RECOMMENDATION ITU-R P.844-1*

IONOSPHERIC FACTORS AFFECTING FREQUENCY SHARING IN THE VHF AND UHF BANDS (30 MHz-3 GHz)

(Question ITU-R 218/3)

(1992-1994)

The ITU Radiocommunication Assembly,

considering

a) that the ionosphere, while primarily responsible for reflection of radio waves below approximately 30 MHz, is capable of supporting propagation in the VHF (30-300 MHz) band under some conditions, during relatively short periods of time, and in certain areas of the world;

b) that propagation mechanisms which exist for relatively short periods of time should be taken into consideration when planning radio systems which share frequencies;

c) that frequency sharing is important in the efficient use of the radio spectrum,

recommends

that the following information be taken into account when planning radio systems which make use of frequency sharing in the VHF and UHF bands (30 MHz-3 GHz).

1. Terrestrial propagation

1.1 Introduction

Radio propagation at VHF is mainly controlled by physical objects, such as terrain and ground cover (clutter), and tropospheric factors, principally refraction. However, at VHF, ionospheric propagation over long distances can take place with relatively small losses. Such propagation events may be significant in causing interference at VHF, particularly for systems requiring high reliability.

1.2 Summary of potential ionospheric interference mechanisms

Table 1 provides a summary of ionospheric propagation mechanisms which may be significant causes of interference at VHF. Further information on the more important mechanisms is given in the following sections.

1.3 Normal F-region propagation

Near the peak of the solar cycle long-distance propagation via the F2 layer can occur for a significant fraction of the time at frequencies above 30 MHz. This effect extends to 70 MHz at low latitudes. Figures 1, 2 and 3 show, for a path length of 4 000 km, values of the MUF exceeded for 1% of hours for three seasons at sunspot maximum.

1.4 Trans-equatorial propagation (TEP)

Strong transmission can occur, particularly during high sunspot years, over long North-South paths spanning the geomagnetic equator.

There appear to be two types of trans-equatorial propagation characterized by the times of peak occurrence, fading characteristics and modes of propagation.

* Radiocommunication Study Group 3 made editorial amendments to this Recommendation in 2000 in accordance with Resolution ITU-R 44.

TABLE 1

Main causes of ionospheric interference to stations working at frequencies between 30 and 300 MHz

Cause of interference	Latitude zone	Period of severe interference	Approximate highest frequency with severe interference (MHz)	Approximate frequency above which interference is negligible (MHz)	Approximate range of distances affected (km)	Principal distinguishing features
Regular F-layer reflections	Mid	Day, equinox and winter, solar-cycle maximum	50	60	E-W paths 3 000-6 000 or N-S paths 3 000-10 000	Occurrence broadly in accordance with regular-layer morphology
	Low	Afternoon to late evening, solar-cycle maximum	60	70		
Sporadic-E reflections	High	Night	70	90	500-4 000	Principally during summer months in mid latitudes. Sudden onset and conclusion, beginning later and ending earlier with increase of operating frequency. Area concerned relatively small and mobile. Duration minutes or hours. No associated signal enhancements at short range
	Mid	Day and evening, summer	60	83-135 (1)		
	Low	Day	60	90		
Sporadic-E scatter	Low	Evening to midnight	60	90	Up to 2 000	

(1) For 0.1% of the time during the hours 0800-2300 LT for May to August (111 min total) the following frequencies may be derived from Annex 1 to Recommendation ITU-R P.534 for a distance of 1 800 km and $\Gamma = 30$ dB for temperate zone:

Region A (Europe and North Africa): 83 MHz

Region B (North America): 93 MHz

Region C (Asia): 135 MHz

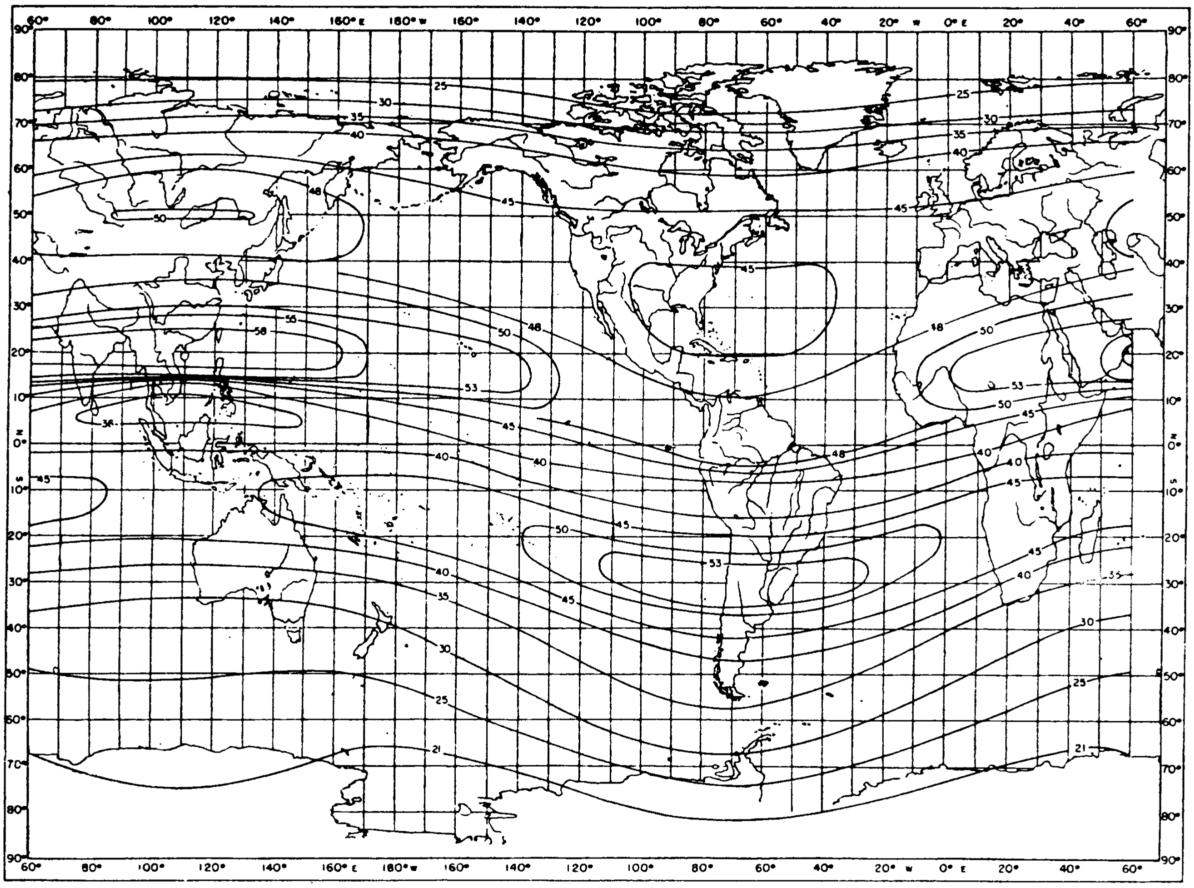
Region D (Average for Northern Hemisphere): 115 MHz

TABLE 1 (*continued*)

Cause of interference	Latitude zone	Period of severe interference	Approximate highest frequency with severe interference (MHz)	Approximate frequency above which interference is negligible (MHz)	Approximate range of distances affected (km)	Principal distinguishing features
Reflections from meteoric ionization	All	Particularly during showers	May be important anywhere in the range		Up to 2 000	Signal bursts with durations from a fraction of a second to several minutes. Marked diurnal variation, maximum 0600 h local time, minimum 1800 h. Some activity present at all times, but considerable increases during predictable shower periods
Reflections from magnetic field aligned columns of auroral ionization	High	Late afternoon and night				Associated with geomagnetic disturbances, typically when local K-index reaches 5 or more. Characteristic rasping note due to multiple Doppler shifting. Normal duration a few hours, often afternoon to midnight.
Scattering in the F region	Low	Evening to midnight, equinox	60	80	1 000-4 000	
Special transequatorial effects	Low	Evening to midnight	60	80	4 000-9 000	Paths generally aligned symmetrically across the dip equator. Generally around equinoctial periods with regular occurrences. Strong signals. Refer to main text for further details.

FIGURE 1

MUF for a path length of 4 000 km exceeded during 1% of hours – December solstice; sunspot maximum



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The first type of TEP, which is called the afternoon type, has the characteristics:

– a peak occurrence around 1700-1900 h LMT, the time being measured at the point where the circuit cuts the magnetic equator;

– normally strong steady signals with a low fading rate and a small Doppler spread (about ± 2-4 Hz);

– path lengths of about 6 000-9 000 km and sometimes longer.

The second type of TEP, which is called the evening type, generally supports higher frequencies than the afternoon type and has very different characteristics:

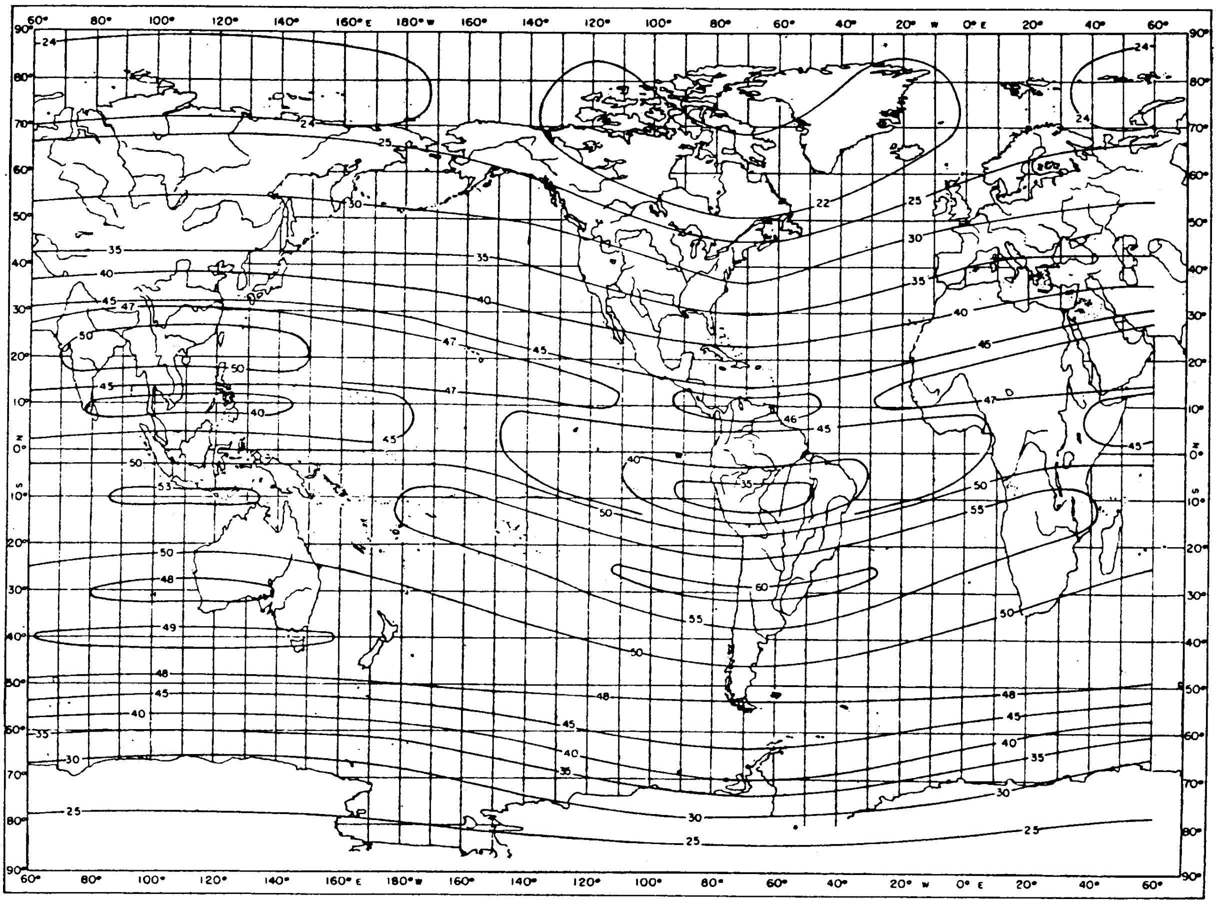
– a peak occurrence around 2000-2300 h LMT;

– high signal strengths but with deep and rapid fading at rates up to about 15 Hz and a large Doppler spread which sometimes exceeds 40 Hz;

– path lengths usually shorter than for the afternoon-type mode, being about 3 000-6 000 km.

FIGURE 2

MUF for a path length of 4 000 km exceeded during 1% of hours – June solstice; sunspot maximum



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1.5 Sporadic-E propagation

Sporadic-E ionization appears as an intensification in ionization in the form of a horizontal sheet of about 1 km average thickness and a horizontal dimension of the order of 100 km. The height is commonly 100 to 120 km. Such sporadic-E layers can cause abnormal VHF propagation for periods lasting for several hours.

The occurrence of sporadic-E propagation decreases with increasing frequency, but can be a significant cause of interference at frequencies up to about 135 MHz.

Recommendation ITU-R P.534 provides a method for calculating sporadic-E field strengths and probability of occurrence.

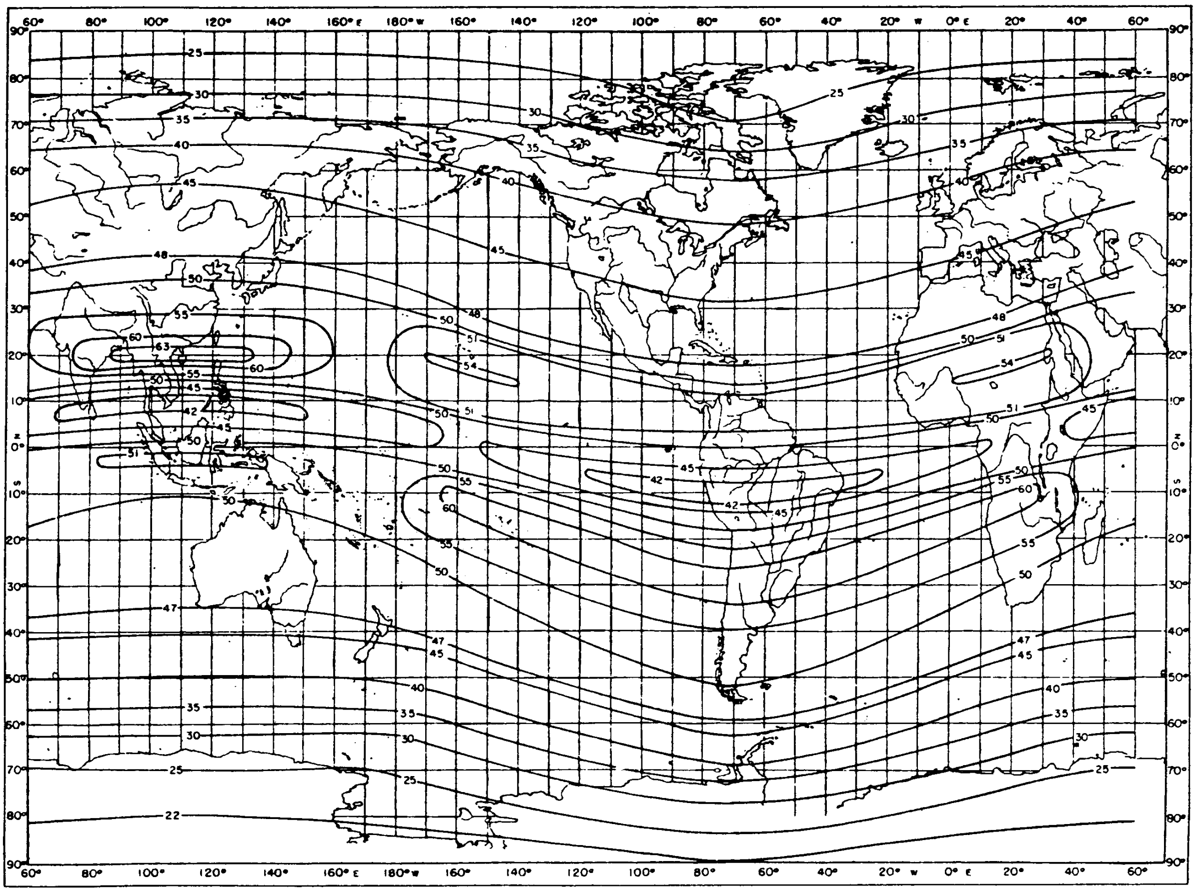
1.6 Meteor-trail ionization

Scattering from ionization due to meteor-trails can produce VHF interference over ranges up to approximately 2 000 km. Although individual meteor trails remain effective for periods measured in seconds, meteor bursts can support continuous or near-continuous propagation for much longer periods of time.

The effect of meteor trails on VHF propagation shows spatial, diurnal and seasonal variations. Further information may be found in Recommendation ITU-R P.843.

FIGURE 3

MUF for a path length of 4 000 km exceeded during 1% of hours – equinox; sunspot maximum



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1.7 Auroral ionization

Field-aligned irregularities in the auroral zones appear during magnetically disturbed periods. Such ionization can produce significant reflections causing propagation which is normally off the great-circle path. This may cause interference at VHF, mainly in mid to high geomagnetic latitudes.

2. Earth-space propagation

Radio propagation at VHF and UHF on Earth-space paths through the ionosphere is subject to attenuation, polarization rotation, amplitude and phase scintillation and ray-path bending. These effects may influence the extent of frequency sharing for satellite services and between satellite and terrestrial services.

For orbiting satellite systems the effect of time and location variations of irregularities in the ionosphere may be important, notably in equatorial and auroral regions.