RECOMMENDATION ITU-R M.1450-3*, **

Characteristics of broadband radio local area networks

(Questions ITU-R 212/8 and ITU-R 236/9)

(2000-2002-2003-2008)

Scope

This Recommendation provides the technical parameters of some broadband radio local area networks (RLANs), and information on RLAN standards and operational characteristics. Basic characteristics of broadband RLANs and general guidance for their system design are also addressed.

The ITU Radiocommunication Assembly,

considering

a)   that broadband radio local area networks (RLANs) are widely used for fixed, semi-fixed (transportable) and portable computer equipment for a variety of broadband applications;

b)   that broadband RLANs are used for fixed, nomadic and mobile wireless access applications;

c)   that broadband RLAN standards currently being developed are compatible with current wired LAN standards;

d)   that it is desirable to establish guidelines for broadband RLANs in various frequency bands;

e)   that broadband RLANs should be implemented with careful consideration to compatibility with other radio applications,

noting

a)   that Report ITU-R F.2086 provides technical and operational characteristics and applications of broadband wireless access systems in the fixed service;

b)   that other information on broadband WAS, including RLANs, is contained in Recommendations ITU-R F.1763, ITU-R M.1652, ITU-R M.1739 and ITU-R M.1801,

recommends

1   the broadband RLAN standards in Table 2 (Notes 1, 2 and 3);

2   that administrations should use Annex 2 for general information on RLANs, including their basic characteristics.

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*   This Recommendation was jointly developed by Radiocommunication Study Groups 8 and 9, and future revisions should be undertaken jointly.

** This Recommendation should be brought to the attention of Telecommunication Standardization Study Group 17, and Radiocommunication Study Groups 3 and 4.

NOTE 1 – Acronyms and terminology used in this Recommendation are given in Table 1.

NOTE 2 – Annex 1 provides detailed information on how to obtain complete standards described in Table 2.

NOTE 3 – This Recommendation does not exclude the implementation of other RLAN systems.

TABLE 1

Acronyms and terms used in this Recommendation

AP	Access point
Access method	Scheme used to provide multiple access to a channel
ARIB	Association of Radio Industries and Businesses
Bit rate	The rate of transfer of a bit of information from one network device to another
BPSK	Binary phase shift keying
BRAN	Broadband Radio Access Networks (A technical committee of ETSI)
Channelization	Bandwidth of each channel and number of channels that can be contained in the RF bandwidth allocation
CSMA/CA	Carrier sensing multiple access with collision avoidance
DFS	Dynamic frequency selection
DSSS	Direct sequence spread spectrum
EIRP	Equivalent isotropically radiated power
ETSI	European Telecommunications Standards Institute
Frequency band	Nominal operating spectrum of operation
HIPERLAN2	High performance radio LAN 2
HiSWANa	High speed wireless access network – type a
HSWA	High speed wireless access
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
LAN	Local area network
LBT	Listen before talk
Modulation	The method used to put information onto an RF carrier
MMAC	Multimedia mobile access communication
OFDM	Orthogonal frequency division multiplexing
PSD	Power spectral density
RF	Radio frequency
RLAN	Radio local area network

Tx power	Transmitter power – RF power in Watts produced by the transmitter
PSTN	Public switched telephone network
QAM	Quadrature amplitude modulation
QPSK	Quaternary phase shift keying
SSMA	Spread spectrum multiple access
TCP	Transmission control protocol
TDMA	Time division multiple access
TDD	Time division duplex
TPC	Transmit power control
WATM	Wireless asynchronous transfer mode

TABLE 2

Technical parameters associated with broadband RLAN standards

| Characteristics	IEEE Std 802.11-2007 (Clause 15, commonly known as 802.11b)	IEEE Std 802.11-2007 (Clause 17, commonly known as 802.11a[1])	IEEE Std 802.11-2007 (Clause 18, commonly known as 802.11g[1])	IEEE Std 802.11-2007 (Clause 17, Annex I and Annex J, commonly known as 802.11j)	ETSI BRAN HIPERLAN2 [1, 2]	ARIB HiSWANa[1]
Access method	CSMA/CA, SSMA	CSMA/CA	CSMA/CA	CSMA/CA	TDMA/TDD	TDMA/TDD
Modulation	CCK (8 complex chip spreading)	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Fig. 1)	DSSS/CCK OFDM PBCC DSSS-OFDM	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Fig. 1)	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Fig. 1)	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Fig. 1)
Data rate	1, 2, 5.5 and 11 Mbit/s	6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s	1, 2, 5.5, 6, 9, 11, 12, 18, 22, 24, 33, 36, 48 and 54 Mbit/s	3, 4.5, 6, 9, 12, 18, 24 and 27 Mbit/s for 10 MHz channel spacing 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s for 20 MHz channel spacing	6, 9, 12, 18, 27, 36 and 54 Mbit/s	6, 9, 12, 18, 27, 36 and 54 Mbit/s
Frequency band	2 400-2 483.5 MHz	5 150-5 250 MHz[5] 5 250-5 350 MHz[4] 5 470-5 725 MHz[4] 5 725-5 825 MHz	2 400-2 483.5 MHz	4 900-5 000 MHz[3]	5 150-5 350[5] and 5 470-5 725 MHz[4]	4 900 to 5 000 MHz[3] 5 150 to 5 250 MHz[5]
Channelization	5 MHz	5 MHz	5 MHz	5 MHz	20 MHz	20 MHz channel spacing 4 channels in 100 MHz
Spectrum mask	802.11b mask (Fig. 2)	OFDM mask (Fig. 1)	OFDM mask (Fig. 1)	OFDM mask (Fig. 1)	OFDM mask (Fig. 1)	OFDM mask (Fig. 1)
Transmitter						
Interference mitigation	LBT	LBT/DFS/TPC	LBT	LBT	LBT/DFS/TPC	LBT
Receiver						
Sensitivity	Listed in Standard	Listed in Standard	Listed in Standard	Listed in Standard	Listed in Standard	Listed in Standard

[1] Parameters for the physical layer are common between IEEE 802.11a and ETSI BRAN HIPERLAN2 and ARIB HiSWANa.

[2] WATM (Wireless ATM) and advanced IP with QoS are intended for use over ETSI BRAN HIPERLAN2 physical transport.

[3] See 802.11j-2004, and JAPAN MIC ordinance for Regulating Radio Equipment, Articles 49-20 and 49-21.

[4] DFS rules apply in the 5 250-5 350 and 5 470-5 725 MHz bands in many administrations and administrations must be consulted.

[5] Pursuant to Resolution 229 (WRC-03), operation in the 5 150-5 250 MHz band is limited to indoor use.

FIGURE 1

OFDM transmit spectrum mask for 802.11a, 11g, 11j, HIPERLAN2 and HiSWANa systems
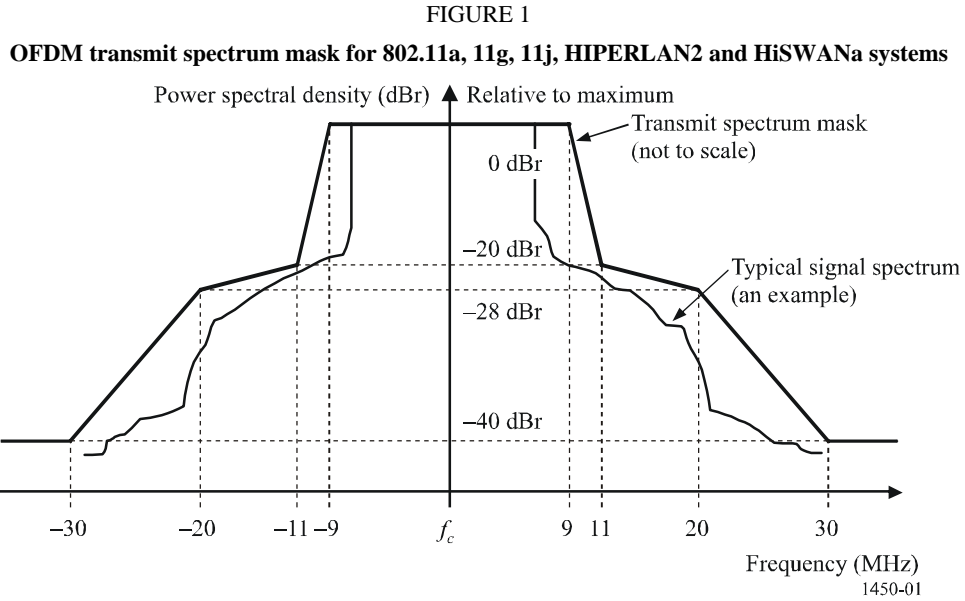
NOTE 1 – The outer heavy line is the spectrum mask for 802.11a, 11g, 11j, HIPERLAN2 and HiSWANa, and the inner thin line is the envelope spectrum of OFDM signals with 52 subcarriers.

NOTE 2 – The measurements shall be made using a 100 kHz resolution bandwidth and a 30 kHz video bandwidth.

NOTE 3 – In the case of the 10 MHz channel spacing in 802.11j, the frequency scale shall be half.

FIGURE 2

Transmit spectrum mask for 802.11b
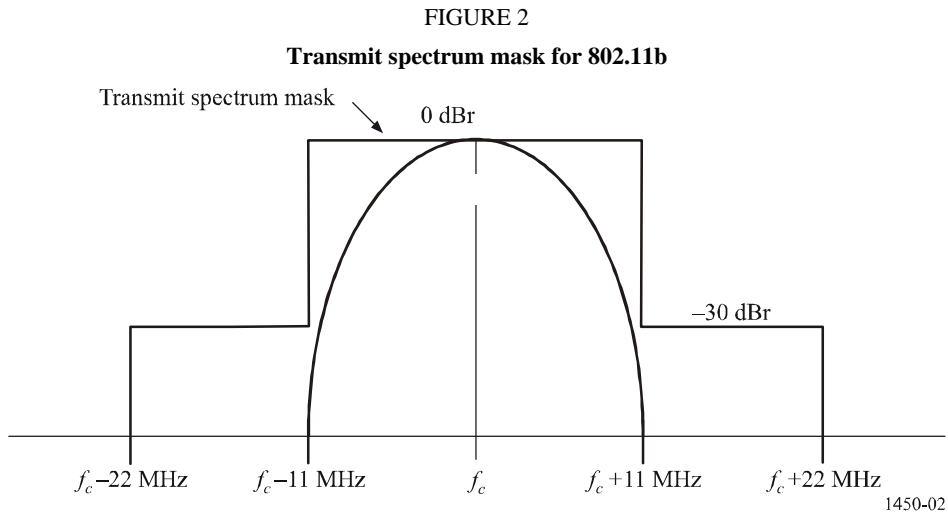
Annex 1

Obtaining additional information on RLAN standards

The HIPERLAN2 standards are TS 101 475 for the physical layer and TS 101 761-1 to TS 101 761-5 for the DLC layer, and these can be downloaded from the ETSI Publications Download Area at: http://www.etsi.org/services_products/freestandard/home.htm.

The IEEE 802.11 standards can be downloaded from:
http://standards.ieee.org/getieee802/index.html

IEEE 802.11 has developed a set of standards for RLANs, IEEE Std 802.11 – 2007, which has been harmonized with IEC/ISO[1]. The medium access control (MAC) and physical characteristics for wireless local area networks (LANs) are specified in ISO/IEC 8802-11:2005, which is part of a series of standards for local and metropolitan area networks. The medium access control unit in ISO/IEC 8802-11:2005 is designed to support physical layer units as they may be adopted dependent on the availability of spectrum. ISO/IEC 8802-11:2005 contains five physical layer units: four radio units, operating in the 2 400-2 500 MHz band and in the bands comprising 5 150-5 250 MHz, 5 250-5 350 MHz, 5 470-5 725 MHz, and 5 725-5 825 MHz, and one baseband infrared (IR) unit. One radio unit employs the frequency-hopping spread spectrum (FHSS) technique, two employ the direct sequence spread spectrum (DSSS) technique, and another employs the orthogonal frequency division multiplexing (OFDM) technique.

1   ISO/IEC 8802-11:2005, 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

Annex 2

Basic characteristics of broadband RLANs
and general guidance for deployment

1   Introduction

Broadband RLAN standards have been designed to allow compatibility with wired LANs such as IEEE 802.3, 10BASE-T, 100BASE-T and 51.2 Mbit/s ATM at comparable data rates. Some broadband RLANs have been developed to be compatible with current wired LANs and are intended to function as a wireless extension of wired LANs using TCP/IP and ATM protocols. Recent spectrum allocations by some administrations promote development of broadband RLANs. This allows applications such as audio/video streaming to be supported with high QoS.

Portability is a feature provided by broadband RLANs but not wired LANs. New laptop and palmtop computers are portable and have the ability, when connected to a wired LAN, to provide interactive services. However, when they are connected to wired LANs they are no longer portable.

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[1] ISO/IEC 8802-11:2005, 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.

Broadband RLANs allow portable computing devices to remain portable and operate at maximum potential.

Private on-premise, computer networks are not covered by traditional definitions of fixed and mobile wireless access and should be considered. The nomadic users are no longer bound to a desk. Instead, they are able to carry their computing devices with them and maintain contact with the wired LAN in a facility. In addition, mobile devices such as cellular telephones are beginning to incorporate the ability to connect to wireless LANs when available to supplement traditional cellular networks.

Speeds of notebook computers and hand-held computing devices continue to increase. Many of these devices are able to provide interactive communications between users on a wired network but sacrifice portability when connected. Multimedia applications and services require broadband communications facilities not only for wired terminals but also for portable and personal communications devices. Wired local area network standards, i.e. IEEE 802.3ab 1000BASE-T, are able to transport high rate, multimedia applications. To maintain portability, future wireless LANs will need to transport higher data rates. Broadband RLANs are generally interpreted as those that can provide data throughput greater than 10 Mbit/s.

2   Mobility

Broadband RLANs may be either pseudo fixed as in the case of a desktop computer that may be transported from place to place or portable as in the case of a laptop or palmtop devices working on batteries or cellular telephones with integrated wireless LAN connectivity. Relative velocity between these devices and an RLAN wireless access point remains low. In warehousing applications, RLANs may be used to maintain contact with lift trucks at speeds of up to 6 m/s. RLAN devices are generally not designed to be used at automotive or higher speeds.

3   Operational environment and considerations of interface

Broadband RLANs are predominantly deployed inside buildings, in offices, factories, warehouses, etc. For RLAN devices deployed inside buildings, emissions are attenuated by the structure.

RLANs utilize low power levels because of the short distances inside buildings. Power spectral density requirements are based on the basic service area of a single RLAN defined by a circle with a radius from 10 to 50 m. When larger networks are required, RLANS may be logically concatenated via bridge or router function to form larger networks without increasing their composite power spectral density.

One of the most useful RLAN features is the connection of mobile computer users to a wireless LAN network. In other words, a mobile user can be connected to his own LAN subnetwork anywhere within the RLAN service area. The service area may expand to other locations under different LAN subnetworks, enhancing the mobile user's convenience.

There are several remote access network techniques to enable the RLAN service area to extend to other RLANs under different subnetworks. International Engineering Task Force (IETF) has developed a number of the protocol standards on this subject.

To achieve the coverage areas specified above, it is assumed that RLANs require a peak power spectral density of e.g. approximately 10 mW/MHz in the 5 GHz operating frequency range (see Table 3). For data transmission, some standards use higher power spectral density for initialization and control the transmit power according to evaluation of the RF link quality. This technique is referred to as transmit power control (TPC). The required power spectral density is proportional to the square of the operating frequency. The large scale, average power spectral density will be

substantially lower than the peak value. RLAN devices share the frequency spectrum on a time basis. Activity ratio will vary depending on the usage, in terms of application and period of the day.

Broadband RLAN devices are normally deployed in high-density configurations and may use an etiquette such as listen before talk and dynamic channel selection (referred to here as dynamic frequency selection, DFS), TPC to facilitate spectrum sharing between devices.

4   System architecture including fixed applications

Broadband RLANs are often point-to-multipoint architecture. Point-to-multipoint applications commonly use omnidirectional, down-looking antennas. The multipoint architecture employs several system configurations:

–   point-to-multipoint centralized system (multiple devices connecting to a central device or access point via a radio interface);

–   point-to-multipoint non-centralized system (multiple devices communicating in a small area on an ad hoc basis);

–   RLAN technology is sometimes used to implement fixed applications, which provide point-to-multipoint (P-MP) or point-to-point (P-P) links, e.g. between buildings in a campus environment. P-MP systems usually adopt cellular deployment using frequency reuse schemes similar to mobile applications. Technical examples of such schemes are given in Report ITU-R F.2086 (§ 6.6). Point-to-point systems commonly use directional antennas that allow greater distance between devices with a narrow lobe angle. This allows band sharing via channel and spatial reuse with a minimum of interference with other applications.

–   RLAN technology is sometimes used for multipoint-to-multipoint (fixed and/or mobile mesh network topology, in which multiple nodes relay a message to its destination). Omnidirectional and/or directional antennas are used for links between the nodes of the mesh network. These links may use one or multiple RF channels. The mesh topology enhances the overall reliability of the network by enabling multiple redundant communications paths throughout the network. If one link fails for any reason (including the introduction of strong RF interference), the network automatically routes messages through alternate paths.

5   Interference mitigation techniques under frequency sharing environments

RLANs are generally intended to operate in unlicensed or license-exempt spectrum and must allow adjacent uncoordinated networks to coexist whilst providing high service quality to users. In the 5 GHz bands, sharing with primary services must also be possible. Whilst multiple access techniques might allow a single frequency channel to be used by several nodes, support of many users with high service quality requires that enough channels are available to ensure access to the radio resource is not limited through queuing, etc. One technique that achieves a flexible sharing of the radio resource is DFS.

In DFS all radio resources are available at all RLAN nodes. A node (usually a controller node or access point (AP)) can temporarily allocate a channel and the selection of a suitable channel is performed based on interference detected or certain quality criteria, e.g. received signal strength, C/I. To obtain relevant quality criteria both the mobile terminals and the access point make measurements at regular intervals and report this to the entity making the selection.

In the 5 250-5 350 and 5 470-5 725 MHz bands, DFS must be implemented to ensure compatible operation with systems in the co-primary services, i.e. the radiolocation service.

DFS can also be implemented to ensure that all available frequency channels are utilized with equal probability. This maximizes the availability of a channel to node when it is ready to transmit, and it also ensures that the RF energy is spread uniformly over all channels when integrated over a large number of users. The latter effect facilitates sharing with other services that may be sensitive to the aggregated interference in any particular channel, such as satellite-borne receivers.

TPC is intended to reduce unnecessary device power consumption, but also aids in spectrum reuse by reducing the interference range of RLAN nodes.

6 General technical characteristics

Table 3 summarizes technical characteristics applicable to operation of RLANs in certain frequency bands and in certain geographic areas, in accordance with Resolution 229 (WRC-03).

TABLE 3

**General technical requirements applicable in certain geographic areas
in the 2.4 and 5 GHz bands**

General band designation	Administration or region	Specific frequency band (MHz)	Transmitter output power (mW) (except as noted)	Antenna gain (dBi)
2.4 GHz band	USA	2 400-2 483.5	1 000	0-6 dBi[1] (Omni)
	Canada	2 400-2 483.5	4 W EIRP[2]	N/A
	Europe	2 400-2 483.5	100 mW (EIRP)[3]	N/A
	Japan	2 471-2 497 2 400-2 483.5	10 mW/MHz[4] 10 mW/MHz[4]	0-6 dBi (Omni) 0-6 dBi (Omni)
5 GHz band[5],[6]	USA	5 150-5 250[7]	50 2.5 mW/MHz	0-6 dBi[1] (Omni)
		5 250-5 350	250 12.5 mW/MHz	0-6 dBi[1] (Omni)
		5 470-5 725	250 12.5 mW/MHz	0-6 dBi[1] (Omni)
		5 725-5 850	1 000 50.1 mW/MHz	0-6 dBi[8] (Omni)
	Canada	5 150-5 250[7]	200 mW EIRP 10 dBm/MHz EIRP	
		5 250-5 350	250 12.5 mW/MHz (11 dBm/MHz) 1 000 mW EIRP[9]	
		5 470-5 725	250 12.5 mW/MHz (11 dBm/MHz) 1 000 mW EIRP[9]	
		5 725-5 850	1 000 50.1 mW/MHz[9]	
	Europe	5 150-5 250[7]	200 mW (EIRP) 0.25 mW/25 kHz	N/A
		5 250-5 350[10]	200 mW (EIRP) 10 mW/MHz	
		5 470-5 725	1 000 mW (EIRP) 50 mW/MHz	

TABLE 3 (*end*)

General band designation	Administration or region	Specific frequency band (MHz)	Transmitter output power (mW) (except as noted)	Antenna gain (dBi)
	Japan[4]	4 900-5 000[11]	250 mW 50 mW/MHz	13 dBi
		5 150-5 250[7] 5 250-5 350[10] 5 470-5 725	10 mW/MHz (EIRP) 10 mW/MHz (EIRP) 50 mW/MHz (EIRP)	N/A N/A N/A

[1] In the United States of America, for antenna gains greater than 6 dBi, some reduction in output power required. See Sections 15.407 and 15.247 of the FCC's rules for details.

[2] Canada permits point-to-point systems in this band with EIRP >4 W provided that the higher EIRP is achieved by employing higher gain antenna, but not higher transmitter output power.

[3] This requirement refers to ETSI EN 300 328.

[4] See Japan MIC ordinance for Regulating Radio Equipment, Articles 49-20 and 49-21 for details.

[5] Resolution 229 (WRC-03) establishes the conditions under which WAS, including RLANs, may use the 5 150-5 250, 5 250-5 350 and 5 470-5 725 MHz.

[6] DFS rules apply in the 5 250-5 350 and 5 470-5 725 MHz bands in regions and administrations and must be consulted.

[7] Pursuant to Resolution 229 (WRC-03), operation in the 5 150-5 250 MHz band is limited to indoor use.

[8] In the United States of America, for antenna gains greater than 6 dBi, some reduction in output power required, except for systems solely used for point-to-point. See Sections 15.407 and 15.247 of the FCC's rules for details.

[9] See RSS-210, Annex 9 for the detailed rules on devices with maximum EIRP greater than 200 mW: http://strategis.ic.gc.ca/epic/site/smt-gst.nsf/en/sf01320e.html.

[10] In Europe and Japan, operation in the 5 250-5 350 MHz band is also limited to indoor use.

[11] For fixed wireless access, registered.