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TECHNICAL REPORT

colour inside

Transmitting equipment for radiocommunication – Radio-over-fibre technologies for spectrum measurement – 100-GHz spectrum measurement equipment

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TRANSMITTING EQUIPMENT FOR RADIOCOMMUNICATION – RADIO-OVER-FIBRE TECHNOLOGIES FOR SPECTRUM MEASUREMENT – 100-GHZ SPECTRUM MEASUREMENT EQUIPMENT

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IEC TR 63100, which is a Technical Report, has been prepared by IEC technical committee 103: Transmitting equipment for radiocommunication:

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

Enquiry draft	Report on voting
103/157/DTR	103/163/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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A bilingual version of this publication may be issued at a later date.

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TRANSMITTING EQUIPMENT FOR RADIOCOMMUNICATION – RADIO-OVER-FIBRE TECHNOLOGIES FOR SPECTRUM MEASUREMENT – 100-GHZ SPECTRUM MEASUREMENT EQUIPMENT

1 Scope

This document describes 100-GHz spectrum measurement methods using RoF technologies. It covers the background to measurement over 100 GHz, the configuration of a spectrum analyser, the key technologies, such as mm-wave tunable filter, and RoF-technologies-based local oscillator, and provides some measured examples.

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

mm-wave	millimeter-wave
ADAS	advanced driving assistant systems
FOD	foreign object and debris
ODU	outdoor unit
IDU	indoor unit
HDTV	high-definition television
MPEG	moving pictures experts group
DUT	device under test
UTC-PD	uni-travelling-carrier photodiode
SD	standard deviation
LSB	lower sideband
USB	upper sideband
DANL	displayed average noise level
TOI	third order intercept
ACLR	adjacent channel leakage power ratio
SNR	signal-to-noise ratio
IR	infra-red
SPA	spectrum analyser

LIDAR	light detection and ranging
RBW	resolution bandwidth
OBW	occupied bandwidth
VBW	video bandwidth
FM CW	frequency modulated continuous wave
ATT	attenuator
ASK	amplitude shift keying
BPSK	binary phase shift keying
QPSK	quadrature phase shift keying
LO	local oscillator
RF	radio frequency
IF	intermediate frequency
RoF Sig Gen	radio over fibre technologies-based local signal generation

4 Background to measurement over 100 GHz

4.1 General

The following applications depend heavily on the development of mm-wave technology:

- IEEE 802.11ad wireless devices;
- automotive radar;
- airport ground radar;
- mobile backhaul;
- uncompressed HD signal transmission.

4.2 IEEE 802.11ad wireless devices

IEEE 802.11ad wireless devices uses the 60-GHz band to implement multi-gigabit speeds, low latency, and secure connections between devices. Popular applications are replacement of display cables, and wireless connection between laptops. IEEE 802.11ad wireless devices should be checked for bandwidth, 60-GHz in-band emissions, and out-of-band emissions up to 130 GHz. However, there is currently no commercial spectrum analyser with a pre-selector to remove unwanted internal frequency responses at bands over 100 GHz.

4.3 Automotive radar

Advanced driving assistant systems (ADAS) are being developed as a key technology for autonomous vehicles. ADAS uses various sensors, including radar, LIDAR and cameras. An ADAS radar detects small objects at high distance, velocity, and angle resolution using wideband FM CW modulation as the key technology. The world radio communication conference of November 2015 (WRC-15), agreed on the use of the contiguous 4-GHz band from 77 GHz to 81 GHz, and that demand for high-resolution mm-wave radar in the 79-GHz band will increase as ADAS becomes more widespread.

4.4 Airport ground radar

Following the Air France Concorde disaster in 2000, which was caused by engine ingress of runway debris, airport operators have been focusing on foreign object and debris (FOD) detection systems. Several technologies, such as cameras, IR, LIDAR, and other sensors are being tested. One candidate is the mm-wave radar because it can detect small metallic objects using converted automotive radar in the 77-GHz and 90-GHz bands. Both bands require a wider bandwidth for finer resolution and the 92-GHz to 100-GHz band could be used for industrial radio location.

4.5 Mobile backhaul

Mobile phones and terminals communicate by connecting to base stations that transfer data to the core network. Data from multiple base stations distributed throughout the communications area is transferred by a network of systems that collect and transfer data using various exchanges and wired and wireless technologies—this is called the "mobile backhaul". Wired technologies use optical fibres featuring larger traffic capacity than wireless and stable communications quality. However, optical fibre can sometimes suffer from installation problems due to difficult geography and high cost. On the other hand, wireless communications are easier and faster to install and at a lower cost. Wireless also has advantages of easier service restoration after disasters. Wireless backhaul equipment is composed of an outdoor unit (ODU) and an indoor unit (IDU). The wireless signal is transmitted and received by antennas on the ODU. The IDU is connected to the network and handles sending/receiving of IF data to/from the ODU, as well as data transmission.

Most wireless backhaul frequency bands are below 38 GHz but some 60-GHz and 70-GHz to 80-GHz bands have been allocated to secure wider bandwidth for implementing larger-capacity and faster transfers. Since frequency bands and applications depend on national laws governing radio, not all bands are available in all regions.

4.6 Uncompressed HD signal transmission

Digital terrestrial television broadcasting is spreading rapidly, typically as high-definition television (HDTV) broadcasts. Transmitting raw HDTV broadcast materials is difficult because uncompressed HDTV signals have a data rate of 1,5 Gbit/s, requiring a wide bandwidth. Broadcasters normally use microwave radio to transmit broadcast materials, but the current transmission capacity is insufficient. Moving pictures experts group (MPEG) signal compression causes latency that adversely affects smooth conversation in live broadcasts. Consequently, TV broadcasters require high-capacity wireless link technology supporting transmission of uncompressed HD signals. Use of 120-GHz band wireless links with a centre frequency of 125 GHz and data transfer up to 10 Gbit/s supports transmission of uncompressed HD signals. It was trialed at the 2008 Beijing Olympics.

5 Spectrum measurement over 100 GHz

5.1 Overview

The developed 100-GHz spectrum analyser supports signals from 110 GHz to 140 GHz; Figure 1 shows its external appearance and Figure 2 shows the block diagram. The design specifications are listed in Table 1.

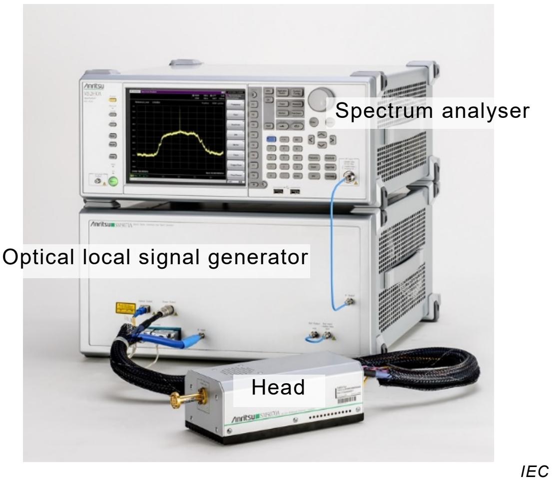

Figure 1 – External appearance of a 100-GHz spectrum analyser

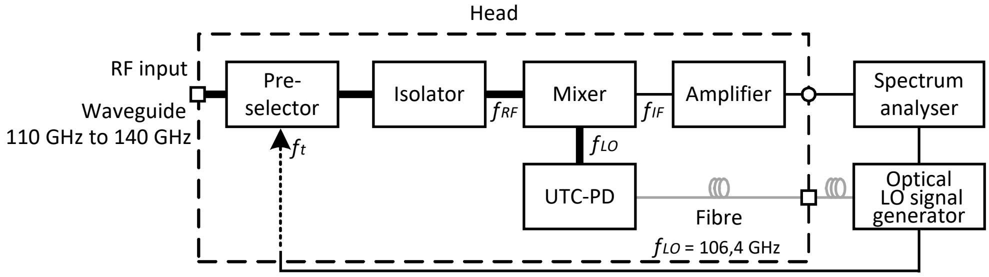

Figure 2 – 100-GHz spectrum analyser block diagram

Table 1 – Design specifications

Frequency band	110 GHz to 140 GHz
SPAN	≤ 30 GHz
DANL	< –140 dBm/Hz
TOI	> +10 dBm
Image response	> 100 dB

The main features are high performance and flexible positioning due to the compact head unit. High performance is achieved using fundamental mixing, a tunable pre-selector (pre-selector), and RoF-technologies-based local signal generation (RoF Sig Gen). Fundamental mixing achieves low noise and fewer multiple responses; the pre-selector achieves low unwanted responses; the RoF Sig Gen decreases unwanted spurious response due to LO signal harmonic components.

The small head unit is easily positioned between the device under test (DUT) and test instruments. Usually, the DUT has a waveguide interface, which can be difficult to position if the test equipment uses a waveguide. The small head unit size is implemented using the RoF Sig Gen feeding a 106,4-GHz optical signal via optical fibre to the head unit. If a local signal over 100 GHz is fed to a head unit, the cable length should be short to prevent cable losses. If a lower-frequency signal is fed to the head unit with multiplication, there should be a multiplier and filters in the head unit, which would be larger than proposed.

5.2 100-GHz spectrum analyser system configuration

As shown in Figure 1, the system is composed of a head unit with WR-08 waveguide input, a commercial spectrum analyser (IF SPA), and RoF Sig Gen. As shown in Figure 2, the head unit is composed of a pre-selector, isolator, mixer, amplifier, and uni-travelling-carrier photodiode (UTC-PD). The mixer uses frequency down-conversion to generate multiple mixing products determined by the LO frequency (f_{LO}) and RF frequency (f_{RF}). The IF frequency (f_{IF}) is obtained as $f_{LO} \pm f_{RF}$. The IF SPA processes the IF signal to display the spectrum. Input of image components to the head unit is reduced by the pre-selector in the head unit.

5.3 Key technologies

5.3.1 General

The key technologies for achieving the design specifications are:

- mm-wave tunable filter;
- RoF-technologies-based local signal generator (RoF Sig Gen).