

# **ANSI/BICSI 008-2018**

## ***Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices***

**DEMONSTRATION VERSION  
NOT FOR RESALE**

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## **PREFACE**

### **Revision History**

**December 20, 2017** First publication of this standard, titled ANSI/BICSI 008-2018, *Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices*

### **Translation Notice**

This standard may have one or more translations available for the convenience of its readers. As translated text may contain inconsistencies when compared to the original text, if differences between the translation and the published English version exist, the English text shall be used as the official and authoritative version.

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# 1 Introduction

## 1.1 General

In-building and campus wireless local area networks (WLANs) are a relatively mature technology, having existed in some form for approximately three decades. The U.S. Federal Communications Commission (FCC) released the Industrial, Scientific and Medical (ISM) radio bands for unlicensed use in 1985. The Institute of Electrical and Electronics Engineers (IEEE) began work on the first version with a working group meeting on September 10, 1990. The first IEEE 802.11 standard was released in June 1997. Since then, a multitude of standards have been developed in the 802.11 family, enhancing the speed, adding features, capabilities and frequency bands and changing the estimated range.

All these standards, however, apply only to the protocols to be used in these networks, impacting equipment design and manufacturing. Throughout all this time, no vendor-neutral standard has been developed concerning the design, implementation or management of an overall WLAN system.

For most of these decades, WLAN system implementers were able to install workable systems without much real design effort, since the fundamental capabilities of the technology far exceeded the systems'. This allowed them to essentially install for coverage only; meaning putting up some nodes, then walk around monitoring the signal strength bars on a laptop.

However, during the last decade or so, the demand for high speed, reliable WLAN access has grown overwhelmingly. Businesses are increasingly using WLANs as an enhancement to, or replacement for, wireline networks. Commercial wireless carriers are actively encouraging their customers to use public and private WLANs instead of the cellular networks. Some non-traditional devices, such as televisions, appliances and vehicles, are coming equipped with WLAN capability.

High speed, reliable WLAN coverage has become so ubiquitous in business, commercial and governmental facilities; their surrounding areas; and increasingly in private homes; that it is now simply expected. The public has come to assume WLAN coverage for their handheld devices will be available practically everywhere they go. Failure to provide coverage in commercial operations, such as restaurants and stores, can be a detriment to business.

This explosion in demand; multiple orders of magnitude increases in data rates; and systems increasingly crowding each other; is pushing the limits of the technology. Systems must now be carefully designed and implemented by highly knowledgeable personnel using the latest test equipment to ensure a fully operational system that does not interfere with other networks.

## 1.2 Purpose

The purpose of this standard is to afford designers, installers and managers an opportunity to enhance their knowledge of quality Wireless Local Area Network (WLAN) systems, understand the requirements of superior performing systems and offer recommendations for the design, installation and management of standards-compliant, vendor-neutral systems.

## 1.3 Categories of Criteria

Two categories of criteria are specified - mandatory and advisory.

- Mandatory criteria generally apply to protection, performance, administration, and compatibility; they specify the absolute minimum acceptable requirements.
- Advisory or desirable criteria are presented when their attainment will enhance the general performance of the WLAN system infrastructure in all its contemplated applications.

Mandatory requirements are designated by the word *shall*; advisory recommendations are designated by the words *should*, *may*, or *desirable*, which are used interchangeably in this standard. When possible, recommendations and requirements were separated to aid in clarity.

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## **2 Scope**

### **2.1 Systems**

This document describes industry- and service provider-neutral standards and acceptable best practices for the design and installation of in-building and campus wireless local area networks (WLANs).

Where appropriate, the document discusses other wireless systems used in local, personal and body area networks (LANs, PANs, BANs), which use technologies such as Bluetooth, radio frequency identification (RFID), ZigBee, and infrared transmission. However, the detailed design, installation, configuration and administration of these smaller systems are not included.

### **2.2 Limitations**

This document does not include details concerning the design and installation of distributed antenna systems (DAS), as these are provided within ANSI/BICSI 006. Some discussion may be included on DAS where these systems interrelate with other WLAN systems.

In addition, this document does not include details concerning the programming or configuration of servers, routers, access points or other electronic devices in the system.

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### 3 Required Standards and Documents

The following standards and documents contain provisions that constitute requirements listed within this standard. Unless otherwise indicated, all standards and documents listed are the latest published version prior to the initial publication of this standard. Parties to agreement based on this standard are encouraged to investigate the possibility of applying a more recent version as applicable.

Where equivalent local codes and standards exist, requirements from these local specifications shall apply. Where reference is made to a requirement that exceeds minimum code requirements, the specification requirement shall take precedence over any apparent conflict with applicable codes.

#### *BICSI*

- ANSI/BICSI 003, *Building Information Modeling (BIM) Practices for Information Technology Systems*
- ANSI/BICSI N2, *Practices for The Installation of Telecommunications and ICT Cabling Intended to Support Remote Power Applications*
- ANSI/NECA/BICSI 607, *Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings*

#### *British Standards Institution (BSI)*

- BS 6701, *Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance*
- BS 7671, *Requirements for Electrical Installations. IET Wiring Regulations*

#### *European Committee for Electrotechnical Standardization (CENELEC)*

- EN 50173-1, *Information technology – Generic cabling systems – Part 1: General requirements*
- EN 50174-1, *Information technology—Cabling installation—Installation specification and quality assurance*
- EN 50174-2, *Information technology – Cabling installation – Installation planning and practices inside buildings*

#### *Institute of Electrical and Electronics Engineers (IEEE)*

- IEEE 802.3, *Standard for Ethernet*
- IEEE 802.11, *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*

#### *International Electrotechnical Commission (IEC)*

- IEC 60364, *Electrical Installations of Buildings*

#### *International Organization for Standardization (ISO)*

- ISO/IEC 11801-1, *Generic cabling for customer premises – Part 1: General requirements*
- ISO/IEC 11801-6, *Generic cabling for customer premises – Part 6: Distributed building services*
- ISO/IEC 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*
- ISO/IEC 18598, *Information technology – Automated infrastructure management (AIM) systems – Requirements, data exchange and applications*
- ISO/IEC 30129, *Information Technology – Telecommunications bonding networks for buildings and other structures*



*National Fire Protection Association (NFPA)*

- NFPA 70<sup>®</sup>, *National Electrical Code*<sup>®</sup> (NEC<sup>®</sup>)

*Telecommunication Industry Association (TIA)*

- ANSI/TIA 526-7-A, *Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures – Part 4-2: Installed Cable Plant – Single-Mode Attenuation and Optical Return Loss Measurement*
- ANSI/TIA-526-14-C, *Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 Edition 2, Fibre-Optic Communications Subsystem Test Procedure – Part 4-1: Installed Cable Plant – Multimode Attenuation Measurement*
- ANSI/TIA-568.0-D, *Generic Telecommunications Cabling for Customer Premises*
- ANSI/TIA-568.1-D, *Commercial Building Telecommunications Cabling Standard*
- ANSI/TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard*
- ANSI/TIA-568.3-D, *Optical Fiber Cabling and Components Standard*
- ANSI/TIA-569-D, *Telecommunications Pathways and Spaces*
- ANSI/TIA-606-C, *Administration Standard for Telecommunications Infrastructure*
- ANSI/TIA-607-C, *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*
- ANSI/TIA-758-B, *Customer-Owned Outside Plant Telecommunications Infrastructure Standard*
- ANSI/TIA-862-B, *Structured Cabling Infrastructure Standard For Intelligent Building Systems*
- ANSI/TIA-1005-A, *Telecommunications Infrastructure Standard for Industrial Premises*
- ANSI/TIA-1152-A, *Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling*
- ANSI/TIA-5048, *Automated Infrastructure Management (AIM) Systems – Requirements, Data Exchange and Applications*

## 4 Definitions, Acronyms, Abbreviations, and Units of Measurement

### 4.1 Definitions

For the purposes of this document, the following terms and definitions apply. Some terms and definitions may also be represented by an acronym as listed in Section 4.2.

<b>absorption</b>	A phenomenon causing attenuation of wave signals (e.g., electrical, electromagnetic, optical, acoustic) when passing through a medium.
<b>access point</b>	A hardware device or a computer wireless adapter with software that acts as a wireless communication hub for users of wireless devices to connect with each other and to bridge those devices to the cabled portion of the network.
<b>address</b>	A unique identification code assigned to a network device that is used to associate a message with its source and destination.
<b>adjacent channel interference</b>	A condition that occurs when two or more access point radios are providing radio frequency (RF) coverage to the same physical area using overlapping frequencies. Simultaneous RF transmission by two or more access point radios in such a configuration can cause system latency issues and throughput degradation.
<b>amplitude</b>	The maximum absolute value reached by a voltage or current waveform.
<b>antenna</b>	A conductive structure specifically designed to couple or radiate electromagnetic energy. In radio frequency systems, the antenna may be used to both transmit and receive electromagnetic energy.
<b>antenna gain</b>	(1) A term used to describe the capability of an antenna to direct signal energy in a particular direction, thereby increasing the effective range of the antenna in the given direction at the expense of range in other directions. (2) The ratio of the power required at the input of a loss-free reference antenna (usually an isotropic radiator or dipole) to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength at the same distance. <small>NOTE: Antenna gain is usually expressed in units of either decibel-isotropic (dBi) or decibel-dipole (dBd).</small>
<b>attenuation</b>	The decrease in magnitude or the power loss of a signal that propagates between points, expressed in decibels (dB) as the ratio of received signal to transmitted signal level. See also insertion loss.
<b>authority having jurisdiction</b>	The building official, electrical inspector, fire marshal, or other individuals or entities responsible for interpretation and enforcement of local building and electrical codes.
<b>cell</b>	The fixed area in which a wireless base station or access point is configured to operate.
<b>coverage area</b>	The area or space served by a device.
<b>coverage area cable</b>	A cable that is used to connect a building system (e.g., building automation, electronic security) device to a service outlet or horizontal connection point.
<b>dipole</b>	An antenna formed by splitting two wires of a two-wire transmission line, and bending them back to form a single straight line. A dipole antenna is considered a narrowband antenna, operating efficiently in only a narrow band of frequencies. Typically, the antenna feed is in the middle where the split occurs.
<b>directional antenna</b>	An antenna characterized by a broad coverage zone that preferentially sends or receives signals in a specific direction. See also <i>omnidirectional antenna</i> .

<b>direct connection</b>	A connection method in which the horizontal cabling supporting a device may directly attach or connect the device through a connectorized cable or hard-wired termination, eliminating the need for an equipment cord and corresponding telecommunications or service outlet.
<b>dynamic rate shifting</b>	A method used by a wireless transmitter to automatically adjust the modulation rate of a link on a frame-by-frame basis in order to quickly adjust to the current radio environment.
<b>effective isotropic radiated power</b>	The power supplied to an antenna multiplied by the antenna gain in dBi in a given direction. Sometimes called equivalent isotropically radiated power.
<b>effective radiated power</b>	The power supplied to an antenna multiplied by the antenna gain in dBd in a given direction.
<b>electromagnetic interference</b>	Radiated or conducted electromagnetic energy that has an undesirable effect on electronic equipment or signal transmissions
<b>equipment outlet</b>	A generic term for the outermost connection facility in a hierarchical star topology. An equipment outlet is commonly classified as a telecommunication outlet or a service outlet.
<b>frequency</b>	The number of cycles or sine waves occurring in a given time. If the unit of time is one second, the frequency is stated in hertz (Hz); one Hz is equal to one cycle per second.
<b>frequency band</b>	A range of frequencies for the operation of different radio communications classes. The International Telecommunications Union recognizes 12 bands from 30 Hz to 3,000 GHz.
<b>gain</b>	The increase in output current, voltage, or power relative to input current, voltage, or power, respectively. Gain is usually expressed in dB.
<b>horizontal connection point</b>	A connection point within horizontal cabling that is placed between the telecommunication room (TR) and equipment outlets or devices supporting intelligent building systems.
<b>isotropic</b>	Radiating with uniformity in all directions from a single point. NOTE: Some objects described as isotropic (e.g., isotropic antenna) are considered an ideal rather than physically existing item.
<b>omnidirectional antenna</b>	An antenna characterized by a broad coverage zone that radiates signals in all horizontal directions equally. See also directional antenna.
<b>path loss</b>	In a communications system, the attenuation undergone by an electromagnetic wave in transit between a transmitter and a receiver. It may be caused by many effects such as free-space loss, refraction, reflection, aperture-medium coupling loss, and absorption.
<b>permanent link</b>	The permanently installed portion of horizontal cabling, excluding cords (e.g., test, equipment, patch).
<b>radio frequency</b>	An electromagnetic frequency between the audio frequencies and the infrared band. This range of frequencies is approximately 10 kHz to 100 GHz and overlaps with the microwave band, which is approximately 3 GHz to 300 GHz.
<b>radio frequency interference</b>	A disturbance in the reception of radio and other electromagnetic signals because of conflict with undesired signals.
<b>repeater</b>	A device (e.g., station, transceiver) used to extend geographical range or coverage ability of wireless systems, incorporating both receive and transmit functions, which may or may not feature frequency translation.

<b>service outlet</b>	An outlet that is used to connect a device or equipment to the ICT infrastructure. Service outlets are typically used by building systems and equipment that are not subject to occasional or frequent disconnections and relocations. See also <i>telecommunications outlet</i> .
<b>site survey</b>	A process used to identify the characteristics of an environment. It is required for the design of a wireless network.
<b>telecommunications</b>	Any transmission, emission, and reception of information (e.g., signs, signals, writings, images, sounds) by cable, radio, optical, or other electromagnetic systems.
<b>telecommunications connector</b>	The receptacle and insertion elements which provide a means of aligning, attaching and achieving continuity between the conductors and optical fibers used within telecommunication and information communication and technology (ICT) applications.
<b>telecommunications outlet</b>	An assembly which consists of a faceplate, body, housing, or supporting bracket, and one or more receptacles or jacks of a telecommunication connector. Telecommunications outlets are typically located to provide ease of connection for communication and data equipment (e.g., computer, phone). See also <i>service outlet</i> .
<b>telecommunications room</b>	A telecommunications space that differs from equipment rooms and entrance facilities in that this space is generally considered a floor-serving or tenant-serving (as opposed to building- or campus-serving) space that provides a connection point between backbone and horizontal cabling.
<b>termination</b>	The physical connection of a conductor to connecting hardware.
<b>topology</b>	The physical or logical arrangement of a system.
<b>transceiver</b>	A radio transmitter and receiver combined into a single unit.
<b>wavelength</b>	The length of a wave measured from any point on one wave to the corresponding point on the next wave, such as from crest to crest. The wavelength of light is usually measured in nanometers.
<b>wireless local area network</b>	A non-public data network using radio frequency technology in which serial transmission is used without store and forward techniques for direct data communication among data stations located on the user's premises.
<b>work area</b>	A building space where the occupants interact with telecommunications terminal equipment, such as an individual office, cubicle, or printer/copier room.
<b>zone cabling</b>	A design methodology that utilizes a connection point centrally located within areas with higher densities of telecommunications outlets and devices being served.

## 4.2 Acronyms and Abbreviations

Abbreviations and acronyms, other than in common usage, are defined below.

AC	ACIadjacent channel interference	IP	OFDM	orthogonal frequency division multiplexing
AHJ	authority having jurisdiction	PHY		physical layer
AP	access point	PoE		power over Ethernet
CCI	co-channel interference	RF		radio frequency
DRS	dynamic rate shifting	RFI		radio frequency interference
DSSS	direct sequence spread spectrum	RFP		request for proposal
EMI	electromagnetic interference	RRM		radio resource management
ER	equipment room	RSSI		received signal strength indicator
ERP-OFDM	extended rate physical orthogonal frequency division multiplexing	SISO		single input, single output
FHSS	frequency hopping spread spectrum	SoW		scope of work
GI	guard interval	SSID		service set identifier
HCP	horizontal connection point	TR		telecommunications room
HR-DSSS	high-rate direct sequence spread spectrum	Vo-Fi		voice over Wi-Fi
ICT	information communication and technology	WBAN		wireless body area network
MAC	media access control	Wi-Fi		wireless fidelity wireless internet
MIMO	multiple input, multiple output	WLAN		wireless local area network
		WPAN		wireless personal area network

## 4.3 Units of Measurement

The units of measurement used in this standard are metric. Approximate conversions from metric to U.S. customary units are provided in parentheses; e.g., 100 millimeters (4 inches).

Units of measurement used in this standard are defined below:

dB	decibel	in	inch
dBd	decibel-dipole	kHz	kilohertz
dB <sub>i</sub>	decibel-isotropic	m	meter
dB <sub>m</sub>	decibel-milliwatt	Mbps	megabits per second
ft	foot	MHz	megahertz
Gbps	gigabits per second	mm	millimeter
GHz	gigahertz	THz	terahertz
Hz	hertz		

## 5 Regulatory and Safety

### 5.1 Local Code Requirements

Local code requirements shall be followed. Always review the local code requirements with the local authority having jurisdiction (AHJ) before proceeding with the installation. This includes reviewing what code and edition is adopted, and what, if any, exceptions to the code are adopted by the governing authority. Most of the code requirements for the job should be included in the scope of work documents. The installer should never take this information for granted, since the telecommunications contractor is fully responsible for all work done on the project.

If no code has been adopted locally, consult with the local regulatory office to determine what agency is responsible for that geographic area and what codes are in effect. Do not depend on other installers, contractors, or even site owner personnel in making these determinations.

### 5.2 Spectrum Allocations

#### 5.2.1 ITU Spectrum Allocation

RF is regulated globally by the International Telecommunication Union (ITU). The ITU divides the world into three regions (see Figure 5-1). RF is typically allocated and coordinated in these regions to prevent interference. The regulation of RF bands has been delegated by treaty to regions and national agencies throughout the world. The agencies have issued regulations that generally comply with ITU rules.

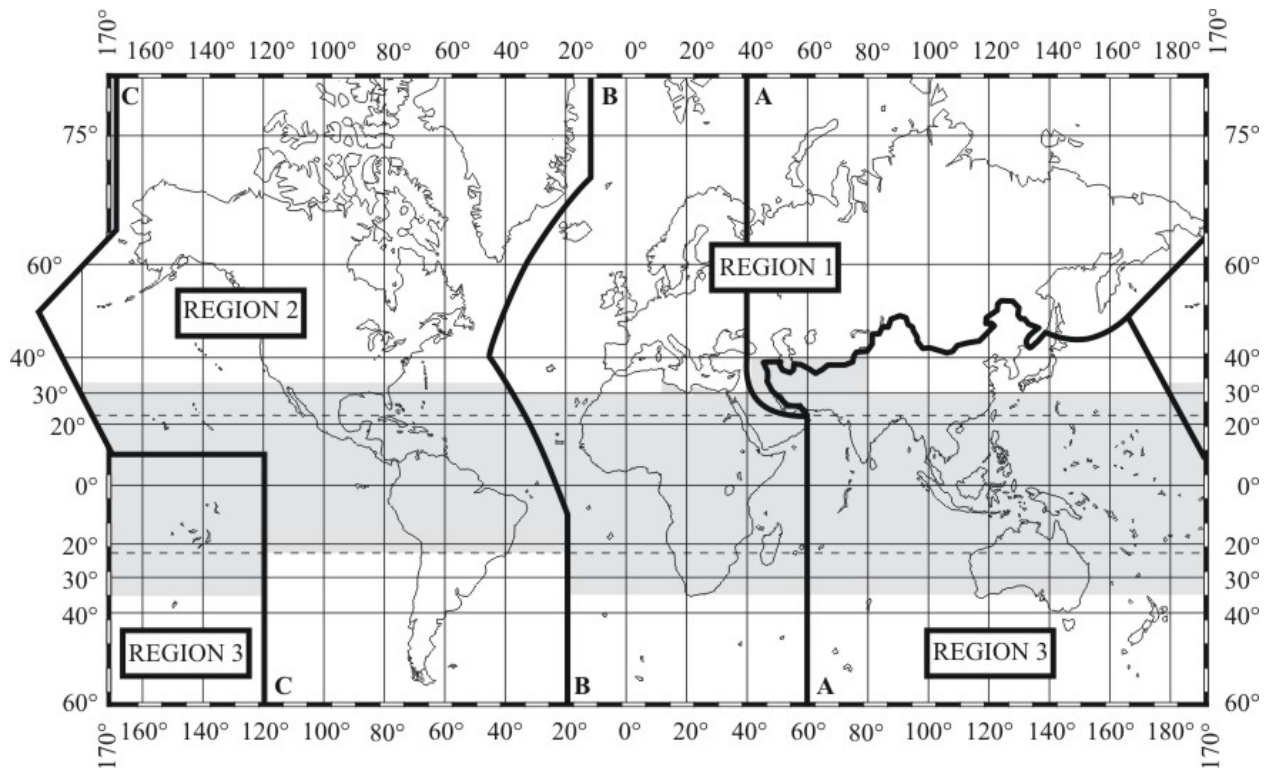


Figure 5-1  
International Telecommunication Union Regions

### **5.2.2 National**

There are currently five distinct frequency bands (i.e., 2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, 5.9 GHz) allowed for WLAN applications, with each frequency band divided into channels. Countries then apply their own regulations including allowed channels, allowed users/uses and maximum power levels within these frequency ranges.

Some countries may also require equipment to have minimum technical capability, such as dynamic frequency selection (DFS) and transmit power control (TPC).

NOTE: Both DFS and TPC were introduced in IEEE 802.11h and have subsequently been integrated into IEEE 802.11i

### **5.3 Safety**

Many countries have developed RF emission safety standards for wireless transmission. While low-power wireless devices do not have discernable health risks, equipment and systems are required to be in compliance with a national or region's established RF emissions safety limit and similar regulations for consumer protection.

Countries may also have regulations defining the maximum equivalent isotropic radiated power (EIRP) of antennas. These requirements typically affect the antenna, but also apply to the entire system.

### **5.4 Requirements**

Any WLAN equipment (e.g., transmitters, antenna) implemented shall be certified as compliant with applicable regulations as set forth by the applicable national body.