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TECHNICAL REPORT

colour inside

Transmitting and receiving equipment for radiocommunication – Radio spectrum measurement method – 300-GHz spectrum measurement equipment

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TRANSMITTING AND RECEIVING EQUIPMENT FOR RADIOCOMMUNICATION – RADIO SPECTRUM MEASUREMENT METHOD – 300-GHz SPECTRUM MEASUREMENT EQUIPMENT

FOREWORD

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The text of this Technical Report is based on the following documents:

Draft	Report on voting
103/206/DTR	103/223/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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- replaced by a revised edition, or
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INTRODUCTION

This document describes a high-dynamic-range spectrum measurement system to measure spectra in the frequency range 140 GHz to 300 GHz. Although millimeter-wave (mmWave) technology has high potential for both industries and users, there are no developed techniques for evaluating spectra suppressing the unwanted response generated in the measurement system. In addition, the commercialized spectrum analyser for this frequency band cannot accurately measure low power input signals due to the insufficient dynamic range while high power signals are input to the spectrum analyser simultaneously. This document describes the high-dynamic-range spectrum measurement system with low unwanted response for measuring spectra in the frequency range 140 GHz to 300 GHz, and proposes an mmWave pre-selector to suppress the unwanted response generated in the measurement system.

TRANSMITTING AND RECEIVING EQUIPMENT FOR RADIOCOMMUNICATION – RADIO SPECTRUM MEASUREMENT METHOD – 300-GHz SPECTRUM MEASUREMENT EQUIPMENT

1 Scope

This document specifies spectrum measurement methods in the frequency range 140 GHz to 300 GHz. This document also provides background information, describes system configurations, key mmWave pre-selector technology, as well as some examples of the spurious measurement of antennas under test (AUTs) over the air.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.2 Abbreviated terms

mmWave	millimetre-wave
ACLR	adjacent channel leakage power ratio
ATT	attenuator
AUT	antenna under test
DANL	displayed average noise level
DUT	device under test
FCC	Federal Communications Commission
FOD	foreign object debris
IF	intermediate frequency
IR	infra-red
LIDAR	light detection and ranging
LO	local oscillator
OOK	on-off-keying
OTA	over the air
PC	personal computer
PHY	physical layer
QAM	quadrature amplitude modulation

RBW	resolution bandwidth
RF	radio frequency
SHM	sub-harmonic mixer
SPA	spectrum analyser
TE mode	transverse electric mode
TOI	third-order intercept
YIG filter	yttrium-iron-garnet filter
WRC	World Radiocommunication Conference

4 Background to measurement up to 300 GHz

4.1 IEEE Std 802.15.3d

The IEEE SA Standards Board approved the first edition of the IEEE Std 802.15.3 standard on March 15, 2016; it was also adopted and approved by the ISO/IEC national bodies. There are three amendments to IEEE Std 802.15.3. IEEE Std 802.15.3d-2017 (Amendment 2) considers non-coherent OOK and coherent QAM up to 64 on the 300-GHz band. Two PHY modes are defined that enable data rates of up to 100 Gb/s using eight different bandwidths between 2,16 GHz and 69,12 GHz. The current frequency plan is depicted in Figure 1, although it considers a broad range of possible channel allocations.

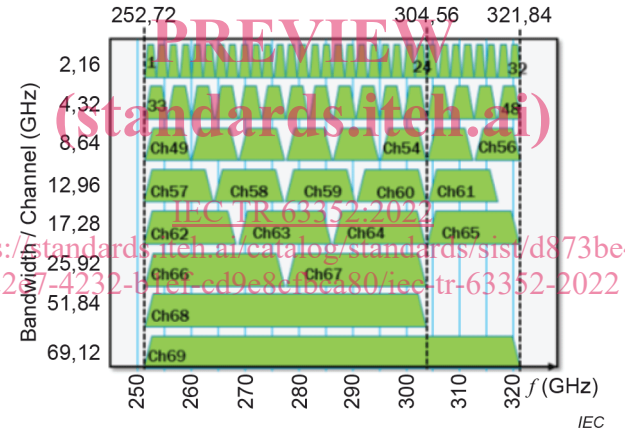

Figure 1 – IEEE Std 802.15.3d-2017 (Amendment 2) frequency plan

4.2 FOD radar

After the Air France Concorde crash in 2000, which was caused by engine ingress of runway debris, airport operators focused on the use of foreign object debris (FOD) detection systems. Several technologies, such as cameras, IR, LIDAR, and other sensors are being tested. One candidate is the mmWave radar because it can detect small metallic objects using converted automotive radar in the 77-GHz band. If the system requires finer resolution, the 92-GHz to 100-GHz band for radio location services should be used for the purpose.

4.3 Experimental frequency license above 95 GHz

The Federal Communications Commission (FCC) announced new rules to encourage the development of new communication technologies and expedite the deployment of new services in the spectrum above 95 GHz, such as data-intensive, high-bandwidth applications, as well as imaging and sensing operations. To enable innovators and entrepreneurs to readily access this spectrum, the Spectrum Horizons First Report and Order creates a new category of experimental licenses for use of frequencies between 95 GHz and 3 THz. These licenses will give innovators the flexibility to conduct experiments lasting up to 10 years, and to more easily market equipment during the experimental period.

4.4 ITU WRC-19 agenda item 1.15

Agenda item 1.15 covers the identification of frequency bands for use by administrations for land-mobile and fixed services applications operating in the 275-GHz to 450-GHz frequency range.

The 275-GHz to 296-GHz, 306-GHz to 313-GHz, 318-GHz to 333-GHz, and 356-GHz to 450-GHz frequency bands are identified for land-mobile and fixed service applications, where no specific conditions are necessary to protect Earth exploration-satellite service (passive) applications.

The 296-GHz to 306-GHz, 313-GHz to 318-GHz, and 333-GHz to 356-GHz frequency bands may only be used by land-mobile and fixed service applications when specific conditions to ensure protection of Earth exploration-satellite service (passive) applications are determined in accordance with Resolution 731 (Rev.WRC-19).

In those parts of the 275-GHz to 450-GHz frequency range where radio-astronomy applications are used, specific conditions (e.g. minimum separation distances and/or avoidance angles) may be necessary to ensure protection of radio-astronomy sites from land-mobile and/or fixed service applications on a case-by-case basis in accordance with Resolution 731 (Rev.WRC-19). Use of the above-mentioned frequency bands by land-mobile and fixed service applications does not preclude the use by, and does not establish priority over, any other applications of radio services in the 275-GHz to 450-GHz range.

4.5 Issue of conventional spectrum measurement for mmWave

Unwanted responses in the spectrum-analyser RF front-end prevent accurate spectrum observation of target signals. There are three main unwanted responses. The first is image response, which occurs when a signal is input to the spectrum analyser at the image frequency. The second is multiple response. The frequency components | m * RF frequency – n * Local frequency | (where m and n are integers) occur due to spectrum-analyser circuit non-linearity. The multiple response occurs when the frequency of the components equals the IF frequency. The third is residual response, which occurs due to multiples of internal frequency components, such as local oscillator frequency and local oscillator intermediate frequency. A pre-selector can be used to suppress image response. (The two other unwanted responses can be suppressed by frequency design.) However, there is no tunable pre-selector like a YIG filter for frequencies above 80 GHz. Figure 2 shows the results of observing a signal using a spectrum analyser without a pre-selector. Unwanted responses can be seen in addition to the wanted signal, making it difficult to recognize the wanted signal.

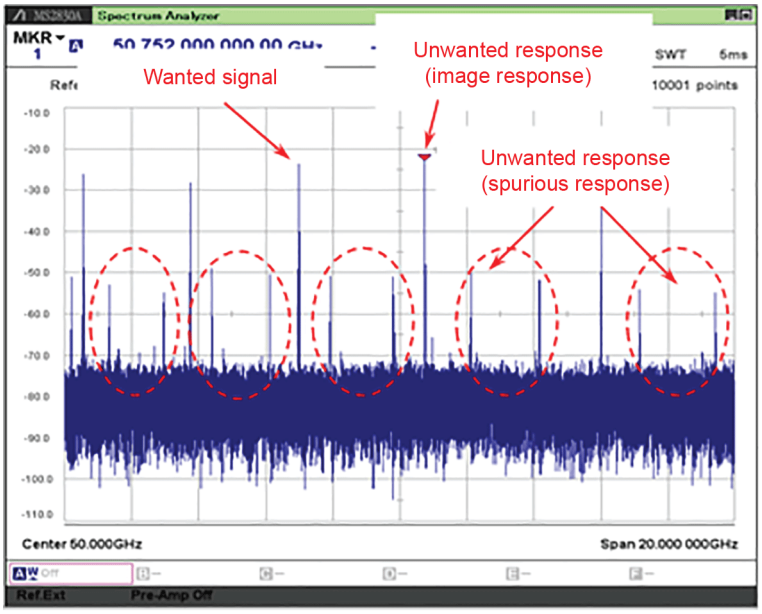

Figure 2 – Spectrum observed by spectrum analyser without pre-selector

5 300-GHz band spectrum measurement

5.1 Overview

The 300-GHz spectrum analyser supports signals from 140 GHz to 300 GHz; the 160-GHz bandwidth is split into three bands and each band is covered by a spectrum analyser. Table 1 shows mmWave frequency band for G-band, H-band and J-band.

Table 1 – Frequency bands covered by spectrum analyser

Frequency [GHz]	140 to 190	185 to 260	255 to 315
Band	G-band	H-band	J-band
Waveguide	WR-5	WR-4	WR-3

Figure 3 shows the external appearance of the J-band spectrum analyser and signal source used for evaluation. The target specifications for the J-band spectrum analyser are given in Table 2.