	Resource Unit
SR	Service Requirements
SSID	Service Set Identifier
STA	Station
SU	Single user
TEC	Telecommunication Engineering Centre
TRP	Total Radiated Power
UL	Uplink
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
WPC	Wireless Planning and Coordination
WoMT	Wi-Fi over Millimeter wave Technology

4 ANNEXURES

4.1 Annexure I: Architecture diagram

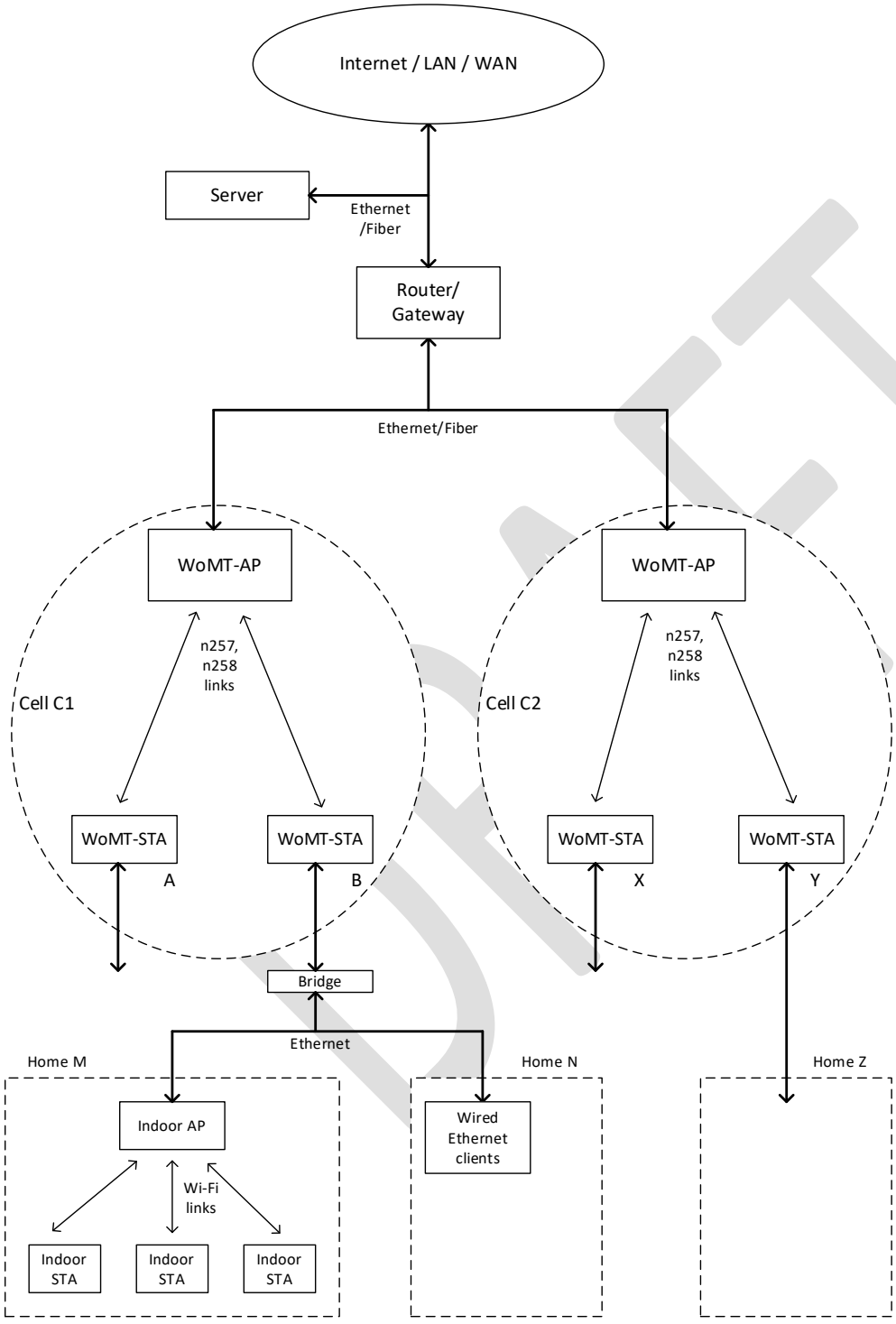

Figure 2: Schematic of WoMT FWA architecture

4.2 Annexure II: Bit rates and throughputs

We tabulate the bit rates and PHY throughputs expected in IEEE 802.11ax (Wi-Fi 6) and IEEE 802.11be (Wi-Fi 7) for signal bandwidths 160MHz and 320MHz only, since these are relevant for WoMT FWA architecture. Moreover, we only provide the data rates for 2, 4 and 8 spatial streams. For full details, refer to the tables below in IEEE 802.11ax standard and IEEE 802.11be Draft 7.0:

- Table 27-104 shows data rates for 11ax 160 MHz, 2 streams across all MCS
- Table 27-105 shows data rates for 11ax 160 MHz, 3 streams across all MCS
- Table 27-106 shows data rates for 11ax 160 MHz, 4 streams across all MCS
- Table 27-107 shows data rates for 11ax 160 MHz, 5 streams across all MCS
- Table 27-108 shows data rates for 11ax 160 MHz, 6 streams across all MCS
- Table 27-109 shows data rates for 11ax 160 MHz, 7 streams across all MCS
- Table 27-110 shows data rates for 11ax 160 MHz, 8 streams across all MCS
- Table 36-86 shows data rates for 11be 320 MHz, 1 stream across all MCS
- To compute data rates for 11be 320 MHz with multiple streams, we scale the data rates for a single stream by the number of spatial streams

4.2.1 Annexure II a: 802.11ax data rates

All data rates refer to physical layer (PHY) data rates from DATA symbols of the PPDU (physical layer packet). We specify the data rates for MCS 11 (1024 QAM, code rate 5/6) and 160 MHz signal bandwidth only.

		802.11ax PHY data rate for 160 MHz MCS 11 (Mbps)		
Antenna config	**Number of spatial streams**	**0.8μs GI**	**1.6μs GI**	**3.2μs GI**
2 x 2	2	2402	2269	2042
4 x 4	4	4804	4537	4083
6 x 6	6	7206	6806	6125
8 x 8	8	9608	9074	8167

4.2.2 Annexure II b: 802.11be data rates

All data rates refer to physical layer (PHY) data rates from DATA symbols of the PPDU (physical layer packet). We specify the data rates for MCS 11 (1024 QAM, code rate 5/6) and 320 MHz signal bandwidth only.

		802.11be PHY data rate for 320 MHz MCS 11 (Mbps)		
Antenna config	**Number of spatial streams**	**0.8µs GI**	**1.6µs GI**	**3.2µs GI**
2 x 2	2	4804	4537	4083
4 x 4	4	9608	9074	8166
6 x 6	6	14411	13611	12250
8 x 8	8	19215	18148	16333

4.3 Annexure III – Transmitter and Receiver Characteristics

Sl. No	Test Clauses	3GPP Standard	Equivalent IEEE Standard	Remarks
1	OTA Adjacent Channel Leakage Power Ratio-5G NR 2-O	3GPP TS 38.141-2 Clause 6.7.3	Not Available in IEEE	The WoMT device shall be compliant to 3GPP test specification limits.
2	OTA Adjacent Channel Selectivity-5G NR 2- O	3GPP TS 38.141-2 Clause 7.5.1	Adjacent channel rejection, IEEE P802.11be (36.3.21.3), IEEE 802.11ax-2021 (27.3.20.3).	
3	OTA Base station output power-5G NR 2-O	3GPP TS 38.141-2 Clause 6.3	Not Available in IEEE	The WoMT device shall be compliant to 3GPP test specification limits.
5	OTA In-band blocking-5G NR 2-O	3GPP TS 38.141-2 Clause 7.5.2	Nonadjacent channel rejection, IEEE P802.11be	

			(36.3.21.4), IEEE 802.11ax-2021(27.3.20.4)	
6	OTA Out-of-band blocking-5G NR 2-O	3GPP TS 38.141-2 Clause 7.6	Not Available in IEEE	
7	OTA Out-of-band emissions-5G NR 2-0	3GPP TS 38.141-2 Clause 6.7.4	Not Available in IEEE	The WoMT device shall be compliant to 3GPP test specification limits.
8	OTA Receiver intermodulation -5G NR 2-O	3GPP TS 38.141-2 Clause 7.8	Not Available in IEEE	
9	OTA Receiver spurious emissions-5G NR 2- O	3GPP TS 38.141-2 Clause 7.7	Not Available in IEEE	The WoMT device shall be compliant to 3GPP test specification limits.
10	OTA Reference sensitivity level-5G NR 2-O	3GPP TS 38.141-2 Clause 7.3	Receiver Sensitivity IEEE P802.11be (36.3.21.2 to 36.3.21.4), IEEE 802.11ax-2021 (27.3.20.2 to 27.3.20.4).	
11	OTA Transmitter spurious emissions-5G NR 2-O	3GPP TS 38.141-2 Clause 6.7.5	Not Available in IEEE	The WoMT device shall be compliant to 3GPP test specification limits.

5 INTERNET LINKS FOR REFERENCES

1. Electromagnetic Compatibility Standard for Telecommunication Equipment, TEC, 2016.
2. IEEE 802.1q: IEEE Standard for Local and Metropolitan Area Networks–Bridges and Bridged Networks
3. IEEE 802.1x: IEEE Standard for Local and Metropolitan Area Networks--Port-Based Network Access Control.
4. IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems Local and Metropolitan Area Networks--Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 1: Enhancements for High-Efficiency WLAN
5. IEEE Approved Draft Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment: Enhancements for Extremely High Throughput (EHT)
6. IEEE Standard for information technology-Telecommunications and information exchange between systems-Local and metropolitan area networks-Specific requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Amendment 6: Medium Access Control (MAC) Security Enhancements
7. IEEE Standard for Local and metropolitan area networks-Media Access Control (MAC) Security
8. IEEE Standard for Ethernet
9. RFC 791 - Internet Protocol
10. RFC 8200 - Internet Protocol, Version 6 (IPv6) Specification
11. RFC 2865 - Remote Authentication Dial In User Service
12. CISPR 32 Electromagnetic compatibility of multimedia equipment - Emission requirements
13. IEC 61000-4-2: Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
14. IEC 61000-4-3: Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
15. IEC 61000-4-4: Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test
16. IEC 61000-4-5: Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test
17. IEC 61000-4-6: Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
18. IEC 61000-4-11: Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase
19. IEC 61000-4-29: Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests
20. TEC 10009: 2024, “Safety Requirements of Telecommunication Equipment”
21. IS 10437: Safety requirements for radio transmitting equipment
22. IEC 60950-1: Information technology equipment - Safety - Part 1: General requirements

23. IEC 62368-1: Audio/video, information and communication technology equipment - Part 1: Safety requirements
24. IEC 60215: Safety requirements for radio transmitting equipment - General requirements and terminology
25. QM-333: STANDARD FOR ENVIRONMENTAL TESTING OF TELECOMMUNICATION EQUIPMENT
26. IEC 60529: Degrees of protection provided by enclosures (IP65, IP67)
27. TEC EMI EMC Standard EN/IEC:61000-4-2.Annex-B
28. TEC EMI EMC Standard EN/IEC:61000-4-4.Annex-B
29. TEC EMI EMC Standard EN/IEC:61000-4-3.Annex-B
30. TEC EMI EMC Standard EN/IEC:61000-4-6.Annex-B
31. TEC EMI EMC Standard EN/IEC:61000-4-5.Annex-B
32. WPA3 Enterprise 192-bit mode
33. WPA3 Enterprise 192-bit deployment guide
34. IEEE 802.1D: IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges
35. NavIC SIGNAL IN SPACE ICD FOR STANDARD POSITIONING SERVICE IN L1 FREQUENCY
36. 5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104)
37. 5G; NR; Base Station (BS) conformance testing Part 2: Radiated conformance testing (3GPP TS 38.141-2)