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Radiocommunication Sector of ITU

Recommendation ITU-R M.2134-0
(10/2019)

Receiver characteristics and protection criteria for systems in the mobile service in the frequency range 27.5-29.5 GHz for use in sharing and compatibility studies

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

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SNG	Satellite news gathering
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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R M.2134-0

Receiver characteristics and protection criteria for systems in the mobile service in the frequency range 27.5-29.5 GHz for use in sharing and compatibility studies

(2019)

Scope

This Recommendation provides the receiver characteristics and protection criteria for systems of the mobile service in the frequency range 27.5-29.5 GHz. These technical and operational characteristics should be utilized in sharing and compatibility studies.[1]

Keywords

Mobile service, technical characteristics, protection criteria

Abbreviations/Glossary

AAS	Advanced antenna system
ACS	Adjacent channel selectivity
AP	Access point
AR	Augmented reality
BS	Base station
FS	Fixed service
FSS	Fixed satellite service
LDPC	Low density parity check
MCS	Modulation and coding schemes
MIMO	Multiple input multiple output
TDD	Time division duplex
UHD	Ultra high definition
UE	User equipment
VR	Virtual reality

The ITU Radiocommunication Assembly,

considering

a) that mobile use of the frequency range 27.5-29.5 GHz or parts thereof, inter alia, for high speed data links, mainly used to convey high definition multi-media, is planned in several countries;

b) that representative receiver technical and operational characteristics of systems in frequency bands allocated to the mobile service are required for use in sharing and compatibility studies;

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[1] This Recommendation does not cover any technical characteristics and protection criteria of ESIM and HAPS under agenda items 1.5 and 1.14 of WRC-19.

c) that procedures and methodologies are needed to analyze the impact of systems in other services on receivers of systems in the mobile service,

noting

a) that the frequency range 27.5-29.5 GHz is allocated worldwide on a primary basis to the mobile service;

b) that the frequency range 27.5-29.5 GHz is also allocated worldwide on a primary basis to the fixed satellite service (Earth-to-space) and the fixed service,

recommends

1 that the technical and operational characteristics of receivers in the mobile service as described in Annex 1 should be used for sharing and compatibility studies involving the mobile service and systems in other services in the frequency range 27.5-29.5 GHz;

2 that the criteria of interfering signal power to mobile system receiver noise power level, in Annex 1 should be used as the required protection level(s) for the mobile systems in the frequency range 27.5-29.5 GHz.

Annex 1

Receiver technical and operational characteristics of systems in the mobile service in the frequency range 27.5-29.5 GHz for use in sharing and compatibility studies

1 Introduction

In the frequency range 27.5-29.5 GHz or parts thereof, mobile systems support a variety of applications including reliable transmission of several gigabits of data for mobile voice, data, and video wideband links, with video-related applications, e.g. ultra-high-definition video streaming, Virtual Reality, etc., as the main driver for the development of these systems.

2 Characteristics of mobile systems in the frequency range 27.5-29.5 GHz

2.1 Introduction

Technology advancements in signal processing, complex modulations, antenna design, and solid-state components are enabling the design and manufacture of communication systems in the frequency range 27.5-29.5 GHz or parts thereof, which are intended to be used to bring about multi-gigabit access to mobile/portable devices. These devices communicate with base station/access point installed mainly in populated areas, providing connectivity to users, households, and enterprises using wide channel bandwidth as large as 100 MHz or larger, e.g. through aggregation.

The wide available bandwidth and state-of-the-art antenna array technology enables delivery of significant amount of content at very high speeds, making applications such as Ultra-High-Definition (UHD) video, virtual reality (VR) and augmented reality (AR) possible. These systems enable connecting thousands of devices in very dense use areas such as stadiums or other arenas, public transportation stops, and other places with large, concentrated numbers of smart device users. Other applications include high speed radio links from the curb to the home, connecting mobile/portable modems and devices inside homes to a network.

2.2 Receivers

The new-generation mobile systems in the frequency range 27.5-29.5 GHz or parts thereof use state-of-the-art digital receiver technology to enhance system performance using advanced modulation and coding techniques. Modulation and Coding Schemes (MCS) for these systems generally encompass BPSK, QPSK, 16QAM, and 64QAM coupled with convolutional, low density parity check (LDPC), and turbo coding.

These systems predominantly use OFDM as the multiple access technique in a time division duplex (TDD) scheme and utilize power control in the uplink.

Receiver filter response of these systems is characterized through adjacent channel selectivity (ACS). Table 1 contains ACS values for base stations and mobile stations in the mobile service in the frequency range 27.5-29.5 GHz.

TABLE 1

Receiver adjacent channel selectivity (ACS)

Receiver adjacent channel selectivity (ACS) (dB)	**Base station**	**Mobile station**
	24	23

2.3 Antennas

Mobile systems in the frequency range 27.5-29.5 GHz or parts thereof utilize advanced antenna array technology using patch elements that can be arranged in a variety of forms. Typically, base station antennas use larger arrays (e.g. up to 256 elements) to achieve higher gain, whereas mobile stations use smaller array sizes due to form factor and power limitations (e.g. up to 32 elements).

The information in Table 2 and associated information in § 4.1 can be used to model the directional antenna pattern for these antennas for use in sharing and compatibility studies.

Base station antennas are typically mounted on street lamps posts or other low-height urban structures with the height in the range of a few floors of buildings. Typical antenna heights for these systems, therefore, range from 10 m (roughly a three-floor building) to 20 metres (roughly a six-floor building) above ground level, depending on the deployment environment. Mobile stations are assumed to operate by users at the street level, hence a height of 1.5 metres is assumed.

3 Protection criteria

Protection criteria of I/N values are provided in Table 2. The specified tolerable I/N is referenced to the mobile receiver input and requires taking in to account all sources of interference. If a single interference source is present, protection of the mobile systems requires that this criterion is not exceeded due to the interference from the single source. If multiple interference sources are present, protection of the mobile systems requires that this criterion is not exceeded due to the aggregate interference from the multiple sources.

4 Summary

The technical parameters of representative mobile systems in the frequency range 27.5-29.5 GHz are presented in Table 2.

TABLE 2

Receiver characteristics of Base Stations and Mobile Stations in the frequency range 27.5-29.5 GHz

	System A (represents deployments in some countries)		**System B (represents deployments in some countries)**		**System C (represents deployments in some countries)**		**System D (represents deployments in some countries)**	
Characteristics	**Base station**	**Mobile station**	**Base station**	**Mobile station**	**Base station**	**Mobile station**	**Base station**	**Mobile station**
Frequency range (GHz)	27.5-28.35		27.5-29.5		27.5-29.5		27.5-29.5	
Receiver bandwidth (MHz)	100		100		200		200	
Antenna pattern type	Directional		Directional		Directional		Directional	
Antenna polarization	Linear		Linear		Linear		Linear	
Peak antenna gain (dBi)	29	14	29	20	23	17	23	14
Antenna pattern model	See antenna pattern in § 4.1 below							
Antenna height (m)	10-20	1.5	10-20	1.5	6 or 15	1.5	6-10	1.5
Receiver noise figure (dB)	6.5	8.5	6	6	10	10	10	10
Protection criterion (dB)	−6		−6		−6		−6	
Base station antenna downtilt (degrees)	10		10		10		10	
Body loss (for handheld UE scenario)	N/A	4 dB	N/A	4 dB	N/A	4 dB	N/A	4 dB
Feeder loss for BS	0	N/A	0	N/A	3 dB	N/A	3 dB	N/A

Sharing studies can assume that the BS antenna beam could vary in a ±60 degrees range in the azimuth plane. Depending on the scenario to be studied[2], in the elevation plane, with respect to the horizontal plane: a range of −6 degrees to −60 degrees for 20 m BS and −3 degrees to −60 degrees for the 10 m BS can be used for System A; a range of −5 to −60 degrees for 20 m BS and −2 degrees to −60 degrees for the 10 m BS for System B; a range of −6 to −60 degrees for 15 m BS and −3 degrees to −60 degrees for the 6 m BS for System C; and a range of −6 to −60 degrees for 10 m BS and −3 degrees to −60 degrees for the 6m BS for System D.

4.1 Reference antenna pattern model

The beamforming antenna pattern is expressed based on an array configuration consisting of a number of identical radiating elements arranged in a planar way with a fixed separation distance (e.g. $\lambda/2$). The elements are assumed to have identical radiation patterns and with maximum directivity perpendicular to the plane housing the elements. Total antenna gain is the sum (logarithmic scale) of the array gain and the element gain.

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[2] Noting the above figures, protection measures of the mobile service should be derived for all elevation angles and utilize, inter alia, the wavelength, the receiver antenna gain pattern, and the receiver noise figure for Mobile service systems and should apply to all azimuth angles.

The formulas that express the element and composite patterns are expressed in Tables 3 and 4 below. In the Tables, the angles θ and φ are defined based on the coordinate system expressed as follows.

The radiation elements are placed uniformly in the y-z plane along the vertical z-axis in a Cartesian coordinate system. The x-y plane denotes the horizontal plane. The elevation angle is denoted as θ (defined between 0° and 180°, with 90° representing perpendicular angle to the array antenna aperture). The azimuth angle is denoted as φ (defined between −180° and 180°).

In an active Advanced antenna system (AAS), the unwanted (out of block) response are different compared to the wanted (in block) response. AAS systems actively control individual signals being fed to individual antenna elements in the array in order to shape and direct the antenna pattern to a wanted shape.

Element pattern

TABLE 3

Element pattern for antenna array model[3]

Horizontal radiation pattern	$A_{E,H}(\varphi) = -\min\left[12\left(\frac{\varphi}{\varphi_{3dB}}\right)^2, A_m\right]$ dB
Horizontal 3 dB beamwidth of single element / degree (φ_{3dB})	80
Front-to-back ratio: A_m and SLA_v	30
Vertical radiation pattern	$A_{E,V}(\theta) = -\min\left[12\left(\frac{\theta - 90}{\theta_{3dB}}\right)^2, SLA_v\right]$ dB
Vertical 3 dB beamwidth of single element / degree (θ_{3dB})	65
Single element pattern	$A_E(\varphi,\theta) = G_{E,\max} - \min\left\{-\left[A_{E,H}(\varphi) + A_{E,V}(\theta)\right], A_m\right\}$
Element Gain (dBi), $G_{E,\max}$	5

Composite antenna pattern

Table 4 illustrates the derivation of the composite antenna pattern, $A_A(\theta,\varphi)$. $A_A(\theta,\varphi)$ is the resulting beamforming antenna pattern from logarithmic sum of the array gain, $10\log_{10}\left(\left|\sum_{m=1}^{N_H}\sum_{n=1}^{N_V} w_{i,n,m} \cdot v_{n,m}\right|^2\right)$, and the element gain $A_E(\theta,\varphi)$. The composite pattern for the base station antenna should be used where the array serves one or more mobile stations with one or more beams, with each beam indicated by the parameter *i*.

3 Table 3 represents a reference antenna pattern, and as such does not represent a maximum or average envelope.

TABLE 4

Composite antenna pattern for base stations and mobile stations beam forming

Configuration	Multiple columns ($N_V \times N_H$ elements)
Composite array radiation pattern in dB $A_A(\theta,\varphi)$	For beam i: $A_{A,Beami}(\theta,\varphi)=A_E(\theta,\varphi)+10\log_{10}\left(\left\lvert\sum_{m=1}^{N_H}\sum_{n=1}^{N_V} w_{i,n,m}\cdot v_{n,m}\right\rvert^2\right)$ the super position vector is given by: $v_{n,m}=\exp\left(i\cdot 2\pi\left((n-1)\cdot\frac{d_V}{\lambda}\cdot\cos(\theta)+(m-1)\cdot\frac{d_H}{\lambda}\cdot\sin(\theta)\cdot\sin(\varphi)\right)\right),$ $n=1,2,\ldots N_V;\, m=1,2,\ldots N_H;$ the weighting is given by: $w_{i,n,m}=\frac{1}{\sqrt{N_H N_V}}\exp\left(i\cdot 2\pi\left((n-1)\cdot\frac{d_V}{\lambda}\cdot\sin(\theta_{i,etilt})-(m-1)\cdot\frac{d_H}{\lambda}\cdot\cos(\theta_{i,etilt})\cdot\sin(\varphi_{i,escan})\right)\right)$
Antenna array configuration (row × column)	Base station: 16x16 (System A and B), 8x8 (System C and D) Mobile station: 4x2 (System A and D) / 8x4 (System B)/ 4x4 (System C)
Horizontal radiating element spacing d/λ	0.5
Vertical radiating element spacing d/λ	0.5

In the absence of particular information concerning the radiation pattern, Recommendation ITU-R F.1336 addresses peak and average patterns of sectoral antennas in the frequency range 400 MHz-70 GHz.