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TECHNICAL REPORT

colour inside

Transmitting equipment for radiocommunication – Radio-over-fibre technologies and their performance standard – Part 1: System applications of radio over fibre technology

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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

Part 1: System applications of radio over fibre technology

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IEC TR 63098-1, 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
103/153/DTR	103/168/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.

A list of all parts in the IEC 63098 series, published under the general title *Transmitting equipment for radiocommunication*, can be found on the IEC website.

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- withdrawn,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
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

Using radio-over-fibre technology, RF modulated optical carriers and signals can be transmitted in optical fibre with very low loss. Fundamentally, radio-over-fibre (RoF) is an analogue transmission system that allows radio frequency signals to be transmitted and processed without being digitized. Remote antenna systems including distributed antenna system (DAS) which use RoF technology in terrestrial broadcasting and mobile communications have also become established infrastructures.

In terrestrial broadcasting, the conventional microwave links for studio-transmitter links (STLs), transmitter-studio links (TSLs), transmitter-transmitter links (TTLs) and field pickup units (FPUs) have been replaced by RoF systems, particularly in Japan.

RoF technology is a promising technology for broadband access networks combined with the mobility and the flexibility of wireless access. An advantage of RoF technology is multiplexing of RF signals. Multiple RF signals can be converged on the physical layer and they are transmitted to the remote site transparently. RoF technology can also be used for multiplexed transmission that supports CATV (cable television) trunk line systems, cellular phone systems, etc. for blind spots, such as inside buildings, underground areas and subways. RoF systems are also used in digital signage systems and rapid and agile deployment of broadcasting and communication services.

This document provides information on the current and latest applications of radio-over-fibre technology, which are already implemented or will be in the near future. This document will also be beneficial to system developers and system users in the fields of mobile communications and optical fibre technologies.

An example of the technical specification of a radio over fibre (RoF) link in accordance with the spectral emission standard for digital terrestrial television broadcasting in Japan is given in Annex A.

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

Part 1: System applications of radio over fibre technology

1 Scope

The purpose of this document is to provide information on the current and latest applications of radio-over-fibre technology. Wireless communication, broadcasting, and airport multilateration systems, which are already implemented or will be in the near future, are introduced. This document includes the basic concept, a brief outline and related standards of the applications of RoF technology.

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

AGC	automatic gain control
CATV	cable television
DAS	distributed antenna system
FPU	field pickup unit, equivalent to microwave link
STL	studio-transmitter link
TSL	transmitter-studio link
TTL	transmitter-transmitter link
TIA	transimpedance amplifier
LNA	low noise amplifier

NF	noise figure
MZ	Mach-Zehnder
BTS	base transceiver station
E/O	electric to optical
O/E	optical to electric
W-CDMA	wideband code division multiple access
LTE	long term evolution
C-RAN	centralized-radio access network
MOF	multi drop optical feeder
DSP	digital signal processing
SCM	sub-carrier multiplexing
RoF	radio over fibre
DRoF	digital radio over fibre
TX	transmitter
RX	receiver
DTTB	digital terrestrial television broadcasting

4 Advantages and disadvantages of RoF

Advantages of RoF are:

- low attenuation,
- low complexity,
- lower cost.

RoF is an analogue transmission system that allows radio frequency signals to be transmitted and processed without being digitized. RF modulated optical carriers and signals can be transmitted in optical fibre with very low propagation loss. By modulating and demodulating the optical signals at the sending and receiving ends of the optical fibre, the optical fibre operates as a low-loss, high-frequency analogue RF transmission medium. RoF technology is more efficient, less complex, and less costly than conventional electronic systems, especially at high microwave and millimetre wave frequencies.

Disadvantages of RoF are:

- dynamic range,
- intermodulation distortion,

- chromatic dispersion.

Basically, the RoF technology is an analogue transmission system and analogue modulation is required. Therefore, the transmission issues that are serious in analogue communication systems are present in RoF systems as well.

The dynamic range of a system is one of the practical issues of the system tolerance when the received power varies. Generally, the dynamic range of RoF systems is limited by optical device parameters such as relative intensity noise and shot noise.

The RoF link system inherently suffers from intermodulation distortions arising from the nonlinearity of both microwave (driver amplifier, transimpedance amplifier [TIA], low-noise amplifier [LNA]) and optical (E/O converter: optical modulator, O/E converter: photodetector) components. A large modulation index introduces more intermodulation. The system should be designed by considering the device features. In particular, adjusting of modulation index, optical power and gain are critical parameters for the optimization of the optical link design. A Mach-Zehnder (MZ) modulator is suitable for broadband signal transmission; however, the transfer curve of an MZ modulator is inherently nonlinear.

Noise figure (NF), optical signal gain and second intermodulation distortions are strongly dependent on the bias condition of the MZ modulator and have trade-off relationships. Stable bias control of an optical modulator is also a technical issue when a Mach-Zehnder intensity modulator is used. Fine-tuned integration of individual devices and circuits is required for an optimal overall performance.

5 Practical applications

5.1 List of applications

Table 1 shows application examples using RoF technology. RoF systems have been utilized in many fields such as broadcasting systems, mobile communication systems and railway systems. In recent years, RoF technology has been applied for the development of an aircraft multilateration systems and train communication systems.

Table 1 – Application examples

Mobile communication system	Broadcasting system	Airport system	Train communication system
• Mobile communication underground service system • In-building mobile enhancement system • Remote radio head See 5.2	• Digital terrestrial • Television broadcasting • Repeating system • Microwave link (ENG) See 5.3	• Multilateration system See 5.4 • Foreign object and debris detection radar system	• Millimetre-wave fronthaul and backhaul
Key ENG: electronic news gathering			

5.2 Mobile communication system

5.2.1 General

RoF systems have been used in mobile communications for an economical and speedy area expansion and area construction in a covered space such as an underground shopping mall and tunnels.