

RECOMMENDATION ITU-R F.1821

**Characteristics of advanced digital high frequency (HF)
radiocommunication systems**

(Question ITU-R 147/9)

(2007)

Scope

This Recommendation specifies the typical RF characteristics of advanced digital HF systems for use in sharing studies for two types of emerging advanced digital HF systems, token passing protocols and wideband modems. Wideband modems are further subdivided into two major systems, multichannel operations and Digital Radio Mondiale operations. A table of characteristics within the Annex to this Recommendation provides a summary of the values needed for sharing studies.

Acronyms

DRM	Digital Radio Mondiale
HFTP	HF token passing
HFWAN	High frequency WAN
ISB	Independent sideband
LSB	Lower sideband
NVIS	Near vertical incidence skywave
OFDM	Orthogonal frequency division multiplex
PSK	Phase-shift keying
QAM	Quadrature amplitude modulation
USB	Upper sideband
WAN	Wide area network
WTRP	Wireless token ring protocol

The ITU-R Radiocommunication Assembly,

considering

- a) that there is an increasing use of the spectrum in the HF bands by advanced digital systems;
- b) that such advanced systems are not standardized and may have different operational technical characteristics;
- c) that the lack of uniformity, in the arrangement and designation of the channels in multichannel transmitters for long-range circuits operating on frequencies below about 30 MHz, may give rise to certain difficulties when one transmitting station has to work with several receiving stations,

recommends

1 that the technical and operational characteristics of advanced digital HF systems described in Annex 1 should be considered representative of those systems operating in the HF frequency bands up to 30 MHz for use in sharing studies.

Annex 1

1 Introduction

HF systems have specific attributes that make them a viable solution for many radiocommunication requirements. They provide a highly versatile means of radiocommunications to a broad base of users and such equipment can be easily transported to remote and lightly populated areas. There are two technologies that are examples of advanced digital HF systems. This Recommendation specifies the characteristics of these types of systems.

For the purpose of this Recommendation spectrum efficiency is defined as an objective with two parts. The first is to achieve maximum throughput (bits/Hertz/s) and the second is to maximize the number of users, per frequency net. These objectives maximize the ability of fixed communications to achieve performance and mission goals.

2 Token passing protocols

Robust token management schemes are conducive for sharing data channels in HF networks where packet loss rates can be driven to extreme levels due to unforeseen variations in propagation. Network performance can be seriously degraded if nodes are out of contact. Data rates are degraded under these circumstances. Propagation perturbations can reduce efficiency in spectrum usage by HF networks.

Token passing can provide efficient medium access control in heavily loaded networks. However, it has been perceived to be too fragile for use in networks with non-negligible packet loss rates. In this Recommendation, a token management approach is presented that quickly recovers from common token loss and duplication scenarios, and deals efficiently with changes in network connectivity and membership.

Token passing protocols generally provide mechanisms for nodes to enter and leave the network. When token passing is to be used in a WAN, the characteristics of the wireless medium introduces additional token management issues:

- The node holding the token may lose connectivity to its successor, which can result in a lost token.
- The node holding the token can lose connectivity to the rest of the network. The network loses the token.
- A network may become partitioned. One subnetwork must create a new token.
- A node may be reachable only by one other node, so a ring topology is not possible if that node is to be included.

- Nodes from two or more rings using the same channel may come within range of each other. This results in interference unless the rings merge or change channel(s).
- Merging of rings or recovery from a lost token may result in multiple tokens in a ring.

The approach to recovery from connectivity problems places nodes that are not members of an active token-passing ring into a disconnected or floating state in which they either wait to be invited to join the remaining ring or periodically solicit other connected nodes to join with them.

The long link turnarounds inherent in fielded HFWAN technology result in token rotation times on the order of a minute. For example, if link turnaround times are 2 s and we allow each of N nodes to transmit for up to 8 s when it receives the token, we achieve a throughput efficiency of at most 80% with a token rotation time (latency) of up to $10N$ s.

If we limit solicitations to join the ring to one per token rotation, and rotate the authority to solicit among the nodes, each node will solicit once in N token rotations.

With ten nodes in a ring, use of the (non-HF oriented) wireless token ring protocol (WTRP) would result in disconnected nodes remaining out of the network for around 10 min (if there are no colliding responses to the eventual SOLICIT_SUCCESSOR); this is not an attractive mode of operation for a dynamic network in the fixed and mobile service.

The time required for WTRP to reform a new ring from the disconnected remains of two colliding rings would be at least that long: a small ring might emerge quickly, but the remaining nodes would then go silent and wait to be invited to join.

The recovery times for HFTP are more attractive. In the case of a lost link, HF requires N slots (whose duration equals a packet plus a turnaround time) to identify a relay. Thereafter, one additional packet time and turnaround time are required *in each token rotation*. In an example ten-node network, this amounts to a pause of less than 30 s while identifying the relay, and lengthening the token rotation time by a bit over 2%.

In the case of colliding rings, HFTP networks will experience packet collisions until one of the nodes initiates the ring merger, while WTRP nodes will go silent as soon as they detect the foreign ring. However, once a MERGE_RINGS request is received and accepted, the merging rings will resume normal data transfers after $(N + 1)$ packet + turnaround times (i.e. after the SET_SUCCESSOR and the fast token rotation of the DOUBLE_TIME_TOKEN). This amounts to less than 30 s in an example ten-node network.

3 Wideband modems

3.1 Multichannel approach

3.1.1 Independent sideband (ISB) operation

There are modems that convey data in multiple independent sidebands simultaneously. Such modems contain independent PSK/QAM modulators for each audio channel (for information on modulation see Recommendation ITU-R F.763-5, Annex 6), but employ a single forward error correction encoder, whose output bit stream is distributed over the individual channels for transmission. When these channels are carried by contiguous frequencies, the S/N of the channels tend to be similar, although channel errors are not perfectly correlated. Thus, some improvement in output is achieved using receiver diversity.