RECOMMENDATION ITU-R SM.1266-0*, **

ADAPTIVE MF/HF SYSTEMS

(1997)

Scope

This Recommendation provides guidance for the adaptive MF/HF systems considering technical benefits of the systems and regulatory aspect of the systems.

Keywords

Adaptive MF/HF systems, digital signal processing, regulatory environment

The ITU Radiocommunication Assembly,

considering

a) that in recent years adaptive MF/HF systems have been developed which automatically select the optimum channel from a predetermined group of channels;

b) that frequencies in the MF/HF bands are heavily used;

c) that World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum (Malaga-Torremolinos, 1992) (WARC-92) allocated more spectrum to the HF broadcasting service while reducing spectrum available for fixed and mobile services, necessitating better use of frequencies allocated to these services;

d) that, in the MF/HF bands, voice traffic is increasingly being replaced by data traffic, which tends to require a high quality channel for short periods;

e) that use of adaptive systems, which release a radio channel when they have no traffic, will improve spectrum efficiency by allowance for frequency sharing;

f) that the use of adaptive systems, which monitor the propagation conditions in real time and release the channel to other users under time-varying propagation conditions, will increase spectrum efficiency;

g) that although current Radio Regulations (RR) do not preclude operation of adaptive MF/HF systems, all the advantages associated with existing and planned adaptive MF/HF systems may be enhanced by a more flexible regulatory environment, a matter requiring the completion of ongoing studies and simulations,

recognizing

a) that the advantages of adaptive MF/HF systems will increase with access to an increasing number of channels,

recommends

1 that administrations encourage the use of adaptive systems;

2 that the information concerning adaptive systems, as given in Annex 1, should be considered when planning new MF/HF communication systems and when proposing modifications to the regulatory and licensing policies for new MF/HF communication systems;

3 that administrations continue to apply current spectrum management procedures in the MF/HF spectrum, but more flexible approaches should be considered based upon the outcome of studies mentioned in § g).

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* This Recommendation should be brought to the attention of Radiocommunication Study Groups 4 and 5.

** Radiocommunication Study Group 1 made editorial amendments to this Recommendation in the years 2018 and 2019 in accordance with Resolution ITU-R 1

ANNEX 1

Adaptive MF/HF systems

1 Adaptive MF/HF technologies

1.1 Introduction

The advent of new component technology, digital signal processing (DSP), and automation has led to the re-examination of system concepts which have been employed in MF and HF systems. MF/HF radiocommunications are subject to a wide array of channel variabilities, including well-known temporal and spatial variations in the propagation characteristics, and time-varying changes in the noise and interference environment, many of these variations being unpredictable. The human operator, schooled in the nature of propagation variability, has had to make critical decisions regarding the appropriate use of authorized frequencies at any given time, often with the aid of a static prediction model.

Engineering solutions have been developed to relieve the operator of much of this burden, taking the variability of propagation conditions into account. These solutions include: adaptive equalization of the channel, adaptive rate of data transmission, adaptive power management, and adaptive application of propagation paths and other resources based upon real-time sounding or channel probing. Though a number of systems using different approaches have been developed and placed in operation by administrations for government and commercial purposes, all of the systems have one thing in common. They are responsive to the time-varying changes in the MF/HF propagation channel, including signal, noise and interference. Below are some considerations that help define the concept of adaptive MF/HF systems.

1.2 Properties of adaptive MF/HF systems

An adaptive system utilizes real-time information about the channel environment and its variations and compensates to optimize performance and such systems match equipment parameters to existing channel conditions in a manner which is both efficient and optimal. Since the environmental state varies with time, the system must update the matching process periodically or even continuously. The update rate is ultimately dependent upon the sensitivity of performance to parameter change. A variety of Real-Time Channel-Evaluation (RTCE) methods are employed by adaptive MF/HF systems.

The types of adaptation used in MF/HF systems depend upon the communication level: transmission, link, network, or system. The attributes associated with each level are shown in Table 1. RTCE methods may be employed and exploited at all levels to facilitate the specified attributes. The most common form of RTCE resides at the link level.

The lower levels of adaptivity may involve various signal processing schemes such as channel equalization, methods which may be made adaptive through use of sounding or more efficient methods for learning the channel. Other low-level schemes include methods involving feedback of signal quality or bit error rate. At higher levels of adaptivity, there is a need to make decisions regarding the communication network, and issues such as frequency sharing and frequency reuse become important.

A fully adaptive MF/HF system typically operates under computer control of most functions, and is capable of automatically establishing and maintaining systemwide operation by immediate response to time-varying changes in the total environment including: system propagation factors, external noise, channel occupancy, and interference conditions.

Some adaptive MF/HF systems may automatically adjust only a subset of the above factors. The most common form of adaptation is frequency selection for performance optimization at the link level. Such systems may be referred to as frequency-adaptive. However, additional forms incorporating RTCE methods are not uncommon at the transmission, network, and system-wide levels. Descriptions of the various adaptive techniques are presented in Recommendation ITU-R F.1110.

TABLE 1

Adaptivity attributes

Transmission	
1	Data rate
2	Coding scheme
3	Transmitting power
4	Antenna pattern
5	Modulation method
Link	
1	Frequency management
2	RTCE (sounding, link quality analysis, etc.)
3	Frequency agility
Network	
1	Routing and flow control
2	Protocol handling
3	Data exchange
4	Network reorganization
System	
1	Resource management
2	Multimedia options
3	Bridge to isolated nodes

Adaptive MF/HF systems may use a number of methods which make it easier to select the best channel for use from among a group of predetermined frequencies. These methods may include passive measures such as spectrum monitoring, active measures such as in-band channel sounding, or frequency modulated continuous wave swept-frequency sounding.

National administrations authorize domestic use of these systems without conflict with the RR. Worldwide use of adaptive systems can be developed by system operators or users coordinating frequency assignments with administrations concerned. However the regulatory and procedural regimes to enable worldwide or regional use are rather arduous.

1.3 Technology benefits

There are significant benefits to the exploitation of adaptivity in the operation of families of MF/HF systems. The ability to adapt to the environment enables a system an opportunity to develop optimum communication capability. Adaptive systems offer specific advantages in ease of operation, improved performance with decreased potential for interference, spectrum efficiency, and some cost savings.

Some adaptive systems have the capability to monitor the channel prior to utilization and to assess the channel quality on a periodic basis using both active and passive procedures. This capability enables the adaptive system to avoid the use of channels which have limited utility and it also reduces the probability of interference to other users of the spectrum, including some adaptive and non-adaptive systems.

The ability to quickly and accurately select the optimum channel or other optimum parameters offers significant advantages over traditional MF/HF technology. This computerized technology not only relieves the operator from performing these functions decreasing skill requirements but performs the functions more quickly and offers the opportunity to real-time updating. In view of the temporal and spatial variation of the HF channel, including the nature of signal and noise, any given frequency will present varying degrees of efficiency for a specified quality of service. Moreover, there may be conditions such that service is impossible at a specific frequency or a set of frequencies. Selection of optimum parameters may be a critical communication requirement, especially in the presence of large propagation disturbances.

In rapidly selecting and regularly updating optimum operating parameters, adaptive MF/HF systems decrease the potential for interference. For example, the adaptive selection the most appropriate frequency of operation at any given instant, and the adaptive utilization of the minimum power required to complete a link, will minimize the probability for interference conflicts with other users. At the same time, this selection process maintains the operating performance level. Adaptive HF systems can provide more efficient methods for exploiting the channels for operation, so that channels exhibiting significant multipath and Doppler spreads may no longer be regarded as poor for certain levels of service. In the face of a varying environment, traditional technologies are faced with fluctuating performance. The operator's alternative before adaptive systems has been to select parameters which depart from the instantaneous optimum.

The use of adaptive systems will promote efficient use of the MF/HF spectrum. In the past, many fixed users have run continuous tapes or keying to keep frequency assignments clear. Some monitoring observations have indicated that nearly 50% of the HF fixed service bands are used in this way. This activity is inefficient. Adaptive systems cycle through their frequency assignments and use channels which are not occupied and do not occupy channels unnecessarily. Because adaptive systems currently have the flexibility to use all of the unplanned bands they make efficient use of the spectrum by using unoccupied frequencies and allow existing users to continue their current use.

Though adaptive systems may cost more than traditional technology, they provide significant opportunities for decreasing operating costs. For example, adaptive systems circumvent the need for experienced operators, and enable a wide class of HF radios, of varying complexity, to link-up and interoperate on a common level. Also, some adaptive systems use adaptive power management which can reduce the financial burden associated with high power transmitters.

2 Implications on:

2.1 Regulation

The World Radiocommunication Conference (Geneva, 1995) in its Resolution 23 (WRC-95) "Provisions Applicable to the Frequency Assignments in the Non-planned Bands Below 28 000 kHz" addressed the suppression of provisions in the RR relating to the examination of frequency assignments in those bands. Resolution No. 23 resolved that the Radiocommunication Bureau (BR) shall not examine or apply the provisions related to the probability of harmful interference. This decision means that there is now no check as to whether a proposed assignment may cause interference, and proposals to introduce new frequency assignments are not now given any guidance by the BR as to whether the assignment should be able to operate without causing interference. Other actions of WRC-95 suppressed the categories of Class of Operation A, B and C.

Although current frequency management procedures allow for the use of adaptive MF/HF systems, more flexible approaches are expected to lead to enhanced utilization of these technologies along with improved spectrum efficiency.

2.2 Licensing

The current regulations permit administrations to license adaptive MF/HF systems. Transborder or worldwide licensing can be accomplished in accordance with RR Article 24 (S18). More flexibility in the use of adaptive MF/HF systems will not eliminate licensing requirements.

3 Summary

Adaptive techniques developed for MF/HF use offer many advantages over older technology. Adaptive systems currently operate on many of the MF/HF channels alongside non-adaptive systems and some benefits of adaptive systems have already begun to be realized.

There are no significant barriers to use of adaptive technology, but it is recognized that the current regulatory environment may inhibit the fullest exploitation of the technology. Therefore ongoing studies and simulations addressing this issue should be continued. Administrations can make domestic provisions for the use of adaptive technologies recognizing the propagation characteristics in the MF/HF spectrum. Regional or worldwide use can be coordinated with other administrations under existing provisions of the RR.

However, although current RR do not preclude operation of adaptive MF/HF systems, all the advantages associated with existing and planned adaptive MF/HF systems may be enhanced by a more flexible regulatory environment, a matter requiring the completion of ongoing studies and simulations.

Additional study is required to formulate the best regulatory approach for managing use of adaptive and non-adaptive systems. Further studies should include an examination of existing and projected adaptive systems, interoperability considerations, and frequency sharing potential and other factors which will permit wider geographic use of adaptive systems. It is anticipated that as the use of adaptive technology becomes more widespread, adaptive MF/HF systems will replace the current technology and thus allow for more efficient use of the spectrum.