

RECOMMENDATION ITU-R F.1332-1*

RADIO-FREQUENCY SIGNAL TRANSPORT THROUGH OPTICAL FIBRES

(Question ITU-R 204/9)

(1997-1999)

The ITU Radiocommunication Assembly,

considering

- a) that optical fibres are widely used in subscriber networks or in-building wiring;
- b) that radio-frequency signal transport through optical fibres may be applied to access links to radio base stations in many wireless applications;
- c) that by using a HFR (see Annex 1, § 2 for acronyms) system the following advantages are expected:
 - intensive deployment of modulators and demodulators and other functional equipment in an optical line termination in front of an optical feeder system contributes to simplification of equipment in remote antenna units as well as to maintenance and operation cost reduction;
 - efficient use of spectral bandwidth available on the radio link;
- d) that the reduction of equipment at the radio base station is realized by the above technique;
- e) that the above technique has advantages in maintenance and operation aspects,

recommends

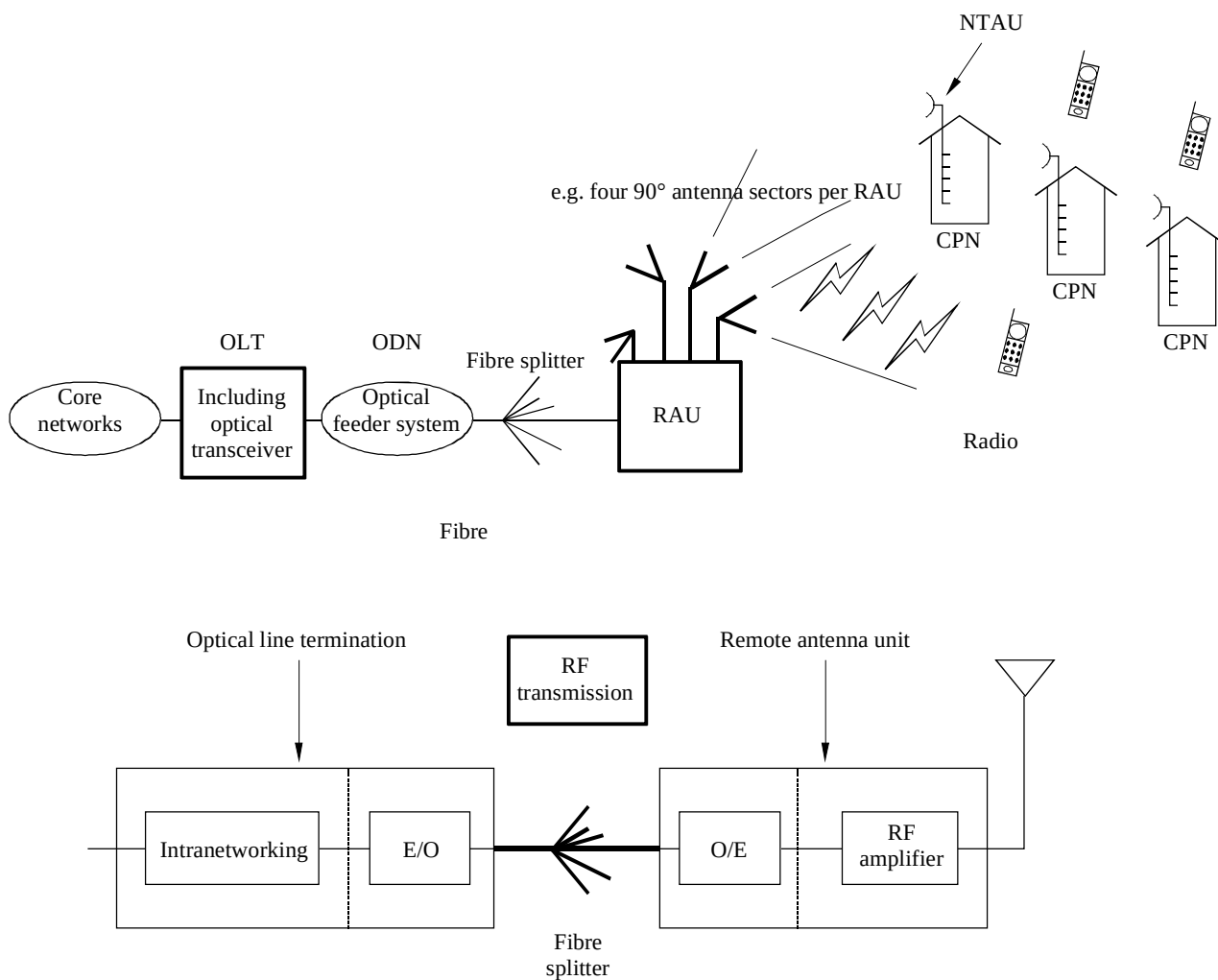
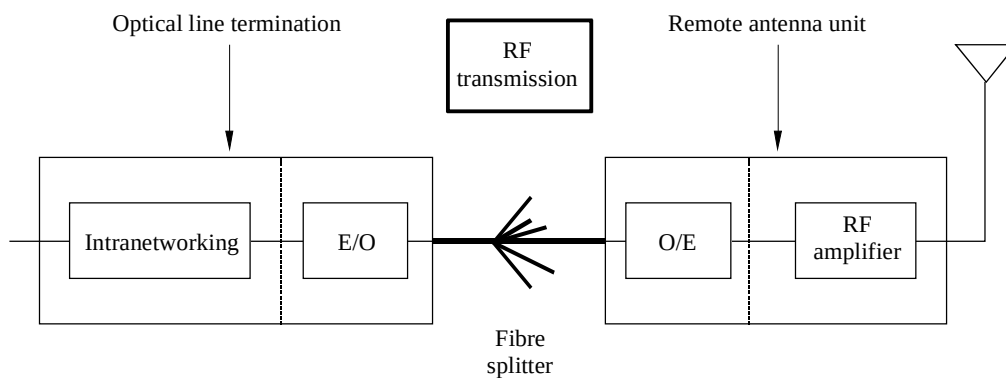
- 1 that Fig. 1 should be referred to for the basic configuration of a HFR system in which radio-frequency signals are transported directly through optical fibres;
- 2 that Table 1 should be referred to for possible applications to the fixed service using a HFR system;
- 3 that when using high-frequency bands above about 10 GHz, the centre frequency of a modulator may be selected to be in intermediate-frequency bands;
- 4 that Fig. 2 should be referred to for the reference configuration of a HFR system between service nodes and customer premises networks. This is in agreement with the reference configuration for optical access networks in ITU-T Recommendation G.983. To support system interoperability the HFR access link is defined between the reference points V and T or between service node interface and user network interface, and comprises the following functional blocks:
 - optical line termination, optical distribution network and remote antenna unit (Part 1) in the optical distribution segment; and
 - remote antenna unit (Part 2), drop medium radio and network termination antenna unit in the drop segment.

To enable transverse system compatibility (mid-span meet) additional reference points (interfaces) within the HFR access link are recommended:

- optical reference points: O_1 between optical line termination and optical distribution network, O_r between optical distribution network and remote antenna unit (according to ITU-T Recommendation G.982);
 - radio reference points: R_1 between remote antenna unit and drop medium radio, R_2 between drop medium radio and network termination antenna unit;
- 5 that for the design of HFR systems the technical information contained in the Annex 1 should be referred to for additional guidance in the application of this Recommendation.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 8 (Working Party 8A) and Telecommunication Standardization Study Group 15 (Working Party 4/15).

FIGURE 1
Basic configuration of HFR system



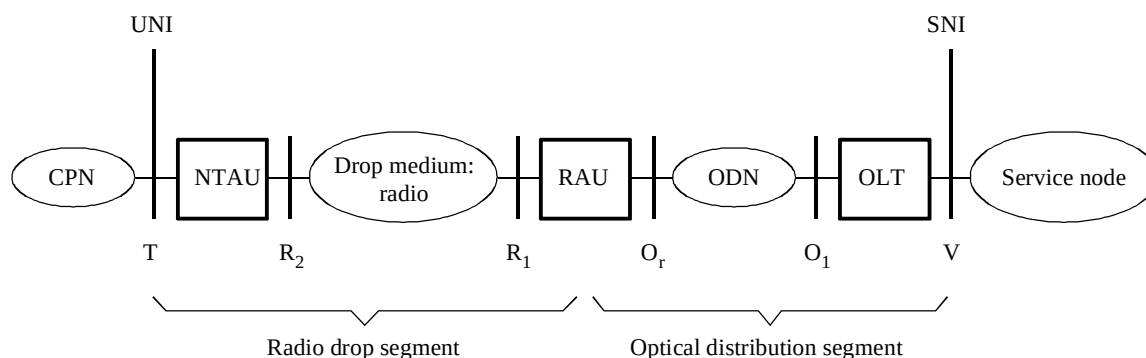
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TABLE 1
Possible applications for the fixed service using HFR systems

Service area	Indoor	Outdoor	
Application	RLAN	FWA	Transportable service
User's terminal	LAN module	Cellular system terminal for fixed use, point-to-point/point-to-multipoint fixed terminal	Transportable video/data/voice terminal
Possible RF ⁽¹⁾	UHF/SHF/EHF	UHF/SHF/EHF	SHF/EHF
Access scheme in the radio link	TDMA/CDMA/FDMA	TDMA/CDMA/FDMA	TDMA/CDMA/FDMA

⁽¹⁾ UHF (decimetric waves): 300-3 000 MHz
SHF (centimetric waves): 3-30 GHz
EHF (millimetric waves): above 30 GHz

FIGURE 2
Reference configuration of HFR access link



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ANNEX 1

1 Introduction

For future broadband (interactive) services optical fibres will be extensively introduced in subscriber networks realizing the concept of what is called FTTC, FTTO or FTTH. On the other hand, customers may wish to use various services provided by different core networks also in wireless applications due to increasing demand and competition, lack of available bandwidth or fast and cost effective deployment. These applications include FWA, transportable data/video voice terminals or transportable personal computers used for RLAN modules. In order to satisfy these demands, it will be effective to introduce HFR systems in which radio-frequency signals are transmitted directly through optical fibres.

This Annex discusses the basic concept and technical basis of HFR systems.

2 Acronyms

AGC	Automatic gain control
CDMA	Code division multiple access
C/N	Carrier-to-noise-ratio
CPN	Customer premises network
E/O	Electric-to-optic conversion
FDMA	Frequency division multiple access
FM	Frequency modulation
FTTC	Fibre to the curb
FTTH	Fibre to the home
FTTO	Fibre to the office

FWA	Fixed wireless access
HFR	Hybrid fibre radio
IF	Intermediate-frequency
IM	Inter-modulation
LAN	Local area network
LD	Laser diode
NTAU	Network termination antenna unit
ODN	Optical distribution network
O/E	Optic-to-electric conversion
OLT	Optical line termination
RAU	Remote antenna unit
RF	Radio-frequency
RLAN	Radio local area network
SCM	Subcarrier multiplex
SEFA	Signal extraction and frequency arrangement
SLC	Signal level compression
SNI	Service node interface
TDD	Time division duplex
TDMA	Time division multiple access
UNI	User network interface

3 Basic configuration of HFR systems

As shown in Figs. 1 and 2 a HFR system is composed of OLT, ODN, RAU, NTAU and fibre/radio links connecting these stations. It can form an infrastructure for access networks providing wireless services to customer premises network which may include many different terminals.

In conventional digital radio equipment, a modulator/demodulator and a power amplifier are generally installed at the same station. However, in HFR systems OLT and RAU comprise many intranetworking functions which are commonly used for more than one RAU (see Fig. 1) depending on the splitting factor of the ODN. Examples for these intranetworking functions are: modulation/demodulation, multiplexing/demultiplexing, control functions and error correction functions the latter of which are mainly necessary because of the worse transmission performance (compared to optical fibre transmission) of the radio link. The system presented in Fig. 1 requires a multiple access technique to cope with upstream traffic demands from many customer terminals. OLT also has a function to control the access technique efficiently utilizing the frequency spectrum. In such cases, the relation between OLT and RAU corresponds to that of point-to-multipoint radio systems for subscriber networks. If radio-frequency signals are already optically transported over the ODN all these functions are located at OLT and the RAUs connected to one OLT are kept small and simple (see lower part of Fig. 1).

However, there is a technical upper limit for the radio frequency to be transmitted through optical fibres due to the operating speed of the E/O (and O/E). When a cost-effective E/O (and O/E) is required to implement HFR systems, an IF transmission could be suitable since the cost effective E/O (and O/E) operates within the IF bands. After being transmitted over the optical fibre link, the IF carriers are converted into radio frequencies at the remote antenna unit (see Fig. 3).