वर्गीय आवश्यकताओं के लिए मानक

टीईसी ३८०२०:२०२१

(सं:टीईसी/जीआर/आर/वाईफ़ाई-002/02/दिस-15 को अधिक्रमित करता है)

STANDARD FOR GENERIC REQUIREMENTS

TEC 38020:2021

(Supersedes No. TEC/GR/R/WiFi-002/02/DEC-15)

वाईफ़ाई ऐक्सेस पॉइंट (एपी)

Wi-Fi Access Point (AP)

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र

खुर्शीदलाल भवन, जनपथ, नई दिल्ली-110001, भारत

TELECOMMUNICATION ENGINEERING CENTRE

KHURSHID LAL BHAWAN, JANPATH, NEW DELHI–110001, INDIA

www.tec.gov.in

Release 3: March 2021

FOREWORD

Telecommunication Engineering Centre (TEC) functions under Department of Telecommunications (DOT), Government of India. Its activities include:

- Issue of Generic Requirements (GR), Interface Requirements (IR), Essential Requirements (ER), Service Requirements (SR) and Standards for Telecom Products and Services
- Field evaluation of products and Systems
- National Fundamental Plans
- Support to DOT on technology issues
- Testing & Certification of Telecom products
- MTCTE Approvals

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

ABSTRACT

This Standard on GR pertains to Wi-Fi Access Point (AP) used for accessing Wireless Local Area Network (WLAN) services provided by Wi-Fi networks. It covers requirements for interoperability, Quality, Electromagnetic Compatibility, Safety and Security. It also covers additional requirements to be met by the AP in case the equipment is meant to be used in the PM WANI network.

CONTENTS

HISTORY SHEET

S. No.	*GR No.*	*Title*	*Remarks*
1.	TEC/GR/CP/WiFi002/01/SEP-11	Generic Requirement for WiFi Access Point (AP)	First Issue
2.	TEC/GR/R/WiFi-002/02/DEC-15	Generic Requirement for Wi-Fi Access Point (AP)	Supersedes TEC GR No. TEC/GR/CP/WiFi002/01/SEP-11
3.	TEC 38020:2021	Standard for Generic Requirement for Wi-Fi Access Point (AP)	Supersedes TEC GR No. TEC/GR/R/WiFi-002/02/DEC-15

REFERENCES

S.NO.	Document No.	Title/Document Name
a) TEC GRs/IRs		
1	TEC/SD/DD/EMC-221/05/OCT-16	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 802.11a	Supplement to 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: High-

		Speed Physical Layer in the 5 GHz Band
4	IEEE 802.11b	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: Higher-speed Physical Layer (PHY) extension in the 2.4 GHz band—Corrigendum1
5	IEEE 802.11d	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: Specification for Operation in Additional Regulatory Domains
6	IEEE 802.11g	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 4: further higher – speed physical layer extension in the 2.4GHz band
7	IEEE 802.11n	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 5: enhancements for higher throughput
8	IEEE 802.11ac	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 4: Enhancements for Very High Throughput for Operation in Bands below 6 GHz.
9	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
10	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
11	IEEE 802.1AE	IEEE Standard for Local and metropolitan area network-Medium Access Control (MAC) Security
12	IEEE 802.11u	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 9: Interworking with External Networks
13	IEEE 802.11r	IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 2: Fast Basic Service Set (BSS) Transition
14	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.
15	IEEE 802.1X	IEEE Standard for Local and metropolitan area networks--Port-Based Network Access Control
c) IETF Standards		
1	RFC 2222	Simple Authentication and Security Layer (SASL)
2	RFC 2253	The LDAP Data Interchange Format (LDIF) - Technical Specification
3	RFC 2849	The LDAP Data Interchange Format (LDIF) - Technical Specification
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	IS 13252 part 1: 2010	Information Technology Equipment –Safety- Part 1: General Requirements
10	IS 10437{1986}	Safety requirements for radio transmitting equipments
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 equipments
14	QM-333	Environmental Testing of Telecommunication Equipment

CHAPTER-1

1.0 Introduction

1.1 This document specifies the Generic Requirements (GR) of Wi-Fi Access Point (AP) used for accessing Wireless Local Area Network (WLAN) services provided by Wi-Fi networks. The schematic of Wi-Fi Network (WLAN) is given in Annexure-I.

Definitions:

i) Access Point (AP):- Any entity that has station (STA) functionality and provides access to the distribution, via the wireless medium (WM) for associated STAs.

ii) Station (STA) :- Any device that contains an IEEE 802.11- conformant and media access control (MAC) physical layer (PHY) interface to the wireless medium (WM).

2.0 Description

2.1 This GR covers requirements for interoperability, Quality, Electromagnetic Compatibility, Safety and Security.

2.2 This GR may be used for certification of following Types of Wi-Fi Access points:

Type A: Wi-Fi Access Point without Router functionality

Type B: Wi-Fi Access Point with Router functionality

Note:

i) Bridge functionality is available in all AP.

ii) For Type B AP supporting routing functionality, the supplier must indicate the essential static and dynamic routing protocols that enable routing.

2.3 This document covers Wi-Fi APs based on suitability for Indoor, Outdoor, Mixed (Indoor & outdoor) applications, LAN capabilities (Optional).

2.4 For all TEC GRs / IRs and International Standards referred to in this document, latest issue shall be applicable unless specified otherwise.

2.5 Prevailing National Regulations shall apply in case of VoIP and Internet telephony.

2.6 The equipment shall support dual stack (IPv4 & IPv6) traffic. The equipment shall conform to IETF RFC 2460 and IETF RFC 791.

2.7 Information to be mentioned on the TEC Certificate is given in Clause 12.0

3.0 Functional/Operational Requirements

3.1 Operating Frequency Range

The operation of equipment shall be in the license free bands of 2.4 and/or 5 GHz bands and as per latest National Frequency Allocation Plan (NFAP) and published WPC GSRs as specified below and further subject to, revision from time to time.

Sr.No.	Frequency Range	Title of the Rule	GSR No.	IND Remarks as per NFAP 2018
1.	2400-2483.5 MHz	Use of Low Power Equipment in the frequency band 2.4 GHz to 2.4835 GHz (Exemption from Licensing Requirement)	GSR No. 45 (E) dated 28-Jan-2005, and subsequent amendments, if any.	

		Rules, 2005		
2.	5150 - 5250 MHz 5250 - 5350 MHz 5470-5725 MHz 5725 - 5875 MHz	Use of Wireless Access Systems (WAS) including Radio Local Area Network (RLAN) in 5GHz (Exemption from Licensing Requirement) Rules, 2018	GSR No. 1048(E) dated 18-Oct.2018 and subsequent amendments, if any.	IND 29

3.2 Conformance to Standards

The equipment shall conform to relevant IEEE 802.11 standard (IEEE 802.11 a/b/g/n/ac/ax).

Note: The procurer may refer to Annexure III of this document for the possible deployment scenarios of Wi-Fi Access Points and the suitability of different IEEE 802.11 standards in them.

3.3 Association rates and Throughput

The Access Point in accordance with the technology used ((IEEE 802.11 a/b/g/n/ac/ax) should support the association rates/bit rates and minimum throughput for the different technologies in different configurations as specified in the Annexures mentioned below:

- In case of IEEE 802.11a: Annexure II a
- In case of IEEE 802.11b: Annexure II b
- In case of IEEE 802.11g: Annexure II c
- In case of IEEE 802.11n : Annexure II d
- In case of IEEE 802.11ac: Annexure II e
- In case of IEEE 802.11ax: Annexure II f

The procurer shall specify/choose the configuration (bandwidth, frequency, bit rate etc) and the technology used (IEEE 802.11 a/b/g/n/ac/ax).

Link budget calculation shall be submitted by Manufacturer/ Supplier.

3.4 Radio

The equipment shall comply with radio requirements specified in Clause 15.4.6 of IEEE 802.11 / clause 18.4.6 of IEEE 802.11b / clause 19.4 of IEEE 802.11g (IEEE 802.11-2007) / clause 20 of IEEE 802.11n-2009/Clause 22 of IEEE 802.11ac-2013 standards/clause 27 of IEEE 802.11 ax, as applicable.

3.5 RF Technology

It shall use Direct Sequence Spread Spectrum (DSSS) technology and/or Orthogonal Frequency Division Multiplexing (OFDM). In Case of IEEE802.11ax AP, as it uses OFDM as well as Orthogonal Frequency Division Multiple Access (OFDMA), there shall be following mandatory features supported in the IEEE 802.11ax AP:

i. Downlink (DL) OFDMA: The AP shall successfully transmit DL OFDMA PPDUs to minimum 4 STAs in all supported bandwidths. The AP shall

support all Resource Unit (RU) sizes for its operating bandwidth.

ii. Uplink (UL) OFDMA: The AP shall successfully receive the corresponding data frames from minimum 4 STAs using OFDMA in all supported bandwidths. The AP shall support all Resource Unit (RU) sizes for its operating bandwidth.

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

iv. DL MU MIMO: This feature shall be mandatory only if the AP declared support for greater than or equal to four Spatial Stream (SS) Downlink (DL) transmission.

v. Uplink (UL) Multi User (MU) MIMO: The AP shall support Uplink Multi user MIMO functionality.

vi. Preamble Format:

   a. HE_SU is a new HE SU PPDU format to be used for communication between the AP and a single STA. The AP shall successfully transmit and receive HE SU PPDUs in all supported bandwidths and number of spatial streams.

   b. HE_MU preamble is used when the AP intends to transmit data simultaneously to multiple client devices. This PPDU format is designed for OFDMA and/or DL MU-MIMO transmission. The AP shall successfully transmit HE MU PPDUs.

   c. HE TB PPDU preamble format including the HE_TRIG preamble format, is used for UL MU transmission that is a response to a Trigger frame, including UL OFDMA. The AP shall successfully receive HE TB PPDUs.

vii. The AP shall support MCSs 0-7 for all supported bandwidths and all supported numbers of spatial streams.

viii. The AP shall successfully transmit and receive BCC-coded PPDUs in

all supported modes for which LDPC is not mandatory for STAs.

ix. 20MHz only mode: The AP shall support 20 MHz bandwidth operating mode.

x. TWT (Target Wake Time) : The AP shall support Target Wake Time functionality.

xi. Spatial Reuse Operation: The AP shall set the BSS Color field in its transmitted High efficiency (HE) frames.

3.6 Transmitter parameters

3.6.1 Effective isotropic radiated power

EIRP limit shall be as per NFAP. The tendering authority may specify EIRP as per requirements but considering interference issues. EIRP specified for 2.4 GHz band and for 5 GHz band as per NFAP 2018 and latest GSR issued by WPC should be complied to. The EIRP specifications must be in conformance to the latest NFAP as and when it is revised.

Sr.No.	Frequency Range	Title of the Rule	GSR No.	Requirements as per GSR	IND Remarks as per NFAP 2018
1.	2400-2483.5 MHz	Use of Low Power Equipment in the	As per Section 3) GSR No. 45 (E)	4w (36 dbm)	-

		frequency band 2.4 GHz to 2.4835 GHz (Exemption from Licensing Requirement) Rules, 2005	dated 28-Jan-2005 , and subsequent amendments, if any.: 4w (36 dbm)		
2.	5150 - 5250 MHz 5250 - 5350 MHz 5470-5725 MHz 5725 - 5875 MHz	Use of Wireless Access Systems (WAS) including Radio Local Area Network (RLAN) in 5GHz (Exemption from Licensing Requirement) Rules, 2018	Section 3). GSR No. 1048(E) dated 18-Oct.2018 and subsequent amendments, if any.	Please refer *Note	IND 29

**Note:*

(i) in the band 5 150-5 250 MHz, for access points operating with transmitting antennas of antenna gain of 6 dBi and less, the maximum conducted output power over the frequency band of operation shall not exceed 30 dBm (1 Watt) and; the maximum power spectral density shall not exceed 17 dBm (50 mW) in any 1 MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the antenna gain exceeds 6 dBi. When used for outdoor access point applications, the maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizontal direction shall not exceed 21 dBm (125 mW);

(ii) fixed point-to-point access points operating in the frequency band 5 150-5 250 MHz may employ antennas with directional gain up to 23 dBi and use the maximum conducted output power and maximum power spectral density as indicated at sub-paragraph (i) above. With access points'/ devices' directional antenna gain higher than of 23 dBi, maximum conducted output power and maximum power spectral density shall be reduced by the amount in dB that the antenna gain exceeds 23 dBi; point-to-multipoint systems, omni directional applications, and multiple collocated transmitters transmitting the same information shall not be considered as point-to-point systems for the purpose of these rules;

(iii) for mobile and portable client devices in the 5 150-5 250 MHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi and in addition, the maximum power spectral density shall not exceed 11 dBm in any 1 MHz band; if transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi;

(iv) in the frequency bands 5 250 – 5 350 MHz and 5 470- 5 725 MHz for access points operating with transmitting antennas of antenna gain 6 dBi and less, the maximum conducted output power over the frequency band of operation shall not exceed 24 dBm

(250 mW) or 11dBm + 10 log B, whichever is less, where 'B' is the emission bandwidth in MHz. In addition, the maximum power spectral density shall not exceed 11dBm in any 1 MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. The use of appropriate interference mitigation technique dynamic frequency selection and or transmit power control shall be mandatory. Transmit power control mechanism may not be required for systems with an e.i.r.p. of less than 500 mW.

(v) in the band 5 725-5 875 MHz, the minimum 6 dB bandwidth of the devices shall be at least 500 kHz and with transmitting antennas of antenna gain 6 dBi and less, the maximum conducted output power over the frequency band of operation shall not exceed 30 dBm (1 W). In addition, the maximum power spectral density shall not exceed 30 dBm in any 500 kHz band. If the transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi;

(vi) Fixed point-to-point access points operating in the 5 725-5 875 MHz band may employ antennas with directional gain up to 23 dBi and use the maximum conducted output power and maximum power spectral density as indicated at sub-paragraph (iv) above. With access point devices directional antenna gain higher than of 23 dBi, maximum conducted output power and maximum power spectral density shall be reduced by the amount in dB that the antenna gain exceeds 23 dBi.

3.6.2 Peak power density

For direct sequence systems, the peak power spectral density shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

3.6.3 Processing gain

The processing gain (the ratio in dB of the signal-to-noise ratio with the system

spreading code turned off to the signal-to-noise ratio with the system spreading code turned on) of the equipment shall be at least 10 dB. This shall be applicable only for direct-sequence spread spectrum (DSSS) Technology.

3.6.4 Field Strength

The field strength of emissions from the equipment shall comply with the following:

Table 1: Field strength of emissions

Fundamental Frequency	Field Strength of Harmonics
2.4 GHz and 5 GHz band (as per NFAP)	≤0.5 mV/ meter

Field strength limits are specified at a distance of 3 meters. Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental.

3.6.5 Spurious emissions of the transmitter

Spurious emissions are emissions outside the frequency range (s) of the equipment as defined in clause 3.6.4.

The level of spurious emissions shall be measured either as:

a) (i) Its power in a specified load (conducted spurious emissions); and

(ii) Its effective radiated power when radiated by the cabinet or structure of the equipment

OR

b) Its effective radiated power when radiated by cabinet and antenna.

The spurious emissions of the equipment shall not exceed the values in tables 2 and 3 in the indicated bands.

Table 2: Transmitter limits for narrowband spurious emissions

Frequency Range	Limit when operating	Limit when in standby
30 MHz -1000 MHz	-36 dBm	-57 dBm
Above 1 GHz —12.75 GHz	-30 dBm	-47 dBm
1.8 GHz — 1.9 GHz 5 .15 GHz — 5.3 GHz	-47 dBm	- 47 dBm

Wideband spurious emission shall not exceed the values given in table 3.

Table 3: Transmitter limits for wideband spurious emissions

Frequency Range	Limit when operating	Limit when in standby
30 MHz —1000MHz	-86 dBm/Hz	-107dBm/Hz
Above 1 GHz —12.75 GHz	-80 dBm/Hz	- 97 dBm/Hz
1.8 GHz— 1.9 GHz 5 .15 GHz — 5.3 GHz	-97 dBm/Hz	- 97 dBm/Hz

3.7 Receiver Parameters

3.7.1 Receiver Sensitivity

As per clause 17.3.10.1 of IEEE 802.11-2007 (for 802.11a/ b/g), clause 20.3.22.1 of IEEE 802.11n -2009 and clause 22.3.19.1 of IEEE 802.11ac-2013 (Refer Annexure –III of this document) and clause 27.3.20.1 of IEEE 802.11 ax.

3.7.2 Spurious emissions of the Receiver

The level of spurious emissions shall be measured either as:

a) (i) Its power in a specified load (conducted spurious emissions); and

(ii) Its effective radiated power when radiated by the cabinet or Structure of the equipment (cabinet radiation);

or

b) Its effective radiated power when radiated by cabinet and antenna.

The spurious emissions of the receiver shall not exceed the values in tables 4 and 5 in the indicated bands.

Table 4: Narrowband spurious emissions limits for receivers

Frequency Range	Limit
30 MHz -1000 MHz	-57 dBm
Above 1 GHz - 12.75 GHz	- 47 dBm

Note: The limit values of Table 4 apply to narrowband emission, e.g. as caused by local oscillator leakage. The measurement bandwidth for such emission may be as small as necessary to get a reliable measurement result. Wideband emission shall not exceed the values given in table 5.

Table 5: Wideband spurious emissions limits for receivers

Frequency Range	Limit
30 MHz- 1000MHz	-107 dBm/Hz
Above 1 GHz - 12.75 GHz	- 97 dBm/Hz

3.8 Bit Rates

It shall support channel bit rates up to:-

As per Clause 3.3 (Annexure II)

- 1, 2, 5.5, and 11 Mbps with feature of automatic data rate selection as per IEEE 802.11b
- 1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48 and 54 Mbps of IEEE 802.11g
- Upto 300Mbps as per IEEE 802.11n-2009 with channel bonding.
- For IEEE 802.11ac
    - Upto 86 Mbps as per IEEE 802.11ac-2013 and 20 MHz channel bandwidth, 1 spatial stream.
    - Upto200 Mbps as per IEEE 802.11ac-2013 and 40 MHz channel bandwidth,1 spatial stream.
    - Upto433 Mbps as per IEEE 802.11ac-2013 and 80 MHz channel bandwidth,1 spatial stream.
    - Upto 867 Mbps as per IEEE 802.11ac-2013 and 160 MHz channel bandwidth, 1 spatial stream.
    - Upto 173.3 Mbps as per IEEE 802.11ac-2013 and 20 MHz channel bandwidth, 2 spatial streams.
    - Upto 400Mbps as per IEEE 802.11ac-2013 and 40 MHz channel bandwidth,2 spatial streams
    - Upto 866.7 Mbps as per IEEE 802.11ac-2013 and 80 MHz channel bandwidth,2 spatial streams.
    - Upto 1733.3 Mbps as per IEEE 802.11ac-2013 and 160 MHz channel bandwidth, 2 spatial streams.
    - Upto 346.7 Mbps as per IEEE 802.11ac-2013 and 20 MHz channel bandwidth, 4 spatial streams.
    - Upto 800Mbps as per IEEE 802.11ac-2013 and 40 MHz channel bandwidth,4 spatial streams

- Upto 1733.3 Mbps as per IEEE 802.11ac-2013 and 80 MHz channel bandwidth,4 spatial streams.
- Upto 3446.7 Mbps as per IEEE 802.11ac-2013 and 160 MHz channel bandwidth, 4 spatial streams.

- For IEEE 802.11ax
  - Upto 143.4Mbps as per IEEE 802.11ax and 20MHz channel bandwidth, 1 spatial stream
  - Upto 286.8Mbps as per IEEE 802.11ax and 40MHz channel bandwidth, 1 spatial stream
  - Upto 600.5Mbps as per IEEE 802.11ax and 80MHz channel bandwidth, 1 spatial stream
  - Upto 1201Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 1 spatial stream
  - Upto 286.8 Mbps as per IEEE 802.11ax and 20MHz channel bandwidth, 2 spatial streams
  - Upto 573.5Mbps as per IEEE 802.11ax and 40MHz channel bandwidth, 2 spatial streams
  - Upto 1201Mbps as per IEEE 802.11ax and 80MHz channel bandwidth, 2 spatial streams
  - Upto 2402Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 2 spatial stream
  - Upto 573.5Mbps as per IEEE 802.11ax and 20MHz channel bandwidth, 4 spatial streams
  - Upto 1147.1Mbps as per IEEE 802.11ax and 40MHz channel bandwidth, 4 spatial streams
  - Upto 2402Mbps as per IEEE 802.11ax and 80MHz channel bandwidth, 4 spatial streams
  - Upto 4803.9Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 4 spatial streams

- Upto 1147.1Mbps as per IEEE 802.11ax and 20MHz channel bandwidth, 8 spatial streams
- Upto 2294.1Mbps as per IEEE 802.11ax and 40MHz channel bandwidth, 8 spatial streams
- Upto 4803Mbps as per IEEE 802.11ax and 80MHz channel bandwidth, 8 spatial streams
- Upto 9607.8Mbps as per IEEE 802.11ax and 160MHz channel bandwidth, 8 spatial streams

3.9 Antenna

Antenna arrangement depends on application (Indoor and/or Outdoor). The details of antenna (like gain, frequency-range, beamwidth, integrated/external, size, etc.), interconnecting cables and interfaces depending on application requirements (like type of configuration, data rates, path profile, etc.) shall be indicated by the supplier.

3.10 The equipment shall have visual status indication on the unit in case of indoor deployment and on EMS/ WLAN controller in case of outdoor deployment for

i) Activity over Radio

ii) Activity over the Ethernet

iii) Operating / Faulty State

iv) Power indicator

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

3.11 Power supply requirements

The equipment should be able to operate on AC/DC/PoE(Power over Ethernet). The AC power supply shall be of 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.

3.12 Interference detection and avoidance.

The equipment should dynamically sense the spectrum and select the clean channel for effective throughput.

3.13 Channel bonding

The AP may support channel bonding mode as per IEEE 802.11n/ac/ax standards with fallback mechanisms in case of collisions

3.14 It shall be possible to configure AP to support backward compatibility with IEEE 802.11 a/b/g/n/ac based CPEs.

4 Interface Requirements

4.1 The equipment should adhere to the Clause no. 2.0 and the sub-clauses under it of TEC IR No. TEC/IR/R/WiFiAP/001/01. MARCH 2015.

4.2 The Equipment shall be “Wi-Fi CERTIFIED™”.

Note: -

- If the equipment is “Wi-Fi CERTIFIED™” clauses/parameters already tested may not be tested again for TEC certification.
- If the equipment is not “Wi-Fi CERTIFIED™”, then equipment shall be tested by TEC against this GR, for TEC certification purposes.

4.3 Radio interface shall conform to IEEE standards 802.11a/b/g/n/ac/ax as applicable.

4.4 SNMP v2, v3 or above, or XML/CAPWAP/JSON shall be supported for management by a central NOC/EMS/ WLAN Controller.

4.5 **Interfaces:** Equipment shall support 10/100/1000/2500/10000 Mbps electrical or optical Ethernet Interface.

4.6 **Interface Ports**: Auto sensing IEEE 802.3 10/100/1000/2500/10000 BASE-T Ethernet.

4.7 IPv4 and IPv6 addressing shall be supported.

5 Quality Requirements

5.1 The manufacturer shall have a valid ISO 9001:2008 or any other equivalent ISO certificate.

5.2 The equipment shall meet the environmental requirements as per 'Category B-2' (in case of Indoor equipment) and 'Category D' (in case of Outdoor equipment) of QM-333 March 2010 Standard for Environmental Testing of Telecommunication Equipment.

5.3 The MTBF (Mean Time between Failure) and MTTR (Mean Time To Restore) predicted shall be provided and the manufacturer shall furnish observed values.

5.4 In case of outdoor deployment of Wi-Fi Access Point, it should be minimum IP-65 compliant. The equipment may be IP-67 compliant as per user/procurer's requirement.

6 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 accredited test lab shall be furnished from a test agency.

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

Name of EMC Standard: "CISPR 32 (2015) with amendments - Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment".

Limits:-

i) To comply with Class B of CISPR 32 (2015) with amendments for indoor deployments and Class A of CISPR 32 (2015) with amendments for outdoor deployments.

b) Immunity to Electrostatic discharge:

Name of EMC Standard: IEC 61000-4-2 {2008) "Testing and measurement techniques of Electrostatic discharge immunity test".

Limits: -

i) Contact discharge level 2 {± 4 kV} or higher voltage;

ii) Air discharge level 3 {± 8 kV} or higher voltage;

c) Immunity to radiated RF:

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

Limits:-

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.

d) Immunity to fast transients(burst):

Name of EMC Standard: IEC 61000- 4- 4 {2012) "Testing and measurement techniques of electrical fast transients/burst immunity test"

Limits:-

Test Level 2 i.e. a) 1 kV for AC/DC power lines; b) 0. 5 kV for signal / control / data / telecom lines;

e) Immunity to surges:

Name of EMC Standard: IEC 61000-4-5 (2014) “Testing & Measurement techniques for Surge immunity test"

Limits:-

i) For mains power input ports : (a)2 kV peak open circuit voltage for line to ground coupling (b) 1 kV peak open circuit voltage for line to line coupling

ii) For telecom ports : (a) 2kV peak open circuit voltage for line to ground (b) 0.5KV peak open circuit voltage for line to line coupling.

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

Name of EMC Standard: IEC 61000-4-6 (2013) with amendments) "Testing & measurement techniques-Immunity to conducted disturbances induced by radio-frequency fields”

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.

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

Name of EMC Standard: IEC 61000-4-11 (2014) “Testing & measurement techniques- voltage dips, short interruptions and voltage variations immunity tests”

Limits:-

i) a voltage dip corresponding to a reduction of the supply voltage of 30% for 500ms (i.e. 70 % supply voltage for 500 ms)

ii) a voltage dip corresponding to a reduction of the supply voltage of 60% for 200ms; (i.e. 40% supply voltage for 200ms) and

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 10s.

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 and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests

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, 300 ms and 1000ms. Applicable Performance Criteria shall be C.
v. Voltage variations corresponding to 80% and 120%of supply for 100 ms to10s as per Table 1c of IEC 61000-4-29. Applicable Performance Criteria shall be B.

Note: - For checking compliance with the above EMC requirements, the method of

measurements shall be in accordance with TEC Standard No. TEC/SD/DD/EMC-221/05/OCT-16 and the referenced base standards i.e. IEC and CISPR standards 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 (h) and TEC Standard TEC/SD/DD/EMC-221/05/OCT-16. The details of IEC/CISPR and their corresponding Euro Norms are as follows:

IEC/CISPR	Euro Norm
CISPR 11	EN 55011
CISPR 32	EN55032
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
IEC 61000-4-29	EN 61000-4-29

7 Safety Requirements

7.1 The equipment shall conform to:

a) IS 13252 part 1: 2010 “Information Technology Equipment –Safety- Part 1: General Requirements” [equivalent to IEC 60950-1 {2005} “Information Technology Equipment –Safety- Part 1: General Requirements”]

OR

IEC 62368-1: 2018 “Audio/video, information and communication technology equipment - Part 1: Safety requirements”

b) IS 10437{1986} “Safety requirements for radio transmitting equipments” [equivalent to IEC 60215].

8 Security Requirements

8.1 Equipment shall conform to WPA2 based on IEEE 802.11i standard, access control authentication based on 802.1X / EAP Standard and in case of IEEE 802.11ax, equipment shall also conform to WPA3 personal and WPA 3 enterprise.

8.2 Equipment shall conform to Media Access control security based on 802.1 AE as an optional requirement.

8.3 Service Set Identifier (SSID) shall be definable by Administrator.

8.4 In case of authentication and authorization is implemented through a RADIUS server, IETF RFC 2865 should be supported and optionally if required IETF RFC 2866, 2867 may also be supported.

9 Other Requirements

9.1 Identification of Equipment

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

ii) The 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) Above markings shall be legible, indelible and easily visible.

9.2 Documentation

Detailed documentation in English or Hindi 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)

10 Optional requirements

10.1 Requirements for Type-'A'

Type 'A' Access Point without routing but bridging functionality with Ethernet LAN/WAN ports, may also support, as per the procurer's requirements, some or all of the functionalities as below:

i) IEEE 802.1q VLAN tagging (SSID to VLAN Mapping)

ii) Mesh (Easy Mesh or 802.11s) and repeater modes of operation

iii) ARP (IETF RFC 826)

iv) IEEE 802.1p priority

v) Spectrum sensing and reporting capability

vi) Multiple SSID support for operator sharing.

vii) Support for VAP (Virtual Access Point)

viii) Configuration of parameters through web interface when link to NOC/EMS/WLAN Controller is not available.

ix) NavIC support on board

x) Concurrent clients per radio

xi) Support of dying gasp (DG) feature for Outdoor deployment

10.2 Requirements for Type-'B'

Type 'B' Access Point with built in routing and bridging functionality with Ethernet LAN/WAN ports, may also support, as per the procurer's requirements, some or all of the functionalities as below:

i) IEEE 802.1q VLAN tagging

ii) PPPoE for WAN port.

iii) DHCP Server, client(optional), relay (RFC 2131, 951 and 3046)

iv) ARP (IETF RFC 826)

v) IEEE 802.1p priority

vi) VPN Client

vii) Firewall Support

viii)NAT

ix) NavIC support on board

x) Concurrent clients per radio

xi) Support of dying gasp (DG) feature for Outdoor deployment

10.3 In case of Hotspot 2.0 deployment, relevant features of IEEE 802.11u should be supported by the AP.

10.4 In case of SIM based authentication EAP-SIM, AKA, EAP-AKA' should be supported while for non-SIM based authentication EAP-TLS, EAP- TTLS, EAP- should be supported by the AP.

11 Additional Requirements for WANI compliant Wi-Fi Access Point

For a WANI compliant Wi-Fi Access Point, the following requirements apply:

11.1 In case of standalone operation wherein a single Wi-Fi AP has been deployed as a PDO and parented by PDOA

a) The Access Point must be configured in Router mode.

b) The Access Point must have DHCP server for IP allocation to the connected devices.

11.2 In case of cluster deployment of multiple Wi-Fi APs under a single PDO network, requirement of router mode of operation and DHCP server functionality may be provisioned for the cluster instead of a single Wi-Fi AP.

11.3 In case of cluster deployment of Wi-Fi APs under a single PDO network, they must support SSID based roaming/Fast BSS Transition (802.11r) for faster reassociation with roaming.

11.4 The Access Point must support a minimum of 20 connected devices concurrently.

11.5 The Access Point must be deployed with storage facility so as to be able to transfer IP Detail Record to PDOA after end of session or periodically after every 24 hours.

11.6 The Access point must support network clock synchronization.

11.7 As backup, the Access Point must be deployed with a minimum storage to ensure IPDR logging for minimum 3 days.

11.8 The Access Point shall be able to present a uniquely branded user interface called Captive Portal when the wireless client device connects to it.

11.9 Provision for Whitelisting of PDOA related IPs/URLs.

11.10 The operation of Wireless Access Point shall be in the license free bands of 2.4 and/or 5 GHz bands and as per latest National Frequency Allocation Plan (NFAP) and published WPC GSRs as mentioned in Clause 3.1

\

CHAPTER-2

12 Information for the procurer of product

For procurement purposes, purchaser may specify the following:

i) Equipment should be compliant to which of the IEEE standards as per Clause 3.2.

ii) Application : Indoor Or Outdoor Or Both

iii) Frequency of operation: As per clause 3.1

iv) MIMO Configuration (for e.g. 2x2, 3x3 and above) (In case of IEEE 802.11n, 802.11ac and 802.11ax) as per Clause 3.3.

v) Clause 3.10: Option for power supply requirements

vi) Clause 4.5 & 4.6: 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 8.4.

ix) Requirements as per Clause 9.2(iv).

x) Requirements as per Clause 10.1&10.2: Type ‘A’ or Type ‘B’.

xi) Requirements as per clauses 10.3, 10.4.

xii) Validation requirements for the equipment.

xiii) The requirement for IEEE 802.1AE as per clause 8.2 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, in case of outdoor deployment of Wi-Fi Access Point as per clause 5.4 shall be specified by the procurer.

13 Specific remarks / information to be mentioned in the Certificate

13.1 IEEE Standard

13.2 Frequency of operation:

13.3 Minimum Throughput

13.4 Channel Bandwidth:

13.5 Type A: Wi-Fi Access Point without Router functionality

Or

Type B: Wi-Fi Access Point with Router functionality

13.6 Application: (Indoor/ Outdoor/ both Indoor & Outdoor):

13.7 MIMO Configuration (in case of IEEE 802.11n,802.11ac) and 802.11ax:

13.8 Interface Ports: Type and number of Ports

13.9 "AC Power/DC Power/PoE/non-conventional energy sources like Solar Power/ Wind Power etc."

13.10 Whether Equipment is "Wi-Fi CERTIFIED™" (Yes/No)

13.11 Whether Equipment is WANI compliant.

ABBREVIATIONS

AP	Access Point
API	Application Program Interface
BCC	Block check character
CD	Compact Disc
CDR	Call Details Records
CISC	Complex Instruction Set Computer
CISPR	Comite International Special des Perturbations Radioelectriques
CPE	Customer Premises Equipment
DAT	Digital Audio Tape
DC	Direct Current
DHCP	Dynamic Host Configuration Protocol
DNIS	Dialled Number Identification Service
DNS	Domain Name Service
DSSS	Direct Sequence Spread Spectrum
EAP	Extensible Authentication Protocol
EAP-TLS	Extensible Authentication Protocol -Transport Layer Security
EAP-TTLS	Extensible Authentication Protocol-Tunnelled Transport Layer Security
EIRP	Effective Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMS	Electronic Message Service
FCAPS	Fault Configuration Accounting Performance Security
FTP	File Transfer Protocol
FWS	Firewall System

GB	Giga Byte
GHz	Giga Hertz
GR	Generic Requirement
GRIC	Global Reach Internet Connection
GSM	Global System for Mobile Communications
GSR	General Statutory Rules
GUI	Graphic User Interface
HDD	Hard Disk Drive
HTTP	Hypertext Transfer Protocol
HE	High Efficiency
ID	Identification Data
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
IETF	Internet Engineers Task Force
IP	Internet Protocol
IR	Interface Requirements
ISO	International Standards Organisation
ITU	International Telecommunication Union
IVR	Interactive Voice Response
LAN	Local Area Network
LCI	LDAP Configuration Interface
LDAP	Lightweight Directory Access Protocol
LDPC	Low Density Parity Check
LED	Light Emitting Diode
MAC	Media Access Control
MCS	Modulation and coding scheme
MIB	Management Information Base
MIMO	Multiple-input and Multiple-output
MTBF	Mean Time Between Faults
MTTR	Mean Time To Restore

MU	Multi-unit
mW	Milli watts
NAI	Network Access Identifier
NAT	Network Address Translator
NavIC	Navigation with Indian Constellation
NE	Network Element
NFAP	National Foundation for American Policy
NMS	Network Management System
NOC	Network Operation Centre
OFDM	Orthogonal Frequency Division Multiplexing
OS	Operating System
PDO	Public Data Office
POE	Power over Ethernet
PPP	Point-to-Point Protocol
PPPoE	Point to Point Protocol over Ethernet
PPTP	Point to Point Tunnelling Protocol
PPDU	Physical layer Packet Data Unit
QA	Quality Assurance
QM	Quality Manual
QoS	Quality of Service
QR	Quality Requirements
RADIUS	Remote Authentication Dial In User Service
RAID	Redundant Array of Independent Desks
RAM	Random Access memory
RDBMS	Relational Database Management System
RF	Radio-Frequency
RFC	Request For Comment
RIP	Routing Information Protocol
RISC	Reduced Instruction Set Computer

RP	Radio Paging
SASL	Simple Authentication Security Layer
SD	Secure Digital
SIM	Subscriber Identity Module
SMPP	Short Message Peer to Peer Protocol
SNMP	Simple Network Management Protocol
SQL	Structured Query Language
SSID	Service Set identifier
SSL	Secured Socket Layer
SU	Single-unit
TB	Trigger based
TCP	Transmission Control Protocol
TEC	Telecom Engineering Centre
TMN	Telecommunication Management Network
TSTP	Test Setup and Test Procedure
URL	Uniform Resource Locator
UTF	Unicode Transformation Format
VAP	Virtual Access Point
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
XML	Extensible Markup Language
STA	Station

======== End of the document ========

Annexure- I

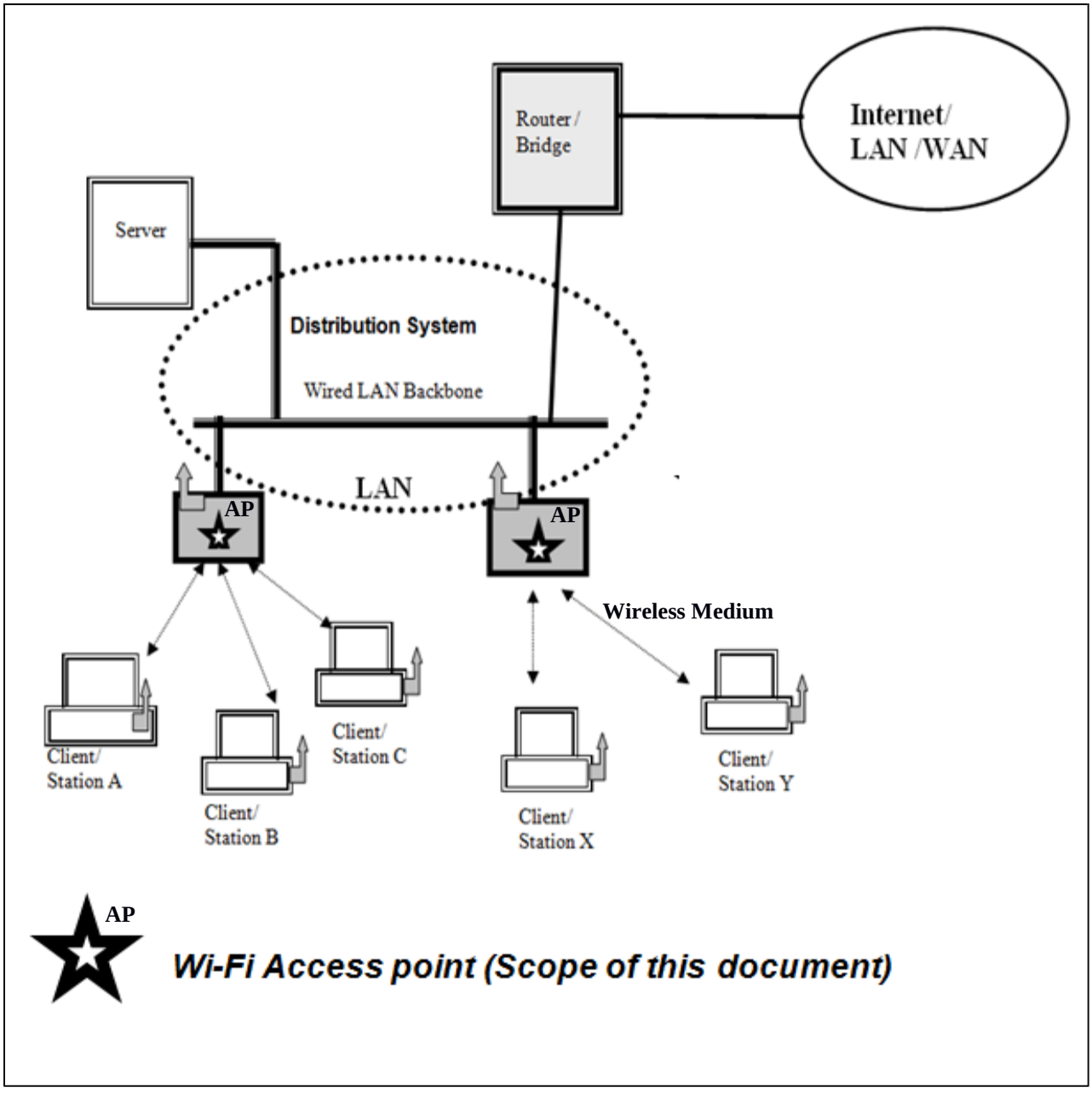

Figure 1 Schematic of Wireless LAN

Annexure II

Bit Rates and Throughput

Annexure II a

IEEE 802.11 a

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	54Mbps	28Mbps	64-QAM OFDM

Annexure II b

IEEE 802.11 b

Frequency	Bandwidth	Association Rate/Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	11 Mbps	7 Mbps	DSSS

Annexure II c

IEEE 802.11 g

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	54Mbps	28 Mbps	64-QAM OFDM

Annexure II d

IEEE 802.11 n (1x1)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4GHz	20 MHz	65Mbps	45Mbps	MCS 7 (64 – QAM)
5 GHz	20 MHz	65Mbps	45Mbps	MCS 7 (64 – QAM)
2.4GHz with channel bonding	40 MHz	150Mbps	105Mbps	MCS 7 (64 – QAM)
5 GHz with channel bonding	40 MHz	150Mbps	105Mbps	MCS 7 (64 – QAM)

IEEE 802.11 n (2x2)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4GHz	20 MHz	130Mbps	100Mbps	MCS 15 (64 – QAM)
5 GHz	20 MHz	130Mbps	100Mbps	MCS 15 (64 – QAM)

2.4GHz with channel bonding	40 MHz	300Mbps	150Mbps	MCS 15 (64 – QAM)
5 GHz with channel bonding	40 MHz	300Mbps	150Mbps	MCS 15 (64 – QAM)

IEEE 802.11 n (3x3)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4GHz	20 MHz	195Mbps	136Mbps	MCS 23 (64 – QAM)
5 GHz	20 MHz	195Mbps	136Mbps	MCS 23 (64 – QAM)
2.4GHz with channel bonding	40 MHz	450Mbps	315Mbps	MCS 23 (64 – QAM)
5 GHz with channel bonding	40 MHz	450Mbps	315Mbps	MCS 23 (64 – QAM)

IEEE 802.11 n (4x4)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4GHz	20 MHz	260Mbps	182Mbps	MCS 31 (64 – QAM)
5 GHz	20 MHz	260Mbps	182Mbps	MCS 31 (64 – QAM)
2.4GHz with channel bonding	40 MHz	600Mbps	420Mbps	MCS 31 (64 – QAM)
5 GHz with channel bonding	40 MHz	600Mbps	420Mbps	MCS 31 (64 – QAM)

Annexure II e

IEEE 802.11 ac (1x1)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	86 Mbps	40 Mbps	MCS 09 (256 – QAM)
5 GHz	40 MHz	200 Mbps	90 Mbps	MCS 09 (256 – QAM)
5 GHz	80 MHz	433 Mbps	195 Mbps	MCS 09 (256 – QAM)
5 GHz	160 MHz	867 Mbps	390 Mbps	MCS 09 (256 – QAM)

IEEE 802.11 ac (2x2)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	173 Mbps	70 Mbps	MCS 09 (256 – QAM)
5 GHz	40 MHz	400 Mbps	160 Mbps	MCS 09 (256 – QAM)
5 GHz	80 MHz	867 Mbps	347 Mbps	MCS 09 (256 – QAM)
5 GHz	160 MHz	1733 Mbps	693 Mbps	MCS 09 (256 – QAM)

IEEE 802.11 ac (3x3)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	289 Mbps	115 Mbps	MCS 09 (256 – QAM)
5 GHz	40 MHz	600 Mbps	240 Mbps	MCS 09 (256 – QAM)
5 GHz	80 MHz	1300 Mbps	520 Mbps	MCS 09 (256 – QAM)
5 GHz	160 MHz	2340 Mbps	936 Mbps	MCS 09 (256 – QAM)

IEEE 802.11 ac (4x4)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	347 Mbps	139 Mbps	MCS 09 (256 – QAM)
5 GHz	40 MHz	800 Mbps	320 Mbps	MCS 09 (256 – QAM)
5 GHz	80 MHz	1733 Mbps	693 Mbps	MCS 09 (256 – QAM)
5 GHz	160MHz	3467 Mbps	1386 Mbps	MCS 09 (256 – QAM)

Note: MCS 8 and MCS 9 are optional in case of IEEE 802.11ac .

Annexure II f

IEEE 802.11 ax (1x1)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	143.4 Mbps	80 Mbps	MCS 11 (1024 – QAM)
5 GHz	40 MHz	286.8 Mbps	160 Mbps	MCS 11 (1024 – QAM)
5 GHz	80 MHz	600 Mbps	360 Mbps	MCS 11 (1024 – QAM)
5 GHz	160 MHz	1201 Mbps	760 Mbps	MCS 11 (1024 – QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	143.4 Mbps	80 Mbps	MCS 11 (1024 – QAM)
2.4 GHz	40 MHz	286.8 Mbps	160 Mbps	MCS 11 (1024 – QAM)

IEEE 802.11 ax (2x2)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	286.8 Mbps	160 Mbps	MCS 11 (1024 QAM)
5 GHz	40 MHz	573.5 Mbps	320 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	1201 Mbps	720 Mbps	MCS 11 (1024 QAM)
5 GHz	160 MHz	2402 Mbps	1440 Mbps	MCS 11 (1024 QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	286.8 Mbps	160 Mbps	MCS 11 (1024 QAM)
2.4 GHz	40 MHz	573.5 Mbps	320 Mbps	MCS 11 (1024 QAM)

IEEE 802.11 ax (3x3)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	430.1Mbps	240 Mbps	MCS 11 (1024 QAM)
5 GHz	40 MHz	860.3 Mbps	480 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	1801 Mbps	1080 Mbps	MCS 11 (1024 QAM)
5 GHz	160 MHz	3602.9 Mbps	2160 Mbps	MCS 11 (1024 QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	430.1 Mbps	240 Mbps	MCS 11 (1024 QAM)

2.4 GHz	40 MHz	860.3 Mbps	480 Mbps	MCS 11 (1024 QAM)

IEEE 802.11 ax (4x4)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	573.5Mbps	320 Mbps	MCS 11 (1024 QAM)
5 GHz	40 MHz	1147.1 Mbps	640 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	2402Mbps	1440 Mbps	MCS 11 (1024 QAM)
5 GHz	160 MHz	4803.9 Mbps	2880 Mbps	MCS 11 (1024 QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	573.5Mbps	320 Mbps	MCS 11 (1024 QAM)
2.4 GHz	40 MHz	1147.1 Mbps	640 Mbps	MCS 11 (1024 QAM)

IEE 802.11 ax (5x5)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	716.9Mbps	400 Mbps	MCS 11 (1024 QAM)
5 GHz	40 MHz	1433.8Mbps	800 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	3002.5Mbps	1800 Mbps	MCS 11 (1024 QAM)

5 GHz	160 MHz	6004.9 Mbps	3600 Mbps	MCS 11 (1024 QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	716.9Mbps	400 Mbps	MCS 11 (1024 QAM)
2.4 GHz	40 MHz	1433.8Mbps	800 Mbps	MCS 11 (1024 QAM)

IEE 802.11 ax (6x6)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	860.3Mbps	480 Mbps	MCS 11 (1024 QAM)

5 GHz	40 MHz	1720.6 Mbps	960 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	3602.9 Mbps	2160 Mbps	MCS 11 (1024 QAM)
5 GHz	160 MHz	7205.9 Mbps	4320 Mbps	MCS 11 (1024 QAM)

Frequency	**Bandwidth**	**Physical Data Rate**	**Minimum Throughput**	**Modulation**
2.4 GHz	20 MHz	860.3Mbps	480 Mbps	MCS 11 (1024 QAM)
2.4 GHz	40 MHz	1720.6 Mbps	960 Mbps	MCS 11 (1024 QAM)

IEE 802.11 ax (7x7)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	1003.7Mbps	560 Mbps	MCS 11 (1024 QAM)
5 GHz	40 MHz	2007.4 Mbps	1120 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	4203.4Mbps	2520 Mbps	MCS 11 (1024 QAM)
5 GHz	160 MHz	8406.9 Mbps	5040 Mbps	MCS 11 (1024 QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	1003.7Mbps	560 Mbps	MCS 11 (1024 QAM)

2.4 GHz	40 MHz	2007.4 Mbps	1120 Mbps	MCS 11 (1024 QAM)

IEE 802.11 ax (8x8)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
5 GHz	20 MHz	1147.1Mbps	640 Mbps	MCS 11 (1024 QAM)
5 GHz	40 MHz	2294.1 Mbps	1280 Mbps	MCS 11 (1024 QAM)
5 GHz	80 MHz	4803.9 Mbps	2280 Mbps	MCS 11 (1024 QAM)
5 GHz	160 MHz	9607.8 Mbps	5760 Mbps	MCS 11 (1024 QAM)

Frequency	Bandwidth	Physical Data Rate	Minimum Throughput	Modulation
2.4 GHz	20 MHz	1147.1Mbps	640 Mbps	MCS 11 (1024 QAM)
2.4 GHz	40 MHz	2294.1 Mbps	1280 Mbps	MCS 11 (1024 QAM)

Note: MCS 10 and MCS 11 are optional in case of IEEE 802.11ax.

Annexure-III

Receiver Sensitivity

1. **Clause 17.3.10.1 of IEEE 802.11-2007 for 802.11(a/b/g) –**

Receiver minimum input sensitivity :- The packet error rate (PER) shall be less than 10% at a PSDU length of 1000 octets for rate-dependent input levels shall be the numbers listed in Table 17-13 or less. The minimum input levels are measured at the antenna connector (noise factor of 10 dB and 5 dB implementation margins are assumed).

Table 17-13—Receiver performance requirements

Modulation	Coding rate (R)	Adjacent channel rejection (dB)	Alternate adjacent channel rejection (dB)	Minimum sensitivity (dBm) (20 MHz channel spacing)	Minimum sensitivity (dBm) (10 MHz channel spacing)	Minimum sensitivity (dBm) (5 MHz channel spacing)
BPSK	1/2	16	32	–82	–85	–88
BPSK	3/4	15	31	–81	–84	–87
QPSK	1/2	13	29	–79	–82	–85
QPSK	3/4	11	27	–77	–80	–83
16-QAM	1/2	8	24	–74	–77	–80
16-QAM	3/4	4	20	–70	–73	–76
64-QAM	2/3	0	16	–66	–69	–72
64-QAM	3/4	–1	15	–65	–68	–71

2. Clause 20.3.22.1 of IEEE 802.11n-2009

Receiver minimum input sensitivity:-The packet error rate (PER) shall be less than 10% for a PSDU length of 4096 octets with the rate-dependent input levels listed in Table 20-22 or less. The minimum input levels are measured at the antenna connectors and are referenced as the average power per receive antenna. The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized device under test input ports. Each output port of the transmitting STA shall be connected through a cable to one input port of the device under test. The test in this subclause and the minimum sensitivity levels specified in Table 20-22 apply only to non-STBC modes, MCSs 0–31, 800 ns GI, and BCC.

Table 20-22—Receiver minimum input level sensitivity

Modulation	Rate (R)	Adjacent channel rejection (dB)	Nonadjacent channel rejection (dB)	Minimum sensitivity (20 MHz channel spacing) (dBm)	Minimum sensitivity (40 MHz channel spacing) (dBm)
BPSK	1/2	16	32	–82	–79
QPSK	1/2	13	29	–79	–76
QPSK	3/4	11	27	–77	–74
16-QAM	1/2	8	24	–74	–71
16-QAM	3/4	4	20	–70	–67
64-QAM	2/3	0	16	–66	–63
64-QAM	3/4	–1	15	–65	–62
64-QAM	5/6	–2	14	–64	–61

3. Clause 22.3.19.1of IEEE 802.11ac-2013

Receiver minimum input sensitivity:-The packet error ratio (PER) shall be less than 10% for a PSDU length of 4096 octets with the rate-dependent input levels listed in Table 22-25. The test in this subclause and the minimum sensitivity levels specified in Table 22-25 apply only to non-STBC modes, 800 ns GI, BCC, and VHT PPDUs.

Table 22-25—Receiver minimum input level sensitivity

Modulation	Rate (R)	Minimum sensitivity (20 MHz PPDU) (dBm)	Minimum sensitivity (40 MHz PPDU) (dBm)	Minimum sensitivity (80 MHz PPDU) (dBm)	Minimum sensitivity (160 MHz or 80+80 MHz PPDU) (dBm)
BPSK	1/2	–82	–79	–76	–73
QPSK	1/2	–79	–76	–73	–70
QPSK	3/4	–77	–74	–71	–68
16-QAM	1/2	–74	–71	–68	–65
16-QAM	3/4	–70	–67	–64	–61
64-QAM	2/3	–66	–63	–60	–57
64-QAM	3/4	–65	–62	–59	–56
64-QAM	5/6	–64	–61	–58	–55
256-QAM	3/4	–59	–56	–53	–50
256-QAM	5/6	–57	–54	–51	–48

Clause 27.3.20.1 of IEEE 802.11ax Receiver minimum input sensitivity: The packet error rate (PER) shall be less than 10% for a PSDU with the rate-dependent input levels listed in Table 27-51 (Receiver minimum input level sensitivity). The PSDU length shall be 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations.

Table 27-51—Receiver minimum input level sensitivity

Modulation		Rate (R)	Minimum sensitivity (20 MHz PPDU) (dBm)	Minimum sensitivity (40 MHz PPDU) (dBm)	Minimum sensitivity (80 MHz PPDU) (dBm)	Minimum sensitivity (160 MHz or 80+80 MHz PPDU) (dBm)
Without DCM	With DCM					
N/A	BPSK	1/2	–82	–79	–76	–73
BPSK	QPSK	1/2	–82	–79	–76	–73
QPSK	16-QAM	1/2	–79	–76	–73	–70
QPSK	16-QAM	3/4	–77	–74	–71	–68
16-QAM	N/A	1/2	–74	–71	–68	–65
16-QAM	N/A	3/4	–70	–67	–64	–61
64-QAM	N/A	2/3	–66	–63	–60	–57
64-QAM	N/A	3/4	–65	–62	–59	–56
64-QAM	N/A	5/6	–64	–61	–58	–55
256-QAM	N/A	3/4	–59	–56	–53	–50
256-QAM	N/A	5/6	–57	–54	–51	–48
1024-QAM	N/A	3/4	–54	–51	–48	–45
1024-QAM	N/A	5/6	–52	–49	–46	–43

Table 27-52—Minimum required adjacent and nonadjacent channel rejection levels

Modulation		Rate (R)	Adjacent channel rejection (dB)		Nonadjacent channel rejection (dB)	
Without DCM	With DCM		20/40/80/160 MHz Channel	80+80 MHz Channel	20/40/80/160 MHz Channel	80+80 MHz Channel
N/A	BPSK	1/2	16	13	32	29
BPSK	QPSK	1/2	16	13	32	29
QPSK	16-QAM	1/2	13	10	29	26
QPSK	16-QAM	3/4	11	8	27	24
16-QAM	N/A	1/2	8	5	24	21
16-QAM	N/A	3/4	4	1	20	17
64-QAM	N/A	2/3	0	–3	16	13
64-QAM	N/A	3/4	–1	–4	15	12
64-QAM	N/A	5/6	–2	–5	14	11
256-QAM	N/A	3/4	–7	–10	9	6
256-QAM	N/A	5/6	–9	–12	7	4
1024-QAM	N/A	3/4	–12	–15	4	1
1024-QAM	N/A	5/6	–14	–17	2	–1

Adjacent channel rejection: The interfering signal in the adjacent channel shall be a signal compliant with the HE PHY, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. The corresponding rejection shall be no less than specified in Table 27-52 (Minimum required adjacent and nonadjacent channel rejection levels).

Nonadjacent channel rejection: The interfering signal in the nonadjacent channel shall be a signal compliant with the HE PHY, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. The corresponding rejection shall be no less than specified in Table 27-52 (Minimum required adjacent and nonadjacent channel rejection levels).

Table 27-52—Minimum required adjacent and nonadjacent channel rejection levels

Modulation		Rate (R)	Adjacent channel rejection (dB)		Nonadjacent channel rejection (dB)	
Without DCM	With DCM		20/40/80/160 MHz Channel	80+80 MHz Channel	20/40/80/160 MHz Channel	80+80 MHz Channel
N/A	BPSK	1/2	16	13	32	29
BPSK	QPSK	1/2	16	13	32	29
QPSK	16-QAM	1/2	13	10	29	26
QPSK	16-QAM	3/4	11	8	27	24
16-QAM	N/A	1/2	8	5	24	21
16-QAM	N/A	3/4	4	1	20	17
64-QAM	N/A	2/3	0	–3	16	13
64-QAM	N/A	3/4	–1	–4	15	12
64-QAM	N/A	5/6	–2	–5	14	11
256-QAM	N/A	3/4	–7	–10	9	6
256-QAM	N/A	5/6	–9	–12	7	4
1024-QAM	N/A	3/4	–12	–15	4	1
1024-QAM	N/A	5/6	–14	–17	2	–1

Receiver maximum input level: The receiver shall provide a maximum PER of 10% at a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations, for a maximum input level of –30 dBm in the 5 GHz and 6 GHz bands and –20 dBm in the 2.4 GHz band, measured at each antenna for any baseband HE modulation.

Annexure-IV

Information on some of the possible deployment scenarios of Wi-Fi AP and the IEEE technology employed

1. Outdoor Rural/Semi Urban Broadband Solutions

Providing broadband services in Villages, Gram Panchayat or Village Schools and other institutions are some of the examples of such solutions. Typically users in such deployment will be using low cost mobile handsets, tablets, laptops etc which normally do not support evolving standards like 802.11ac/ax. Usage pattern and the affordability of the end users is also key for such deployment. Typical applications will be accessing internet, e-mail etc. Hence 802.11 a/b/g/n/ac/ax Access Point is apt for such solutions.

2. Public Broadband Wi-Fi (Indoor/Outdoor) Solutions

Providing broadband services in cities and enterprises for applications such as internet access, e-mail, file transfer, video conferencing etc. There will be all type of users requiring compatibility of devices with Access Point. Hence IEEE 802.11 a/b/g/n/ac/ax based Access Points are apt for such solutions.

3. Indoor 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, gaming etc. These applications can be best supported by 802.11n/ac/ax Access Point. Hotspot support can also be considered depending upon its availability in user devices.