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RECOMMENDATION ITU-R M.2003-1

Multiple Gigabit Wireless Systems in frequencies around 60 GHz

(Question ITU-R 212-3/5)

(2012-2015)

Keywords

MGWS, WLAN, RLAN, Wireless Local Access, Networks, Radio Local Area Networks

Scope

This Recommendation provides general characteristics and radio interface standards for Multiple Gigabit Wireless Systems in frequencies around 60 GHz.

The ITU Radiocommunication Assembly,

considering

a) that Multiple Gigabit Wireless Systems (MGWS) are widely used for fixed, semi-fixed (transportable) and portable computer equipment for a variety of broadband applications;

b) that MGWS are expected to encompass applications for wireless digital video, audio, and control applications, as well as multiple gigabit wireless local area networks (WLAN);

c) that MGWS standards have been developed for operation in the 60 GHz frequency range;

d) that MGWS should be implemented with careful consideration to compatibility with other radio applications;

e) that many administrations permit MGWS including radio local area networks (RLANs) devices to operate in the 60 GHz frequency range on a license-exempt basis;

f) that harmonized frequencies in the 60 GHz frequency range for the mobile service would facilitate the introduction of MGWS including RLANs,

recognizing

a) that both consumers and manufacturers will benefit from global harmonization of the 60 GHz spectrum for MGWS;

b) that although MGWS systems have been predominantly used for indoor applications there are administrations which allow outdoor use of these systems,

noting

a) that several standards provide options for MGWS implementation,

recommends

1 that the MGWS standards and their system characteristics contained in Annex 1 should be used.

Annex 1

General characteristics of 60 GHz Multiple Gigabit Wireless Systems

1 Overview

Multiple Gigabit Wireless System (MGWS) radiocommunication networks can be used in short-range, line-of-sight and non-line-of-sight circumstances. Total communication range and performance will vary depending on the environment, but multiple gigabit performance is typically expected at ranges around 10 m for in-room use. These networks can be deployed with an access point as in existing WLAN deployments or without such an infrastructure such as in both WLAN in ad hoc mode and wireless personal area network (WPAN).

When access points are used, they are mounted indoor with service covering home or an office space with a nomadic user terminal typically also used indoor, i.e. the entire WLAN system would be used in indoor environment.

When access points are not used, MGWS devices are allowed to communicate by setting up direct links for data exchange between the devices/equipment. Typical applications include equipment to equipment (e.g. laptop to projector) and a consumer electronics (CE) device to a kiosk[1], and it may be assumed that usage would predominantly be indoors.

2 Technical characteristics of MGWS

2.1 Spectrum

A minimum of 7 GHz contiguous spectrum in the 57-66 GHz is needed to satisfy the requirements[2] of the applications envisioned to be used in this spectrum, such as uncompressed video (e.g. high definition multimedia interface (HDMI) at 3 Gbit/s), wireless docking and rapid download/upload. This would allow at least three channels for flexibility and improved connectivity. Furthermore, channel bandwidth of 2 160 MHz allows simpler modulation schemes to achieve multi-Gbit/s data rates, which is suitable for adoption by low power devices such as smartphones, tablets, netbook and notebook PCs.

2.2 Channel bandwidth and centre frequencies

A 2 160 MHz channel bandwidth is required. It is important that MGWS standards employ the same channelization in order to promote better coexistence. Four centre frequencies are recommended to be at 58.32, 60.48, 62.64, and 64.80 GHz.

2.3 Transmit mask

The following mask is applicable to single channel operation.

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[1]   In this context, a kiosk is a booth providing distribution of, and providing access to, electronic content such as movies, music, video, e-books, etc.

[2]   System requirements are provided in the standards contained in Annex 1.

FIGURE 1

Spectral mask for single channel operation

−17 dBr
−22 dBr
−30 dBr

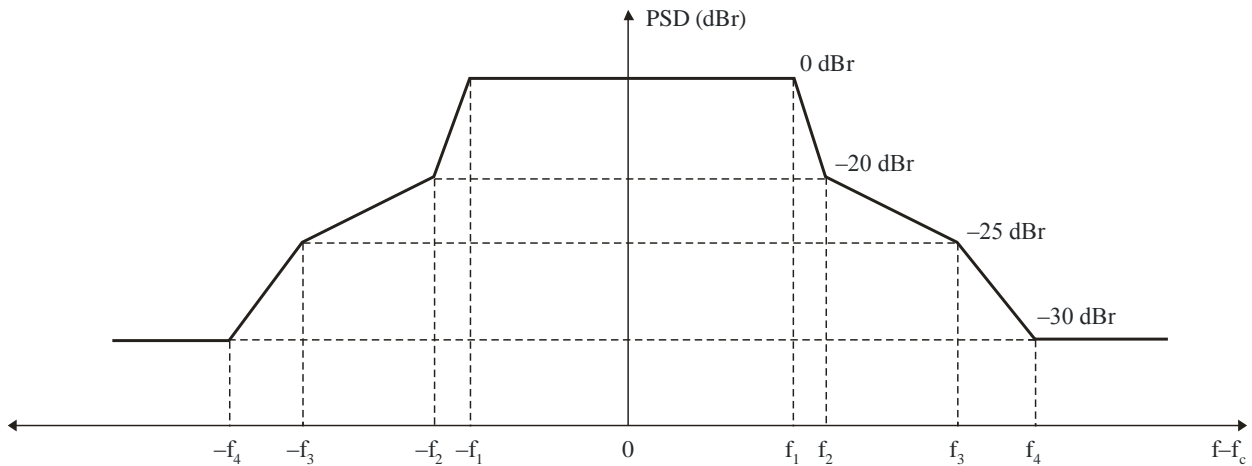−3.06 −2.7 −1.2 −0.94 0.94 1.2 2.7 3.06 (f–f$_c$) GHz
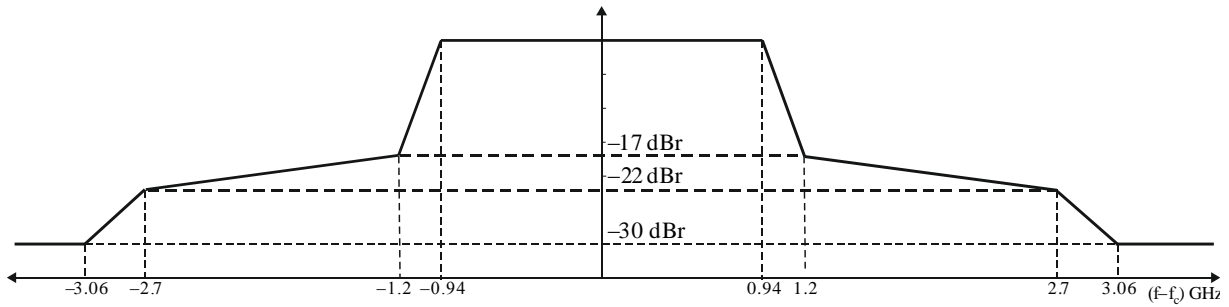
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In Fig. 1 above, f_c is the carrier centre frequency.

The following mask (Fig. 2 and Table 1) is applicable when channel bonding of more than one contiguous channel is used.

FIGURE 2

Spectral mask for more than one contiguous channel with channel bonding

PSD (dBr)

0 dBr

−20 dBr

−25 dBr

−30 dBr

−f$_4$ −f$_3$ −f$_2$ −f$_1$ 0 f$_1$ f$_2$ f$_3$ f$_4$ f–f$_c$

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TABLE 1

Transmit spectral mask parameters

Channel bonding	f_1 (GHz)	f_2 (GHz)	f_3 (GHz)	f_4 (GHz)
Two-bonded channel transmission	2.100	2.160	3.000	4.000
Three-bonded channel transmission	3.150	32.40	4.500	6.000
Four-bonded channel transmission	4.200	4.320	6.000	8.000

2.4 Common characteristics

2.4.1 Transmit and receive operating temperature range

Transmit and receive operating temperature range follows IEEE Std 802.11-2012.

2.4.2   Centre frequency tolerance

The transmitter centre frequency tolerance should be ±20 ppm maximum for the 60 GHz band.

2.4.3   Symbol clock tolerance

The symbol clock frequency tolerance should be ±20 ppm maximum for the 60 GHz band. The transmit centre frequency and the symbol clock frequency are derived from the same reference oscillator.

2.4.4   Transmit centre frequency leakage

The transmitter centre frequency leakage should not exceed −23 dB relative to the overall transmitted power, or, equivalently, 2.5 dB relative to the average energy of the rest of the subcarriers (in orthogonal frequency division multiplexing (OFDM)).

2.4.5   Transmit ramp up and ramp down

The transmit power-on ramp is defined as the time it takes for a transmitter to rise from less than 10% to greater than 90% of the average power to be transmitted in the frame.

The transmit power-on ramp should be around 10 ns.

The transmit power-down ramp is defined as the time it takes the transmitter to fall from greater than 90% to less than 10% of the maximum power to be transmitted in the frame.

The transmit power-down ramp should be around 10 ns.

2.4.6   Maximum input level

The receiver maximum input level is the maximum power level of the incoming signal, in dBm, present at the input of the receiver for which the error rate criterion (defined at the RX sensitivity section) is met. A compliant receiver has a receiver maximum input level of at least −33 dBm for each of the modulation formats that the receiver supports.

2.4.7   System characteristics

To exploit the full potential that MGWS can provide including the support of the applications and services described herein, certain system level characteristics need to be satisfied:

1)   **Throughput**: every MGWS device should provide a means of achieving a maximum throughput, as measured at the top of the medium access control layer, of at least 1 Gbps data rate.

2)   **Range**: the system should provide a means of achieving a range of at least 10 m at 1 Gbps, as measured at the top of the medium access control layer, in some NLoS PHY channel conditions.

In addition to the aforementioned characteristics, when the system supports uncompressed video streaming further characteristics described in Table 2 need to be met.

TABLE 2

System characteristics

Parameter	Value	Description
Rate	3 Gbps	Uncompressed video, 1 080 p (RGB): 1 920 × 1 080 pixels, 24 bits/pixels, 60 frames/s
Packet loss rate (8 kbyte payload)	1e-8	
Delay[3]	10 ms	

2.4.8 Channel access schemes

The basic access scheme is time division multiple access (TDMA), which is necessary to deal with the challenges of operation in 60 GHz, the directional nature of communication, and applications such as wireless display. TDMA can provide the necessary bandwidth guarantee to applications sensitive to quality of service given its reservation characteristics while being power efficient since devices do not need to stay awake when not communicating.

In addition, since TDMA is scheduled, stations know exactly to which other station they will communicate to and when, hence are able to steer the main lobe of their antenna towards the intended destination and obviate the need for omnidirectional communication needed for contention-based access.

Contention-based access, such as provided by in Wi-Fi, should also be supported for usages including web browsing and file transfer. However, instead of being the basic access scheme, contention-based access should be used within periods of time allocated in the TDMA channel access infrastructure.

2.5 Parameters for coexistence

For improved coexistence, it is important that all MGWS utilize the same channelization.

Examples of channelization:

1) IEEE:

    a) IEEE Std 802.11ad-2012[4] defines a channel bandwidth of 2 160 MHz.

    b) IEEE Std 802.15.3c-2009[5] defines a channel bandwidth of 2 160 MHz.

Prior to starting operation on a channel, a MGWS should scan the channel in an attempt to ensure that its operation will not cause interference to other MGWS operating on that channel.

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[3] This represents delay from top of MAC layer in one end to the top of MAC layer at the other end.

[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 3: Enhancements for Very High Throughput in the 60 GHz Band, December 2012.

[5] IEEE Standard for Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 15.3: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPANs) – Amendment 2: Millimeter-wave-based Alternative Physical Layer Extension.

Examples of interference mitigation techniques:

1) IEEE:

   a) IEEE Std 802.11ad-2012 access point should not start a network on a channel where the signal level is at or above −48 dBm or upon detecting a valid IEEE Std 802.15.3c-2009 common mode signalling (CMS) preamble at a receive level equal to or greater than −60 dBm. Several other interference mitigation techniques are defined such as channel switching, transmit power control, beamforming, to name a few.

   b) IEEE Std 802.15.3c-2009 does not allow a piconet controller to start a new piconet on a channel currently occupied by another piconet controller. A common mode signalling (CMS) method has been defined to allow multiple piconet controllers to share access in a channel using TDMA slots allocated to child piconets.

2.6 Receive sensitivity levels

Receive Sensitivity levels are typically between −48 and −78 dBm.

Examples of receive sensitivity levels:

1) IEEE: In IEEE Std 802.11ad-2012, the PER is less than 1% (5% for MCS 0) for a PSDU length of 4 096 octets (256 octets for MCS 0).

NOTE – For RF power measurements based on received power density, the input level shall be corrected to compensate for the antenna gain in the implementation. The gain of the antenna is the maximum estimated gain by the manufacturer. In the case of the phased-array antenna, the gain of the phased-array antenna is the maximum sum of estimated element gain −3 dB implementation loss.

2.7 Clear channel assessment (CCA) rules

MGWSs may employ clear channel assessment (CCA) rules to mitigate interference caused to other MGWSs.

For example, in the case of IEEE Std 802.11ad-2012 there are three MCS sets defined and there are specific CCA rules for each MCS set. The three MCS sets are:

a) MCS0: known as the Control MCS and which is based on single-carrier (SC) modulation.

b) MCS1 through MCS12, and MCS25 through MCS31: the SC MCS set.

c) MCS13 through MCS24: and the orthogonal frequency division multiplexing (OFDM) MCS set.

As such, IEEE Std 802.11ad-2012 defines CCA rules applicable to each MCS set, as follows:

a) Control MCS: The start of a valid Control MCS transmission at a receive level greater than the minimum sensitivity for Control MCS (−78 dBm) shall cause CCA to indicate busy with a probability > 90% within 3 μs.

b) SC MCS set: The start of a valid SC MCS transmission at a receive level greater than the minimum sensitivity for MCS1 (−68 dBm) shall cause CCA to indicate busy with a probability > 90% within 1 μs. The receiver shall hold the carrier sense signal busy for any signal 20 dB above the minimum sensitivity for MCS1.

c) OFDM MCS set: The start of a valid OFDM MCS or SC MCS transmission at a receive level greater than the minimum sensitivity for MCS13 (−66 dBm) shall cause CCA to indicate busy with a probability > 90% within 1 μs.

3 Multiple Gigabit Wireless Systems (MGWS) standards

Below is a list of standards that address MGWS specifications:

1) IEEE Std 802.11ad-2012, 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 3: Enhancements for Very High Throughput in the 60 GHz Band. December 2012.

2) IEEE Std 802.15.3c^{TM}-2009, IEEE Standard for Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 15.3: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPANs) – Amendment 2: Millimeter-wave-based Alternative Physical Layer Extension.

3) ETSI EN 302 567 v1.2.1 (2012-01), Broadband Radio Access Networks (BRAN); 60 GHz Multiple-Gigabit WAS/RLAN Systems; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive.

4) Wireless Gigabit Alliance (WGA): WiGig MAC and PHY Specification v1.2, March 2012.

5) ISO/IEC 13156, Information technology – Telecommunications and information exchange between systems – High rate 60 GHz PHY, MAC and PALs.

4 Acronyms and abbreviations

CCA   Clear channel assessment

CE   Consumer electronics

HDMI   High definition multimedia interface

MGWS   Multiple Gigabit Wireless Systems

MCS   Modulation and coding scheme

OFDM   Orthogonal frequency division multiplexing

PER   Packet error rate

RLAN   Radio local area network

SC   Single carrier

TDMA   Time division multiple access

WLAN   Wireless local area network

WPAN   Wireless personal area network

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