International Telecommunication Union



Recommendation ITU-R F.2119-0 (01/2019)

Guidance on technical parameters and methodologies for sharing and compatibility studies related to fixed and land mobile services in the frequency range 1.5-30 MHz

> F Series Fixed service



International Telecommunication

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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	Series of ITU-R Recommendations	
(Also available online at <u>http://www.itu.int/publ/R-REC/en</u>)		
Series	Title	
во	Satellite delivery	
BR	Recording for production, archival and play-out; film for television	
BS	Broadcasting service (sound)	
BT	Broadcasting service (television)	
F	Fixed service	
Μ	Mobile, radiodetermination, amateur and related satellite services	
Р	Radiowave propagation	
RA	Radio astronomy	
RS	Remote sensing systems	
S	Fixed-satellite service	
SA	Space applications and meteorology	
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems	
SM	Spectrum management	
SNG	Satellite news gathering	
TF	Time signals and frequency standards emissions	
V	Vocabulary and related subjects	
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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R F.2119-0

Guidance on technical parameters and methodologies for sharing and compatibility studies related to fixed and land mobile services in the frequency range 1.5-30 MHz

(2019)

Scope

This Recommendation gives guidance to perform sharing studies related to systems in the fixed and land mobile services in the frequency range 1.5-30 MHz. It establishes a list of parameters, that characterize a system to assist in sharing studies, provides information on the methodologies that can be used for sharing analyses involving fixed and land mobile services in this frequency range. It also contains a list of relevant ITU-R Recommendations, Reports and Handbooks.

Related ITU Recommendations, Reports and Handbooks

See Annex 3.

Keywords

HF fixed and mobile service systems, sharing technical characteristics, protection criteria

Abbreviations/Glossary

AWGN	Additive white Gaussian noise
BER	Bit error ratio
FOT	Frequency of optimum transmission
HF	High frequency
I/N	Interference-to-noise ratio
MUF	Maximum usable frequency
SNIR	S/(N+I), Signal-to-noise plus interference ratio
SNR	<i>S</i> / <i>N</i> , Signal-to-noise ratio
SSN	Smoothed sunspot number

The ITU Radiocommunication Assembly,

considering

that the technical characteristics of systems in the fixed and land mobile services in the frequency range 1.5-30 MHz can vary,

noting

the list of relevant Recommendations, Reports and Handbooks listed in Annex 3,

recommends

1 that the list of parameters in Annex 1 should be used as guidance on characteristics of systems in the fixed and land mobile services appropriate for use in sharing studies in the frequency range of 1.5-30 MHz;

2 that Annex 2 should be used as guidance for models to conduct sharing studies.

Annex 1

Technical parameters of fixed and land mobile systems in the frequency range 1.5-30 MHz for sharing and compatibility studies

1 Introduction

For any sharing study, it is necessary to have the characteristics of the systems that need to share the spectrum. Section 2 provides a list of parameters whose values should be able to characterize a system, for use in sharing studies.

The guidance provided in this Recommendation also makes reference to various ITU-R Recommendations related to the prediction of radio wave propagation¹.

2 General list of parameters

It is desirable that the fixed and land mobile service characteristics in the table below be used in sharing studies in the frequency range of 1.5-30 MHz. However, it should be noted that not all the parameters below are relevant for each system. As a result, care should be taken in determining the relevant parameters and their values for sharing studies between specific systems.

¹ Links for software models associated with some of the ITU-R Recommendations on propagation described in this Recommendation may be available on the ITU website on software, data, and validation examples for ionospheric and tropospheric radio wave propagation and radio noise (<u>https://www.itu.int/en/ITU-R/study-groups/rsg3/Pages/iono-tropo-spheric.aspx</u>).

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TABLE 1

General list of parameters and example values

General			
Frequency band (MHz): 1.5 to 30			
Type of emission: analogue J3E, B8E or digital			
Data rate (bit/s): 2 400, 3 200, 4 800, 9 600			
Deployment type: fixed or land mobile			
Evaluation period samples: January, April, July, and October			
Evaluation time samples: every 4 hours			
Sun spot numbers SSN: 10, 100, 200			
Ground conductivity (S/m): 0.005			
Ground dielectric constant: 13			
System			
Channel bandwidth (kHz):			
• 3 for J3E Telephony single-sideband suppressed carrier;			
• 3 for B8E Telephony independent-sideband 2 channels;			
• up to 40 for digital.			
Propagation path: Skywave or groundwave			
Typical grade of service:			
• J3E Telephony single-sideband suppressed carrier:			
• 47 (dB/Hz) (just usable for groundwave propagation);			
\circ 48 (dB/Hz) (just usable for skywave propagation)			
• B8E Telephony independent-sideband 2 channels):			
• 49 (dB/Hz) (just usable for groundwave propagation);			
\circ 50 (dB/Hz) (just usable for skywave propagation).			
• J2D Class of Emission (for BER $\leq 1.0 \times 10^{-5}$):			
\circ 2 400 bit/s groundwave propagation: 40 (dB/Hz);			
 2 400 bit/s skywave propagation: 46 (dB/Hz); 			
 3 200 bit/s groundwave propagation: 43 (dB/Hz); 			
 3 200 bit/s skywave propagation: 49 (dB/Hz); 			
\circ 4 800 bit/s groundwave propagation: 47 (dB/Hz);			
\circ 4 800 skywave propagation: 54 (dB/Hz);			
 9 600 bit/s groundwave propagation: 56 (dB/Hz); 			
\circ 9 600 bit/s skywave propagation: 66 (dB/Hz).			
Distance between transmitter and receiver (km): 100 (short), 1 500 (medium), and 5 000 (long)			
Transmitter			
Location (referenced to the victim receiver's location): North, South, East and West			
Output power (W): 100 (low), 1 000 (medium) and 10 000 (high)			
Transmission feeder line losses (dB): 3, 6 for systems with remote antenna system in upper part of the frequency band			
Type of antenna system(s): dipole, monopole, log periodic, rhombic, V-shaped or loop antenna (including EH antenna)			
Receiver			
Protection criteria (dB): $S/(N+I)$ (degradation to the grade of service in the presences of interference) SNR^2			
Type of antenna system(s): same types defined for transmitter			

² SNR for the desired grade service for groundwave paths "Stable condition" or "AWGN Channel" and for skywave paths "fading condition" are tabulated in Recommendation ITU-R F.339.

The antenna type systems described in the Table above take into account all the specific characteristics of the antenna system configuration, including the antenna height, gain, distance between elements, ground conductivity, etc. These configuration parameters must be designed together at a specific frequency to produce the antenna type. Future studies on these antenna types could also address antenna directivity patterns for these systems.

For studies which consider the adjacent channel impact, characteristics on the emission and blocking masks can be taken from Recommendation ITU-R SM.1539.

Annex 2

Methodologies for sharing and compatibility studies related to systems operating in the fixed and land mobile service in the frequency range 1.5-30 MHz

1 Introduction

The first step in any sharing study is to characterize the environment, system configuration, and sharing conditions of the systems being analysed. Two types of sharing and compatibility conditions need to be considered: in-band, where the systems share the same band and adjacent band analysis where the unwanted emissions of one system may impact the radio receivers in an adjacent band.

Section 2 describes methodologies that can be used for sharing analyses involving the fixed and land mobile services.

2 Methodologies for sharing and compatibility studies

There are two basic MF/HF³ radio propagation modes associated with MF/HF transmissions: skywave and groundwave. These propagation modes are dependent on the separation distance between transmitter and receiver and may impact MF/HF systems that are sharing operating frequencies. Since the interfering signal could follow either a groundwave or a skywave propagation path, calculations for both should be performed if the interfering transmitter is within the groundwave range. The MF/HF spectrum has unique characteristics compared to higher frequency ranges. The received mean signal or noise (or both) power levels of MF/HF systems could exhibit large variations with time. For the analysis of systems operating above 30 MHz, the interference-to-noise ratio (I/N) is often used as an accepted methodology in sharing studies, by considering the interference signal's impact to the degradation of the noise floor. However, for MF/HF systems an analysis based on the I/N ratio does not take into account that some ionospheric links will be operating with sufficiently high link margins such that small variations in the effective noise floor wouldn't significantly affect their grade of service. The consideration of an interference level above a noise level may not necessarily be sufficiently high to make the signal-to-noise-plus-interference ratio (SNIR) degrade the system performance below the minimum signal-to-noise ratio (SNR) associated with the desired system's grade of service.

³ In the ITU-R Radio Regulations, the term "MF" refers to the frequency range 300-3 000 kHz, and the term "HF" refers to the frequency range 3-30 MHz. The guidance related to MF/HF systems provided in this Recommendation is limited to the frequency range 1.5-30 MHz.

Furthermore, an I/N analysis also does not take into account that even though an interfering signal may propagate to a location where the I/N exceeds a particular level, the wanted link's desired signal on the particular frequency under study may not necessarily propagate with sufficient reliability at that location. So, while the I/N criteria may be exceeded, the receiver would not be operating on the interfering frequency since the frequency cannot support the wanted link operations at the given location. With the I/N approach, the frequency under analysis may be sufficiently far away from the frequency of optimum transmission (FOT) that it is unlikely that the wanted link would operate near the frequency under analysis. In general, MF/HF skywave links are not designed to operate as noise limited circuits. Due to the changing characteristics of the ionosphere, MF/HF systems do not use a single frequency and the appropriate operating frequency is selected based on the prevailing parameters.

2.1 Skywave propagation mode

The following step-by-step procedure is recommended for sharing and compatibility studies that would model operations of HF systems.

Step 1: Determine the suitability of the frequency for the victim link, using the parameters listed in Table 1 of Annex 1. The skywave signal propagation predictions in the frequency range 2 to 30 MHz should be performed according to Recommendation ITU-R P.533⁴. MF/HF skywave radio communication links operate best at frequencies between -25% to +10% of the maximum usable frequency (MUF). Operation beyond 10% above the MUF is likely to have unsatisfactory performance, while operation at frequencies lower than -25% below the MUF is likely to have inadequate signal-to-noise ratios. As a result, an interference analysis for a sharing study should consider an operating frequency window below and above MUF as specified above. If the frequency under consideration for the specified time, month, and sun spot number is not inside the frequency window, then it should be assumed that the victim link is not operating on that frequency.

Step 2: Determine the feasibility of the victim link for the required grade of the service within the operating frequency window established in the first step. The median SNR is evaluated for the victim system according to Recommendation ITU-R P.533 for the sun spot numbers, seasons and time intervals. If it is found that the victim link can meet the desired grade of the service, then the interference signal level can be predicted in the next step below.

Step 3: For the time intervals during which the victim link can operate at or above the desired grade of service, determine the interference power at the victim receiver following procedure described in Recommendation ITU-R P.533. Afterwards, evaluate the SNIR to determine the time periods during which the link performance falls below the desired grade of service. The skywave path SNR values required for various types of emissions and grades of service are found in Recommendation ITU-R F.339 (under fading conditions). The transmitter should be located at north and south directions at short, medium and long distances from the receiver. The interference signal source should also be located at four compass points with respect to the victim receiver and at short, medium and long separation distances depending on the situation that is being analysed. The analyses should be repeated over low and high sun spot values, at seasonal and time of day samples.

Step 4: Calculate the victim link availability with and without interference. The propagation predictions performed according to the Recommendation ITU-R P.533 present availability as a probability of signal level, in a time slot for one hour per day during one month. The victim and interfering transmissions should be assumed to be independent, and their joint probability should be used to determine the duration of interference. For example, if for a given hour within a month, the victim link is evaluated to have availability with a 50% probability, and the interfering signal

⁴ REC533 and ITURHFPROP are software models associated with Recommendation ITU-R P.533.

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reaches the victim receiver with 50% probability, then the duration of time during which the victim link will be degraded by the interfering transmitter is determined by the joint probability to be 25% for this example. When the interfering transmitter is not present, the victim link would be able to operate for 15 out of 30 possible hours within that month and time slot. With the interfering transmitter present, the victim link availability would be degraded to 7.5 hours for the given month and time slot.

For sharing studies in this band, with the ionospheric propagation mode, the coverage or interference zones depend on the time of day, the season and the 11-year solar activity cycles. This leads to the fact that HF transmission systems can change frequency more than once in a single day. Thus, it will be necessary to redefine regularly the study parameters (every four hours for example).

2.2 Groundwave propagation mode

The median SNR is evaluated according to Recommendation ITU-R P.368⁵ for seasons and time intervals over a one year period, and then the SNIR is calculated. The noise level is calculated according to Recommendation ITU-R P.372. For the periods when the victim link has achieved an SNR greater than the threshold required for the desired grade of service, the SNIR is evaluated to determine the time period during which the link performance is degraded below the desired level. The SNR values for the frequency band 3-30 MHz are found in Recommendation ITU-R F.339 for stable conditions.

The interfering signal could follow a groundwave or skywave propagation path, with calculations performed accordingly. The victim system transmitter and receiver distances should be within the groundwave propagation distances and the interfering signal could originate from groundwave range to short, medium and long skywave separation distances.

3 Analysis for interference from adaptive systems

For cases where the interference source is from an adaptive system operating according to Recommendation ITU-R F.1778, the analysis for a sharing study can be done as described in § 2 above. If the adaptive system receives the victim link's signal at a level above the thresholds given in Recommendation ITU-R F.1778, then it can be assumed that the adaptive system successfully detected the victims' signal and that a frequency change was performed to prevent the victim link from experiencing interference. However, if the received signal level is below the threshold levels given in the Recommendation ITU-R F.1778, then the transmissions from the adaptive system can be considered as interference and the effect can be analysed according to the appropriate propagation mode (skywave or groundwave).

⁵ GRWAVE is a software model associated with Recommendation ITU-R P.368.

Annex 3

References

The following ITU-R Recommendations and Reports provide fixed and land mobile system characteristics in the frequency range 1.5-30 MHz to be used in sharing studies. Other Recommendations and Reports may also be applicable.

- Recommendation ITU-R F.240 Signal-to-interference protection ratios for various classes of emission in the fixed service below about 30 MHz.
- Recommendation ITU-R F.339 Bandwidths, signal-to-noise ratios and fading allowances in HF fixed and land mobile radiocommunication systems.
- Recommendation ITU-R F.1778 Channel access requirements for HF adaptive systems in the fixed and land mobile services.
- Recommendation ITU-R F.1821 Characteristics of advanced digital high frequency (HF) radiocommunication systems.
- Recommendation ITU-R P.368 Ground-wave propagation curves for frequencies between 10 kHz and 30 MHz.
- Recommendation ITU-R P.372 Radio noise.
- Recommendation ITU-R P.533 Method for the prediction of the performance of HF circuits.
- Recommendation ITU-R SM.1539 Variation of the boundary between the out-of-band and spurious domains required for the application of Recommendations ITU-R SM.1541 and ITU-R SM.329.

Report ITU-R F.2263 – Reliability calculations for adaptive HF fixed service networks.

ITU-R Handbook - Frequency adaptive communication systems and networks in the MF/HF bands.