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INTERNATIONAL STANDARD

colour inside

Transmitting and receiving equipment for radiocommunication – Radio-over-fibre technologies and their performance standard – Part 4: Radio-over-fibre-based indoor distributed antenna system (DAS) for 5G

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TRANSMITTING AND RECEIVING EQUIPMENT FOR RADIOCOMMUNICATION – RADIO-OVER-FIBRE TECHNOLOGIES AND THEIR PERFORMANCE STANDARD –

Part 4: Radio-over-fibre-based indoor distributed antenna system (DAS) for 5G

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Draft	Report on voting
103/253/FDIS	103/254/RVD

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 International Standard 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/publications.

A list of all parts in the IEC 63098 series, published under the general title *Transmitting and receiving equipment for radiocommunication – Radio-over-fibre technologies and their performance standard*, can be found on the IEC website.

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- reconfirmed,
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- amended.

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INTRODUCTION

This document provides the performance standards of the RoF-based 5G indoor distributed antenna system (DAS) network for cost-effectively offering quality of service (QoS) guaranteed 5G mobile communication services with high bandwidth and low-latency characteristics without radio shadowing in an indoor environment. First of all, the system overview, system configurations, and the elements of the system are presented and then the electrical and optical interfaces for each system element are defined. Finally, the detail system performance specifications of each element are described for downlink and uplink configurations.

TRANSMITTING AND RECEIVING EQUIPMENT FOR RADIOCOMMUNICATION – RADIO-OVER-FIBRE TECHNOLOGIES AND THEIR PERFORMANCE STANDARD –

Part 4: Radio-over-fibre-based indoor distributed antenna system (DAS) for 5G

1 Scope

This part of IEC 63098 specifies a radio-over-fibre-based indoor distributed antenna system (DAS) for fifth generation wireless technology 5G.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

3GPP TS 38.104 V15.3.0 (2018-10), 5G; NR; *Base Station (BS) radio transmission and reception*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1.1
radio over fibre
RoF
communication technology in which radio-frequency signals are modulated on light and transmitted over fibre optics

3.1.2
distributed antenna system
DAS
network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure

3.1.3
5G
fifth generation wireless technology for digital cellular networks

3.1.4
main hub unit
MHU
element that links a base station for 5G and a remote antenna unit spatially distributed

3.1.5
remote antenna unit
RAU
element that connects a main hub unit and a subscriber’s mobile terminal

3.1.6
distribution point
split downstream signal from a main hub unit to a remote antenna unit or a combined upstream signal from a remote antenna unit to a main hub unit in a distributed antenna system, which is comprised of an optical splitter or wavelength division multiplexer/demultiplexer

3.2 Abbreviated terms

The abbreviated terms used in this document are given in Table 1.

Table 1 – Abbreviated terms

5G	fifth generation technology standard
ACLR	adjacent channel leakage ratio
CM	control and management
CWDM	coarse wavelength division multiplexing
DAS	distributed antenna system
DUT	device under test
FA	frequency allocation
FS	frequency synchronization
IF	intermediate frequency
Me-CM	MHU electrical interface for system control and management signal
Me-FS	MHU electrical interface for frequency synchronization signal
Me-IF	MHU electrical interface for 5G signal at IF-band signal
Me-TD	MHU electrical interface for TDD synchronization signal
MHU	main hub unit
MIMO	multi input multi output
Mo-IF	MHU optical interface for IF-based data signals and digital-based auxiliary signals
mmWave	millimeter wave
O2I	outdoor-to-indoor
QoS	quality of service
RAU	remote antenna unit
Re-RF	RAU electrical interface for 5G signal at RF-band
Re-CM	RAU electrical interface for system control and management
RF	radio frequency
RoF	radio over fibre
Ro-IF	RAU optical interface for IF-based data signals and digital-based auxiliary signals
TDD	time-division duplexing
VSWR	voltage standing wave ratio

4 RoF based DAS

4.1 System overview

As a follow-on from the 2G network, the DAS has been actively utilized, removing the shaded area of a radio signal in a room or in a specific environment where radio wave arrival is restricted. This is particularly the case for the millimeter wave-based 5G mobile communication system that features broad bandwidth and low latency which requires the use of DASs in order to seamlessly bring the 5G services indoors, due to the property of high frequency electromagnetic waves such as high O2I penetration loss and strong straightness. The bandwidth of the baseband signal accommodated by the 5G system shall be as indicated in 3GPP TS 38.104 V15.3.0. It is up to 100 MHz/FA, where simultaneous transmission of up to 4 FA is normally required. Moreover, the use of MIMO configuration will lead the DAS to handle multi-GHz bandwidth mobile signals, demanding a bandwidth efficient transmission technology. From the perspective of bandwidth usage, RoF transmission is the most prospective candidate. Most of all, there is no redundancy traffic caused by digital to analogue (D/A) conversion and analogue to digital (A/D) conversion. There is no redundancy traffic caused by the specific digital framing procedure that conventional digital transmission always requires. Thus the RoF-based DAS is considered to be a notable solution for realization of mmWave-based 5G indoor network. Figure 1 shows the basic structure of the DAS for the 5G network. The MHU relays the mobile signals from the 5G base station to the RAU. The RAU delivers the 5G wireless signals to a plurality of subscriber equipment, and captures the 5G signals of the user equipment and delivers the signal towards the MHU. In Figure 1, the RoF link builds the connection between the MHU and RAU.

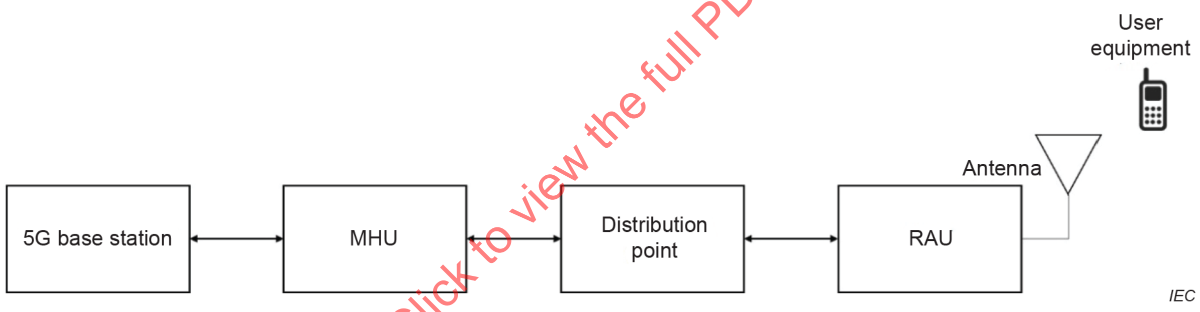

Figure 1 – Basic structure of a distributed antenna system (DAS) for 5G

4.2 System configurations

4.2.1 General

The DAS for 5G consists of various elements in a point-to-point or point-to-multipoint configuration. The system configurations presented in 4.2 can be a standard from the general point of view of cost-effective network deployment and operation as well as efficient 5G service provision.

4.2.2 Point-to-point configuration

The point-to-point configuration considers the case where a single RAU is directly connected to a single MHU without any distribution point, as shown in Figure 2. When the service is provided to a limited or small area, this configuration may be preferred, as the initial stage of 5G service provision.

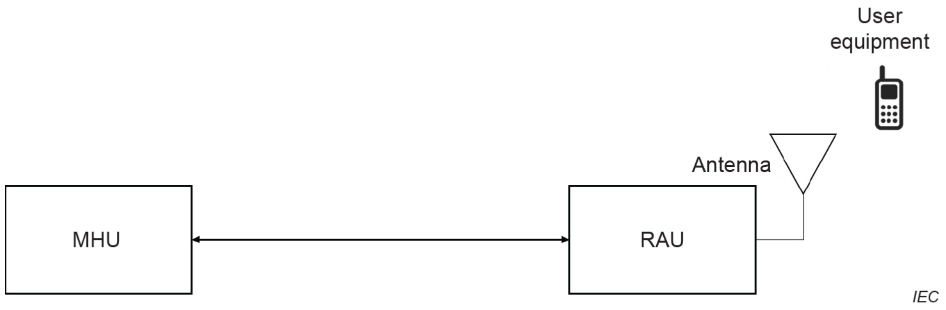

Figure 2 – Point-to-point configuration of DAS

4.2.3 Point-to-multipoint configuration

The point-to-multipoint configuration considers the case where multiple RAUs are connected to a single MHU via the distribution point, as shown in Figure 3. It may be deployed to offer seamless and unbroken network coverage throughout a large geometric area.

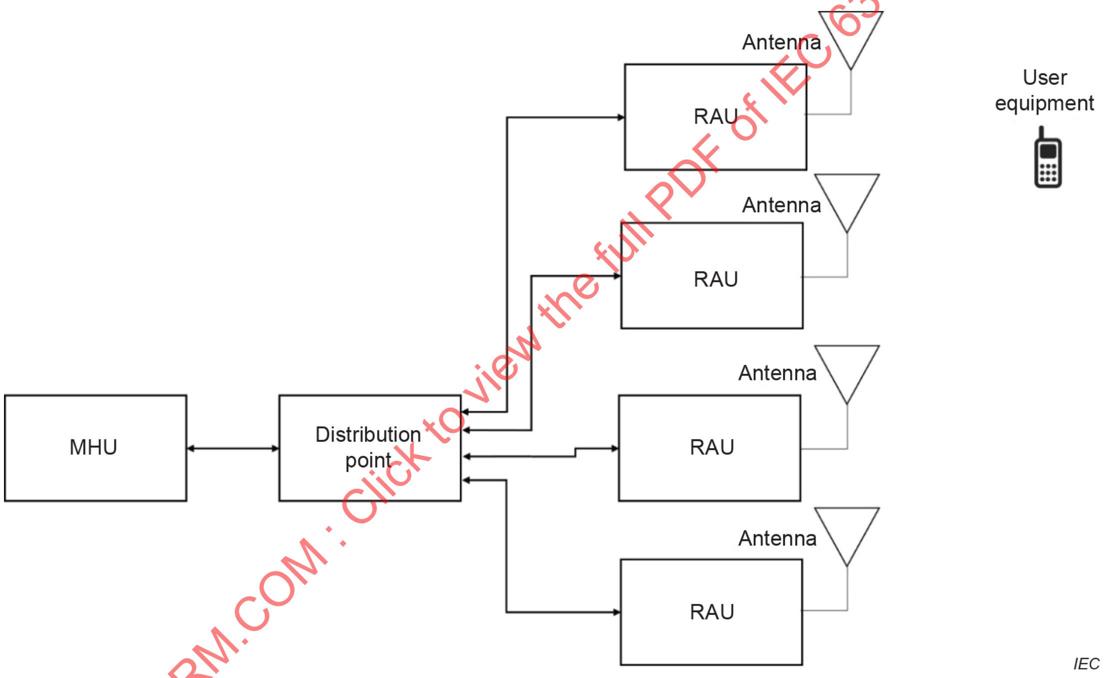

Figure 3 – Point-to-multipoint configuration of DAS

5 System interfaces

5.1 General

The DAS includes electrical and optical interfaces. To be more specific, the MHU and the RAU include electrical and optical interfaces so as to deliver the 5G signal, frequency synchronization signal, time-division duplexing (TDD) signal, and control and management (CM) signal as illustrated in Figure 4. More details of the interfaces are discussed in 5.2 and 5.3.

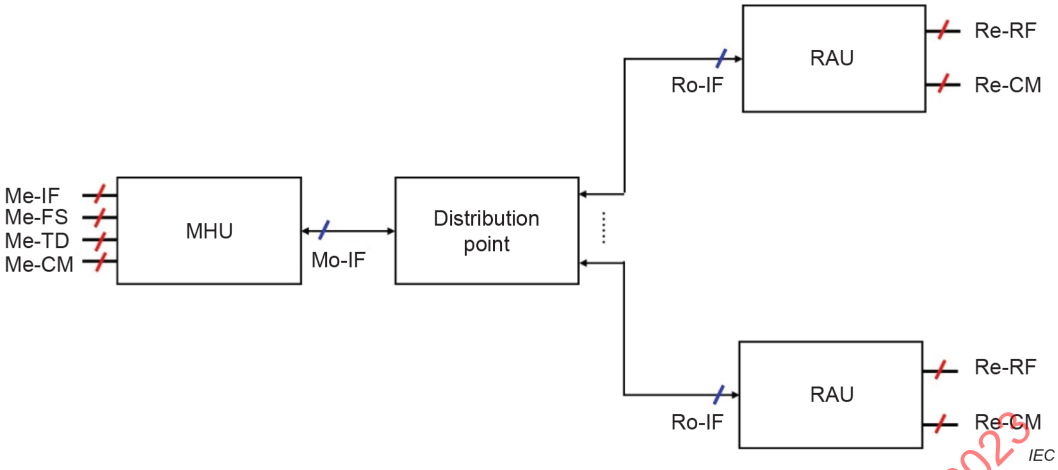

Figure 4 – System interfaces of DAS for 5G

5.2 Electrical interfaces

5.2.1 MHU

The electrical interfaces of the MHU are represented as Me-IF, Me-FS, Me-TD, and Me-CM as shown in Figure 4. All the electrical interfaces of the MHU are basically connected to the 5G base station. Table 2 describes the definitions and functions of the electrical interfaces of the MHU.

Table 2 – Definitions and functions of the electrical interfaces of the MHU

Interface	Definitions	Functions
Me-IF	Electrical interface for 5G signal at IF-band	Electrical in/out interface that receives the analog IF-based downlink 5G signal from the 5G base station, and delivers the analog IF-based uplink 5G signal coming from RAUs, to the 5G base station.
Me-FS	Electrical interface for frequency synchronization signal	Electrical interface that receives the frequency synchronization signal (that propagates towards the RAUs) from the 5G base station or from GPS clock receivers.
Me-TD	Electrical interface for TDD synchronization signal	Electrical interface that receives the TDD (time division duplexing) signal (that propagates towards the RAUs) from the 5G base station.
Me-CM	Electrical interface for system control and management (CM) signal	Electrical in/out interface for the CM signals that are used for monitoring, management and control of the MHU and the (multi-)RAUs connected to the MHU.

5.2.2 RAU

The electrical interfaces of the RAU are marked as Re-RF and Re-CM in Figure 4, which are electrically connected to the millimeter wave antenna operating at the 28 GHz band. Table 3 describes the definitions and functions of the electrical interfaces of the RAU.

Table 3 – Definitions and functions of the electrical interfaces of the RAU

Interface	Definitions	Functions
Re-RF	Electrical interface for 5G signal at RF (mmWave) band	The electrical in/out interface of the RAU that delivers the 5G TDD synchronization signals, etc. at the RF (millimeter wave) band towards the subscriber terminal device via an antenna, and vice versa.
Re-CM	Electrical interface for system control and management (CM) signal	Electrical in/out interface for the CM signal that are used for monitoring, managing and control of the RAU.

5.3 Optical interfaces

5.3.1 MHU

The optical interface of the MHU is marked as Mo-IF in Figure 4, and is optically connected to a single or multiple RAUs through a distribution point. It is defined as an optical interface of a downlink transmission signal transmitted from an MHU to RAUs in a DAS for 5G and an uplink reception signal transmitted from RAUs to a MHU. Table 4 describes the definitions and functions of the MHU's optical interface. Analog IF-based data signal and digital-based auxiliary signals are multiplexed or demultiplexed using CWDM to connect to multiple RAUs.

Table 4 – Definitions and functions of the optical interfaces of the MHU

Interface	Definitions	Functions
Mo-IF	Optical interface for transmission of analog IF-based data signals and digital-based auxiliary signals	Optical interface that transmits analog IF-based data signals (downlink signals) transmitted from a 5G base station and receives analog IF signals (uplink signals) transmitted from RAUs. Optical interface that connects digitized frequency synchronization signal, TDD signal and control and management signal for a DAS using digital sampling technique.

5.3.2 RAU

The optical interface of the RAU is marked as Ro-IF in Figure 4, and is optically connected to the MHU through the distribution point. It is defined as an optical interface of an uplink transmission signal transmitted from RAUs to an MHU and a downlink transmission signal transmitted from an MHU. Table 5 describes the definitions and functions of the optical interface of the RAU. Analog IF-based data signals and digital-based auxiliary signals are multiplexed using CWDM to connect to a MHU.

Table 5 – Definitions and functions of the optical interfaces of the RAU

Interface	Definitions	Functions
Ro-IF	Optical interface for transmission of analog IF-based data signals and digital-based auxiliary signals	Optical interface that receives analog IF-based data signals (downlink signals) transmitted from a 5G base station and transmits analog IF signals (uplink signals) transmitted from RAUs. Optical interface that connects digitized frequency synchronization signal, TDD signal and control and management signal for a DAS using digital sampling technique.

6 Testing

6.1 General

Initial characterization and qualification shall be undertaken when a build standard has been completed and frozen. Qualification maintenance is carried using periodic testing programmes.

Test conditions for all tests unless otherwise stated are 25 °C ± 2 °C.

6.2 Performance testing

Performance testing is undertaken when characterization testing is complete. The performance test plan and recommended performance test failure criteria are specified in Annex A.

7 Environmental specifications

7.1 General safety

All products specified in this document shall conform to IEC 60950-1.

7.2 Laser safety

Fibre optic transmitters and transceivers using the laser diode specified in this document shall be class 1-3R laser certified under any condition of operation. This includes single fault conditions, whether coupled into a fibre or out of an open bore. Fibre optic transmitters and transceivers using the laser diode specified in this document shall be certified to be in conformance with IEC 60825-1.

7.3 Temperature and environment

The measurement should be carried out in a room at a temperature ranging from 5 °C to 35 °C. If the operation temperature ranges of the measurement apparatus are narrower than the above range, the specifications of the measurement apparatus should be followed. It is desirable to control the measurement temperature within ±5 °C in order to suppress the influence of the temperature drift of the measurement apparatus to a minimum. The temperature of the device under test (DUT) can be changed using a temperature controller to verify the temperature dependence of the measured parameters as necessary.

Annex A
(informative)

System performance specifications for radio-over-fibre-based indoor distributed antenna system (DAS) for 5G

A.1 General

System performance specifications describe the performance requirements of the downlink transmitted from the MHU to the RAU and the uplink transmitted from the RAU to the MHU in the DAS.

A.2 Downlink

A.2.1 MHU

The detailed system performance specifications of the MHU for downlink are described in Table A.1.

Table A.1 – System performance specifications of the MHU for downlink

Parameter	Specifications	Unit	Note
Frequency	1,6 ~ 2,4	GHz	
Bandwidth	800	MHz	
Power Level (Input)	−10	dBm	Maximum total power
Input power VSWR	1,5:1		Maximum
Noise floor level	−130	dBm/Hz	Maximum
Gain	0	dB	RF link gain
Gain ripple	±1	dB	Gain flatness
Gain variation with the temperature range 0 °C ~ +60 °C (peak to peak)	±1	dB	
ACLR	45	dBc	Minimum
Wavelength for data signal (analog)	CWDM 16 channel (except for 1 270 nm and 1 330 nm) can be selected for downlink	nm	
Wavelength for auxiliary signal (digitized signal for FS, TDD, etc...)	1 270	nm	CWDM wavelength
Allowable maximum optical link loss	10	dB	
Maximum fibre distance between MHU and RAU	2	km	
Output optical power	+6	dBm	Maximum

A.2.2 RAU

The detailed system performance specifications of the RAU for downlink are described in Table A.2.

Table A.2 – System performance specifications of the RAU for downlink

Parameter	Specifications	Unit	Note
Frequency	1,6 ~ 2,4	GHz	
Bandwidth	800	MHz	
Power Level (output)	−10	dBm	Maximum total power
Output power VSWR	1,5:1		Maximum
Noise floor level	−130	dBm/Hz	Maximum
Gain	0	dB	RF link gain
Gain ripple	±1	dB	Gain flatness
Gain variation with the temperature range 0 °C ~ +60 °C (peak to peak)	±1	dB	
ACLR	45	dBc	Minimum
Wavelength for data signal (analog)	CWDM 16 channel (except for 1 270 nm and 1 330 nm) can be selected for downlink	nm	
Wavelength for auxiliary signal (digitized signal for FS, TDD, etc…)	1 270	nm	CWDM wavelength
Allowable maximum optical link loss	10	dB	
Maximum fibre distance between MHU and RAU	2	km	
Input optical power	−4	dBm	Maximum

A.3 Uplink

A.3.1 MHU

The detailed system performance specifications of the MHU for uplink are described in Table A.3.

Table A.3 – System performance specifications of the MHU for uplink

Parameter	Specifications	Unit	Note
Frequency	1,6 ~ 2,4	GHz	
Bandwidth	800	MHz	
Power Level (output)	−10	dBm	Maximum total power
Output power VSWR	1,5:1		Maximum
Noise floor level	−130	dBm/Hz	Maximum
Gain	0	dB	RF link gain
Gain ripple	±1	dB	Gain flatness
Gain variation with the temperature range 0 °C ~ +60 °C (peak to peak)	±1	dB	
ACLR	45	dBc	Minimum
Wavelength for data signal (analog)	CWDM 16 channel (except for 1 270 nm, 1 330 nm and downlink wavelength) can be selected for downlink	nm	Uplink wavelength is different from all connected RAUs
Wavelength for auxiliary signal (digitized signal for FS, TDD, etc…)	1 330	nm	CWDM wavelength
Allowable maximum optical link loss	10	dB	
Maximum fibre distance between MHU and RAU	2	km	
Input optical power	−4	dBm	Maximum