RECOMMENDATION ITU-R F.1761

Characteristics of HF fixed radiocommunication systems

(Question ITU-R 158/9)

(2006)

Scope

This Recommendation specifies the typical RF characteristics of fixed radiocommunication systems in the 2-30 MHz range.

The ITU Radiocommunication Assembly,

considering

a) the use of fixed and mobile service HF radio communications is a common denominator in achieving interoperable radio communications in multinational efforts;

b) there are two types of categories of systems in this band – adaptive and non-adaptive;

c) that the efficiency of spectrum use in the MF and HF bands shared by the fixed and the mobile services could be improved by the use of frequency adaptive systems in some cases;

d) that trials of frequency adaptive systems which have been undertaken during the past 20 years have demonstrated the feasibility of such systems and their improved spectrum efficiency compared to operator managed systems;

e) that such improved efficiency is attained through:

– shorter call set-up and improved transmission quality by selection of the most suitable assigned channels;

– reduced channel occupancy, permitting the same channels to be used by different networks, yet decreasing the probability of harmful interference;

– minimization of the transmitter power required for each transmission;

– continued optimization of the emissions owing to the sophistication of the systems;

– limited simultaneous use of frequencies to the minimum necessary for communication requirements,

noting

a) that additional information on the technical and operational characteristics of HF fixed systems can be found in Report ITU-R F.2061,

recommends

1 that the technical and operational characteristics of adaptive and non-adaptive systems described in Annex 1 may be used in sharing studies when operating between 2-30 MHz.

Annex 1

Characteristics of HF fixed radiocommunication systems

1 Introduction

HF systems have specific attributes that make them a viable solution for many communications requirements. They provide a highly versatile means of communications to a broad base of users and the reliable and inexpensive equipment can be easily transported to remote and lightly populated areas.

2 Non-adaptive systems

Non-adaptive HF fixed systems are traditional radio systems which require a radio operator to manually establish frequencies. The operator must adjust the parameters of the system for maximum performance by monitoring the conditions of the ionosphere, tracking the variable propagation conditions, and selecting the operating conditions (i.e. primarily the frequency) that will allow the signal to propagate best.

There is extreme variability and unpredictability, in the short term, of the HF propagation environment. Propagation in this band is primarily by the sky-wave mode, utilizing refraction of radio waves from the ionosphere, or in some cases by the surface-wave mode.

3 Adaptive systems

An adaptive MF/HF system is one which automatically (i.e. without the need for intervention by a radio operator) carries out the functions of establishing radiocommunications links and exchanging of information in a manner that copes with the variations and the high probability of interference inherent to MF/HF frequency bands propagating through the ionosphere. In addition, adaptive systems are able to monitor spectrum occupancy in a regular manner, and select operating frequencies so as to avoid causing interference to other users more effectively than many non-adaptive systems now in operation.

4 Technical characteristics

Figure 1 and Tables 1 to 4 contain technical characteristics of representative systems. This information is sufficient for general calculation to assess the compatibility between these systems and systems operating in other services. Required *S*/*N* ratio and protection criteria are stated in Recommendations ITU-R F.339 and ITU-R F.240 and should be used in compatibility studies between adaptive systems and other systems.

Figure 1 indicates SNR requirements to achieve 10^{-4} bit error ratio (BER) in a fading channel for the range of data rates currently used in HF data services. These values were derived from measurements of commercial serial-tone modems, and are intended to represent "typical" performance rather than the best available performance.

Figure 1 can be used to determine protection criteria for various services:

– Digital voice technology (for example, MELP) offers a tradeoff in voice quality versus data rate. State-of-the-art voice systems provide excellent voice quality when operating at 2 400 bit/s, but can operate with reduced voice quality at 1 200 and even 600 bit/s.

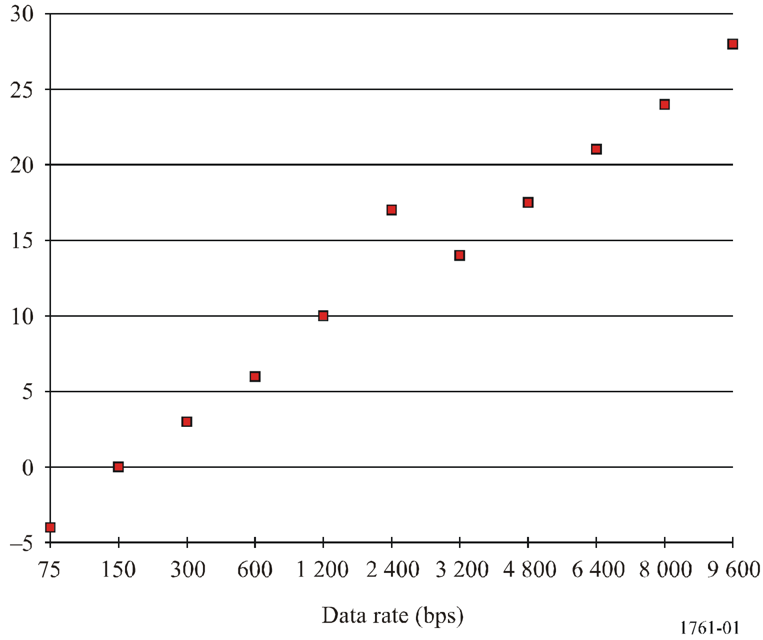
– Data broadcasts generally operate at a fixed data rate (for example 600 bit/s).

– IP over HF operation operates at a fixed data rate in some networks (for example 6 400 or 8 000 bit/s), while fully adaptive networks continually adjust data rates in response to instantaneous channel conditions. In the latter case, some traffic must be discarded when interference causes reductions in data rate, leading to buffer overflows.

FIGURE 1

Example SNR for 1 × 10^{-4} BER in fading channel*, **

SNR (dB) vs. data rate (bit/s)



* Two independent equal average power Rayleigh fading paths, with a fixed 2 ms delay between paths, with 1 Hz fading.

** Technology for data rates for 2 400 bit/s and below predates technology for higher data rates.

TABLE 1

Example technical characteristics of fixed systems in the 2-30 MHz band

Frequency band (MHz)	2-30
Type of emission	Analogue/digital
System	
Channel bandwidth (kHz)	2-6
Modulation type	Single channel suppressed carrier, telephony and telegraphy
Type of operation	Simplex/duplex
Type of deployment	Star network
Typical data rates	2.4-9.6 kbit/s
Typical SINAD	12 dB (voice only)

TABLE 1 (*end*)

Transmitter	
Tx power (dBW)	22
Path length (km)	2 400
Antenna gain (dBi)	6
Antenna height (m) (Relative to ground level)	10-60
Radiation pattern	Omnidirectional/directional
Antenna polarization	Vertical/horizontal
Total loss (dB)	1
Receiver	
IF filter bandwidth (kHz)	3-7
Sensitivity (dBm)	–112
Antenna gain (dBd)	6
Antenna pattern	Omnidirectional/directional (30° beamwidth)

TABLE 2

Analogue (voice single sideband)

Audio output *S*/*N* (dB)	**AWGN (dB)**	**Fading (dB)**
6	48	48
15	57	62
33	65	73

NOTE – Figures in AWGN and fading columns of this Table represent the ratio of signal peak envelope power to the average noise power in a 1 Hz bandwidth.

TABLE 3

Digital (Data)

Modulation	**AWGN channel (dB)**	**Fading (dB)**
64-QAM	21	30
8-PSK	13	20

NOTE – The carrier power to the average noise power in a 3 kHz bandwidth for probability of bit error 1.0×10^{-4} AWGN non-fading stable channel condition.

TABLE 4

Example technical characteristics of adaptive fixed systems in the 2-30 MHz band

Parameter			
Mode of operation	NVIS (near vertical)	Groundwave	Skywave (oblique)
Frequency band (MHz)	2-10	3-30	3-30
Necessary bandwidth (kHz)(1)	3	3	3
Transmitter power (dBW)	10-26	0-26	10-40
Transmit attack time delay (ms)(2)	25	25	25
Transmit release time delay (ms)(3)	10	10	10
Receive AGC attack time delay (ms) Voice Data	30 10	30 10	30 10
Receive AGC release time delay (ms) Voice Data	900-1 200 35	900-1 200 35	900-1 200 35
Signal-to-noise ratio (dB) High-speed data Analogue voice Digital voice	24 21 8	18 15 3	24 21 8
Transmitting antenna gain (dBi)	0-6	0-3	6-15
Maximum e.i.r.p. (dBW)	10-32	0-29	16-55
Antenna polarization	Horizontal	Vertical	Vertical/ horizontal

(1) Channel banding can provide a 12 kHz bandwidth.

(2) Attack-time delay. The time interval from keying-on a transmitter until the transmitted RF signal amplitude has increased to 90% of its steady-state value. This delay excludes any necessary time for automatic antenna tuning.

(3) Release-time delay. The time interval from keying-off a transmitter until the transmitted RF signal amplitude has decreased to 10% of its steady-state value.