



Recommendation ITU-R M.2003-2
(01/2018)

**Multiple Gigabit Wireless Systems in
frequencies around 60 GHz**

M Series
**Mobile, radiodetermination, amateur
and related satellite services**

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RECOMMENDATION ITU-R M.2003-2

Multiple Gigabit Wireless Systems in frequencies around 60 GHz

(Question ITU-R 212-3/5)

(2012-2015-2018)

Scope

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

Keywords

MGWS, WLAN, RLAN, Wireless Local Access, Networks, Radio Local Area Networks, Close Proximity Mobile System (CPMS)

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) and point-to-point close proximity mobile system;
- 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) and personal area networks (WPANs) 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

that several standards provide options for MGWS implementation,

recommends

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 with traditional WLAN topologies. MGWS systems can also be used in very short range high rate proximity communications where the radio range is a few centimetres with devices pairing point-to-point in close proximity of each other.

For WLAN, total communication range and performance will vary depending on system design (e.g. number of antenna elements) as well as the environment, but multiple gigabit performance is typically expected at ranges around 10 m for in-room use when devices typically possess a few (≤ 3) dozen antenna elements, to a few hundred meters for outdoor use when devices can be equipped with several (≥ 6) dozen antenna elements. 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).

For close proximity communication topology is a pair of devices (also known as a pairnet) with performance up to 100 Gbits is expected with range of 10 cm or less (devices nearly touching) with transient connections (rapid setup and teardown); Close proximity device typically will use a single antenna element and very low transmit power.

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. To provide longer ranges and better capacity, the access point is typically equipped with a larger number of antenna elements than the user terminals.

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 kiosk¹, and it may be assumed that usage would predominantly be indoors. In some application, nomadic devices connect with stationary devices (i.e. kiosk, doorway, turnstile, vending machine) for very short duration to transfer large amounts of data, e.g. download 2 hours of HD video content in 250 ms while passing through an entry turnstile at a train station or airport. For the close proximity applications, a high density of devices and users may be concentrated in a small space, for example when passing through the entry ticket gates² at train station or airport.

2 Technical characteristics of MGWS

2.1 Spectrum

A minimum of 7 GHz contiguous spectrum in the 57-71 GHz is needed to satisfy the requirements³ of the applications envisioned to be used in this spectrum, such as uncompressed video (e.g. high

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 In this context, an entry ticket gate has both fare-paying and large-file downloading functions and it is used at railway and subway stations. The large-file contents are video, movies. etc.

³ System requirements are provided in the standards contained in Annex 1.

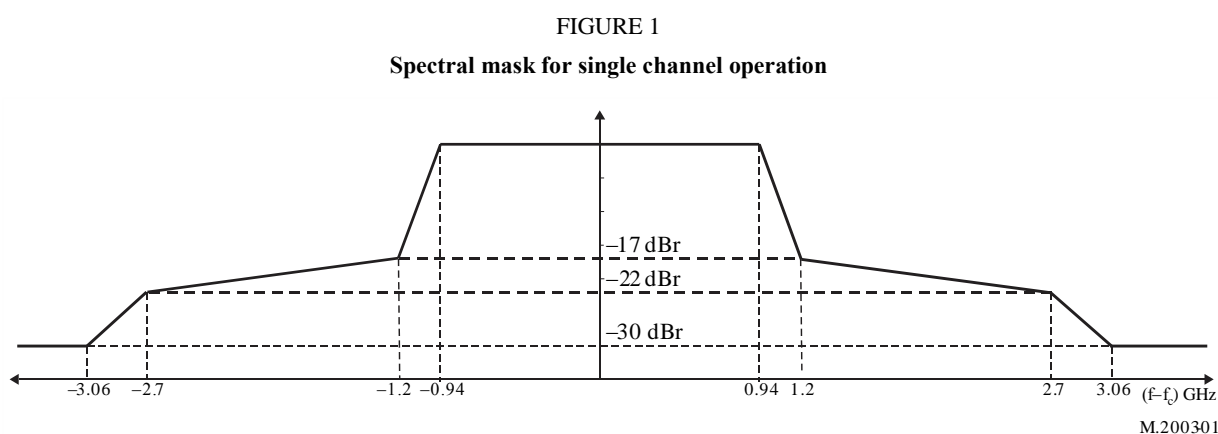
definition multimedia interface (HDMI) at 3 Gbit/s), wireless docking, wireless networking, and rapid download/upload. This would allow up to six channels for flexibility and improved connectivity. Furthermore, for single channels, a channel bandwidth of 2 160 MHz allows simpler modulation schemes to achieve multi-Gbit/s data rates, which is suitable for adoption by low power devices such as smartphones, tablets, netbook and notebook PCs. If single channels are bonded to achieve greater capacity, the bandwidth is defined as an integer multiple of 2 160 MHz to enable coexistence with 2 160 MHz systems.

2.2 Channel bandwidth and centre frequencies

A 2 160 MHz channel bandwidth is required for single channels and bonding of single channels are allowed. It is important that MGWS standards employ the same channelization in order to promote better coexistence. Centre frequencies for single channels are recommended to be at 58.32, 60.48, 62.64, 64.80 GHz, 66.96 GHz, and 69.12 GHz. For bonded channels, centre frequencies depend on how many single channels are bonded, but need to be uniformly spaced with respect to the single channel centre frequencies.

2.3 Transmit mask

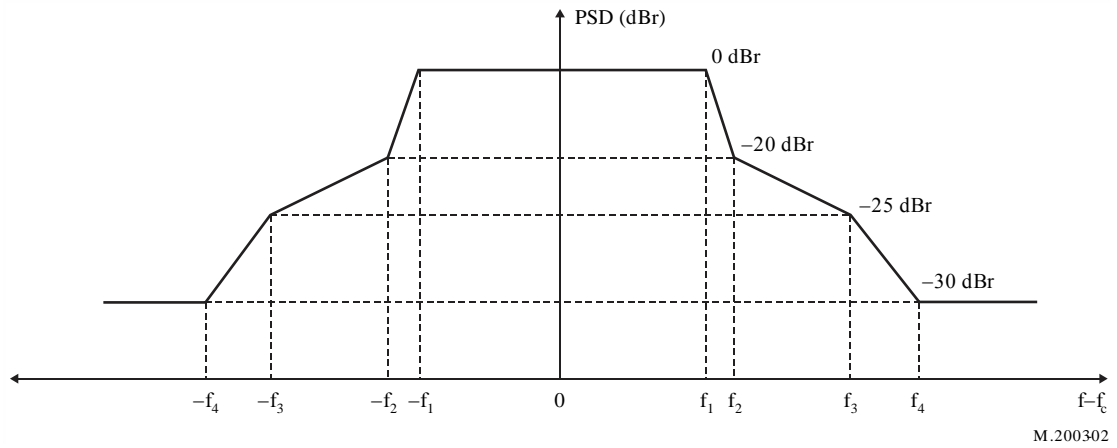
The following mask is applicable to single channel operation.



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



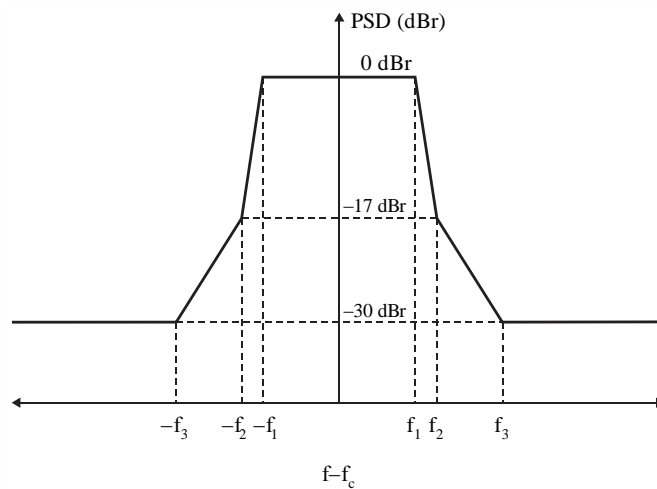
M.200302

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

Alternative spectrum mask (Fig. 3 and Tables 2 and 3) is applicable when channel bonding of more than one contiguous channel is used.

FIGURE 3
Alternative power spectral density mask for channel bonded operation



M.200303

TABLE 2

Relative limit value of transmit power spectral density mask for channel bonded operation

Frequency	Relative limit (dBr)
$ f - f_c < f_1$	0
$f_2 \leq f - f_c < f_1$	$-17(f - f_c - f_1)/(f_2 - f_1)$
$f_3 \leq f - f_c < f_2$	$-17 - 13(f - f_c - f_2)/(f_3 - f_2)$
$f_3 \leq f - f_c $	-30

TABLE 3

Transmit power spectral density mask parameters

Channel bonding	f_1 (GHz)	f_2 (GHz)	f_3 (GHz)
Two-bonded channel	1.880	2.400	4.000
Three-bonded channel	2.820	3.600	6.000
Four-bonded channel	3.760	4.800	8.000

2.4 Common characteristics**2.4.1 Transmit and receive operating temperature range**

Transmit and receive operating temperature range follows IEEE Std 802.11-2016.

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 at the receive antenna(s) of at least 10 microwatts/cm² 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 that supports not more than a single channel operation should provide a means of achieving a maximum throughput, as measured at the top of the medium access control layer, of at least 1 Gbit/s data rate. If the MGWS device supports bonded channel operation, the throughput should scale linearly with the number of bonded channels.
- 2) Range: WLAN systems should provide a means of achieving a range of at least 10 m at 1 Gbit/s, as measured at the top of the medium access control layer, in some NLoS PHY channel conditions. For WPAN and CPMS, systems range should typically be less than 10 cm to achieve high spectrum re-use.

In addition to the aforementioned characteristics, when the system supports uncompressed video streaming further characteristics described in Table 4 need to be met.

TABLE 4
System characteristics

Parameter	Value	Description
Rate	3 Gbit/s	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 ⁴	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,

⁴ This represents delay from top of MAC layer in one end to the top of MAC layer at the other end.

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 802.11-2016⁵ defines a channel bandwidth of 20 MHz.
 - b) IEEE Std 802.15.3-2016⁶ defines a channel bandwidth of 20 MHz.
 - c) IEEE Std 802.15.3e-2017⁷ defines a channel bandwidth of 20 MHz with bonding of up to four channels

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.

Examples of interference mitigation techniques:

- 1) IEEE:
 - a) IEEE Std 802.11-2016 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.
 - c) IEEE Std 802.15.3e-2017 limit the communication range 10 cm or less and EIRP level very low. If the distance between devices becomes more 10 cm, the devices are disassociated and emission power is limited to a periodic beacon.

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 802.11-2016, the PER is less than 1% (5% for MCS 0) for a PSDU length of 4096 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.

⁵ 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, December 2016.

⁶ IEEE Standard for High Data Rate Wireless Multi-Media Networks

⁷ IEEE Standard for High Data Rate Wireless Multi-Media Networks Amendment: High-Rate Close Proximity Point-to-Point Communications.

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 802.11-2016 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 MCS12.6, 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 802.11-2016 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 802.11-2016, 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, December 2016.
- 2) IEEE Std 802.15.3TM-2016, IEEE Standard for High Data Rate Wireless Multi-Media Networks.
- 3) IEEE Std 802.15.3eTM-2017, IEEE Standard for High Data Rate Wireless Multi-Media Networks Amendment: High-Rate Close Proximity Point-to-Point Communications.
- 4) ETSI EN 302 567 v2.1.1 (2017-07), Multiple-Gigabit/s radio equipment operating in the 60 GHz band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.
- 5) Wi-Fi Alliance (WFA) Protocol Adaptation Layer (PAL) specifications:
 - WiGig® Display Extension Technical Specification Version 2.0, March 2015.
 - WiGig® Bus Extension Specification v1.2, October 2014.
 - WiGig® SD (WSD) Extension Specification v1.1, January 2015.
- 6) 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
