



Recommendation ITU-R SM.2093-0
(08/2016)

**Methods for measurements of
indoor radio environment**

SM Series
Spectrum management



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RA	Radio astronomy
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SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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Methods for measurements of indoor radio environment

(2016)

Scope

For indoor radio environment measurements, there is a need to have a uniform, frequency-independent method to produce comparable, accurate and reproducible results between different measurement systems. This Recommendation provides a set of processes or steps that need to be integrated in a measurement procedure resulting in these comparable results.

Keywords

Indoor radio environment measurements, noise measurements

Abbreviations

ACF	Amplitude correction factor
AGC	Automatic gain control
APD	Amplitude probability distribution
CISPR	Comité International Spécial Des Perturbations Radioélectriques
DFT	Discrete Fourier Transformation
FIR	Finite impulse response
IEC	International Electrotechnical Commission
IN	Impulsive noise
I/Q	In-phase/Qadrature
LAN	Local area network
LNA	Low noise amplifier
PC	Personal computer
PLT	Power line telecommunication
RBW	Resolution bandwidth
RFID	Radio Frequency IDentifier
RMS	Root mean square
SCN	Single carrier noise
UWB	Ultra-wide band
VSWR	Voltage standing wave ratio
WGN	White Gaussian noise

Related ITU Recommendations, Reports

Recommendation ITU-R P.372

Recommendation ITU-R SM.1753

Report ITU-R SM.2055

Report ITU-R SM.2155

Report ITU-R SM.2157

NOTE – In every case the latest edition of the Recommendation/Report in force should be used.

The ITU Radiocommunication Assembly,

considering

- a) that, due to the introduction of many types of electrical and electronic equipment (emitting unintentional radio waves), and communication networks (e.g. ultra-wide band (UWB), power line telecommunication (PLT) and computers), the radio environment including interference for indoor applications might be getting worse;
- b) that, radio interference from single and identifiable sources being dominant in indoor environments does not fit the definition of man-made noise specified in Recommendation ITU-R P.372;
- c) that, for efficient spectrum management, administrations and/or manufacturers of radio applications operating indoors need to know the radio environment including interferences;
- d) that there is a need to harmonize the measurement methods for indoor radio environment measurements to achieve reproducible results that can be mutually compared;
- e) that, for the indoor radio environment measurements, certain minimum equipment specifications and measurement methods are required that are different from the ones applied to outdoor radio noise measurements covered in Recommendation ITU-R SM.1753,

recommends

that measurements of indoor radio environment should be carried out as described in Annex 1.

Annex 1

Methods for measuring indoor radio environment

1 Introduction

This Annex describes methods for measuring and evaluating the indoor radio environment faced by radiocommunication applications. Considering the usage of radio devices in indoor locations, measurement of the radio environment in frequency ranges above 30 MHz may be required in practice.

2 Components of radio environment

Major radio sources in indoor environment are emissions from electrical and electronic devices used inside the respective facility.

Radio noises as described in Recommendation ITU-R P.372 may get into a facility from the outdoor environment but its interfering effect is usually less than the emissions from indoor sources.

Using the definition given in Recommendation ITU-R P.372, radio noise is the aggregate of emissions from multiple sources that do not originate from radiocommunication transmitters. If at a given measurement location there is no dominance of single noise sources, the characteristic of the radio noise often has a normal amplitude distribution and can be regarded as white Gaussian noise.

However, with the high density of noise emitting devices especially found in indoor environments, it is virtually impossible to find a location that is not at least temporarily dominated by emissions

from a single source. These sources often emit impulses and/or single carriers. Since radiocommunication equipment has to operate in such an environment, it is necessary to include noise or emissions from nearby sources in measurements of the indoor radio environment. The following components of radio noise are defined in Recommendation ITU-R SM.1753.

TABLE 1
Components of radio noise

Noise component	Properties	Sources (examples)
White Gaussian noise ⁽¹⁾ (WGN)	Uncorrelated electromagnetic vectors Bandwidth equal to or greater than receiver bandwidth Spectral power level increases linear with bandwidth	Computers, power line communication networks, wired computer networks, cosmic noise
Impulsive noise (IN)	Correlated electromagnetic vectors Bandwidth greater than receiver bandwidth Spectral power level rises with square of bandwidth	Ignition sparks, lightning, gas lamp starters, computers, ultra-wideband devices
Single carrier noise (SCN)	One or more distinct spectral lines Bandwidth smaller than receiver bandwidth Spectral power level independent of bandwidth	Wired computer networks, computers, switched mode power supplies

⁽¹⁾ In the context of this Recommendation, WGN is considered to represent a continuous noise signal which exhibits a nearly flat power spectral density in the frequency ranges around the measurement bandwidth.

Recommendation ITU-R SM.1753-2 also includes the following descriptions.

While the WGN component is sufficiently characterized by the r.m.s. value, this is much more difficult for the IN. Modern digital communication services almost always apply error correction, making it more immune especially against impulsive noise. However, when certain pulse lengths and repetition ratios are reached, IN can significantly interfere with the operation of such a service.

It is therefore desirable to measure radio noise in a way that gives not only the level of IN but also certain information about the statistical distribution of pulse parameters.

According to the description, characteristics of WGN and IN should be evaluated separately, since their mechanism of the impact on wireless communication system is different from each other.

Single carrier noise (SCN) is only detected as such when it comes from a single source near the measurement location. However, SCN is often a dominant component of the indoor radio environment where wireless systems must also work. Therefore the levels of all three components defined in Table 1 forming the indoor radio environment should be included in the measurement results.

3 Key parameters of radio environment

The measurement procedures described here will deliver the results for the following key parameters of radio environment:

WGN:

- RMS level, presented as a single value.

IN:

- Peak level, presented as a distribution;
- Impulse/burst duration, presented as a distribution;
- Impulse/burst period, presented as a distribution;
- Total impulse/burst time.

SCN:

- RMS level of the highest interfering single carrier.

The key parameters in indoor environment are presented as a distribution obtained from multiple point measurement described in section 4. The details of the evaluation procedures for the Key parameters are described in section 9.

4 Measurement principles

Unlike outdoor environments, indoor radio environments depend considerably on the exact location of the measurement points, even within a room, because there is a high density of radio noise sources in a room, and there are influences on propagation characteristics due to reflections on the walls, the ceiling or the presence of structures there.

Therefore it is not adequate to determine radio environment characteristics by measurement at only a single point in a room.

Acquiring the radio environment data at multiple points in a room or an installation is recommended. For multiple points measurement, a method that can measure SCN, WGN, and IN in a short time is necessary. The number of measurement points should be decided by considering the floor space of that location (e.g. 50 points per 100 m²).

The method described in this Recommendation adopts post processing of I/Q data obtained by a vector signal analyser or a monitoring receiver. This measurement method is referred to as “I/Q data sampling method”. It can acquire SCN, WGN, and IN data at any combination of resolution bandwidth and centre frequencies from I/Q data as long as they are inside the measured frequency band. Spectrograms, essential for SCN detection, can also be obtained from I/Q data.

5 Environmental categories

The radio environment mainly depends on dominant interference sources used in the building. Therefore, the environment categories for indoor measurement should be based on the usage of electrical and/or electric apparatuses, rather than the surrounding environment of the building as shown in Table 2. The table also shows the examples of locations for each category in order to help categorization of candidate locations.

TABLE 2

Selection criteria for indoor measurement locations and examples

Category	Definition	Examples of locations	Active time (hours)
Domestic	Single house or flat with typical electrical and electronic appliances for private use	Residence, apartment-house, dormitory, guest room in hotel	Evening times e.g. 17:00 – 21:00, but depends on people's lifestyle (Electric devices should be activated for measurement)
Office	Electrical and electronic appliances for business use, IT and telecommunication equipment, e.g. computers, printers, local area networks	Office work room, staff room	Working time e.g. 9:00 – 12:00 and 13:00 – 17:00
Shopping centre	Locations with shops and supermarkets	Retail shop, restaurant, amusement area, reception area, indoor car park, museum, theatre, library	Opening time; activity of devices may depend on the number of customers.
Railway station	Major railway stations inside roofed platform area	Inside roofed platform area including subways	Depends on the traffic. e.g. 7:00 – 10:00, 17:00 – 20:00
Airport terminal	Major airports, inside terminal building	Check-in counter area, boarding area, arrivals area	Depends on the traffic e.g. 8:00 – 21:00
Factory	Inside factory buildings dominated by electrical machinery	Production factory, maintenance facility, warehouse	Working time e.g. 9:00 – 12:00 and 13:00 – 17:00
Hospital	Locations dominated by medical appliances	Clinic, consultation room and treatment room in hospital	Working time e.g. 9:00 – 12:00 and 13:00 – 17:00

6 Equipment specifications

6.1 Receiver and preamplifier

A vector signal analyser or a monitoring receiver which can produce I/Q data is required as a measurement receiver.

An external low noise amplifier (LNA) can be used to improve sensitivity. The following requirements should be applied to the combination of analyser/receiver and LNA.