

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R P.1321-5 (07/2015)

Propagation factors affecting systems using digital modulation techniques at LF and MF

P Series
Radiowave propagation



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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 P.1321-5

Propagation factors affecting systems using digital modulation techniques at LF and MF

(Question ITU-R 225/3)

(1997-2005-2007-2009-2013-2015)

Scope

This Recommendation provides information on the characteristics of LF and MF ground-wave and sky-wave propagation which may affect the use of digital modulation methods in those bands.

Keywords

MF propagation; seasonal variation

The ITU Radiocommunication Assembly,

considering

- a) that digital modulation methods for sound broadcasting purposes at LF and MF are currently being studied;
- b) that information on the propagation characteristics at these frequencies is necessary for use in the design of modulation methods,

recommends

that the information given in Annex 1 should be taken into account in the design of digital modulation methods for broadcasting at MF and LF.

Annex 1**1 Introduction**

The majority of broadcasting services in the MF and LF bands are based on the characteristics of the ground-wave propagation mode (see Recommendation ITU-R P.368). The limiting coverage range, during daytime and in the absence of interference, is determined by the intensity of radio noise due to lightning and to man-made sources (see Recommendation ITU-R P.372) and by the required signal-to-noise ratio. During the hours of darkness, ionospheric sky-wave modes become important (see Recommendation ITU-R P.1147). For analogue amplitude modulation, these modes limit the coverage, since the wave-interference between the ground wave and the varying and phase delayed sky-wave modes results in unsatisfactory signal quality. Sky-wave signals from other distant transmissions may also add significant night-time interference, which may also restrict the service coverage to ranges where the ground wave provides a sufficiently strong signal; aspects of interference from other signals are not further considered in this annex.



Digital modulation methods may also be affected by the presence of delayed signal modes, but suitable modulation design may counter or exploit this effect. This annex presents some very simple models for this multipath environment, which are expected to be suitable for the design of modulation methods. Dependent on the modulation method chosen, more detailed prediction methods may be required for service planning purposes.

2 Propagation modes

2.1 Ground wave mode

The ground wave may often not be constant (see § 4). Also as shown in Recommendation ITU-R P.368, the signal amplitude depends on range and the electrical characteristics of the ground. Also the signal amplitude does not remain constant for small changes in location (from several hundred metres).

2.2 Sky-wave modes

During daylight hours, signal attenuation in the lower D-region part of the ionosphere effectively prevents sky-wave propagation. This annex concentrates on the conditions at night when sky-wave propagation may be significant.

The E-layer of the ionosphere decays after sunset, but the critical frequency, f_oE , will be within the MF broadcast band, at least for times in the first part of the night. Signals at frequencies less than the critical frequency will always be reflected by the E-layer, and multihop reflections will also be supported. Signals at higher frequencies may still be reflected from the E-layer, particularly to longer ranges, but signals will also penetrate the E-layer to be reflected from the higher F-region. Using a simple model for the E-layer, Fig. 1 illustrates the available signal modes for three frequencies in the MF band, showing the way in which mode availability varies with ground range and with time after sunset. These modes will be time delayed compared with the ground wave mode.

Recommendation ITU-R P.1147 provides predictions for the composite signal power for the available sky-wave modes, and thus does not give the necessary information for the relative amplitudes for individual modes. However, Recommendation ITU-R P.684 does provide information, although primarily intended for frequencies less than 500 kHz. In particular, it gives values for the ionospheric reflection coefficient for sunspot minimum conditions, based on experimental results, and on some assumptions, as stated in the Recommendation.

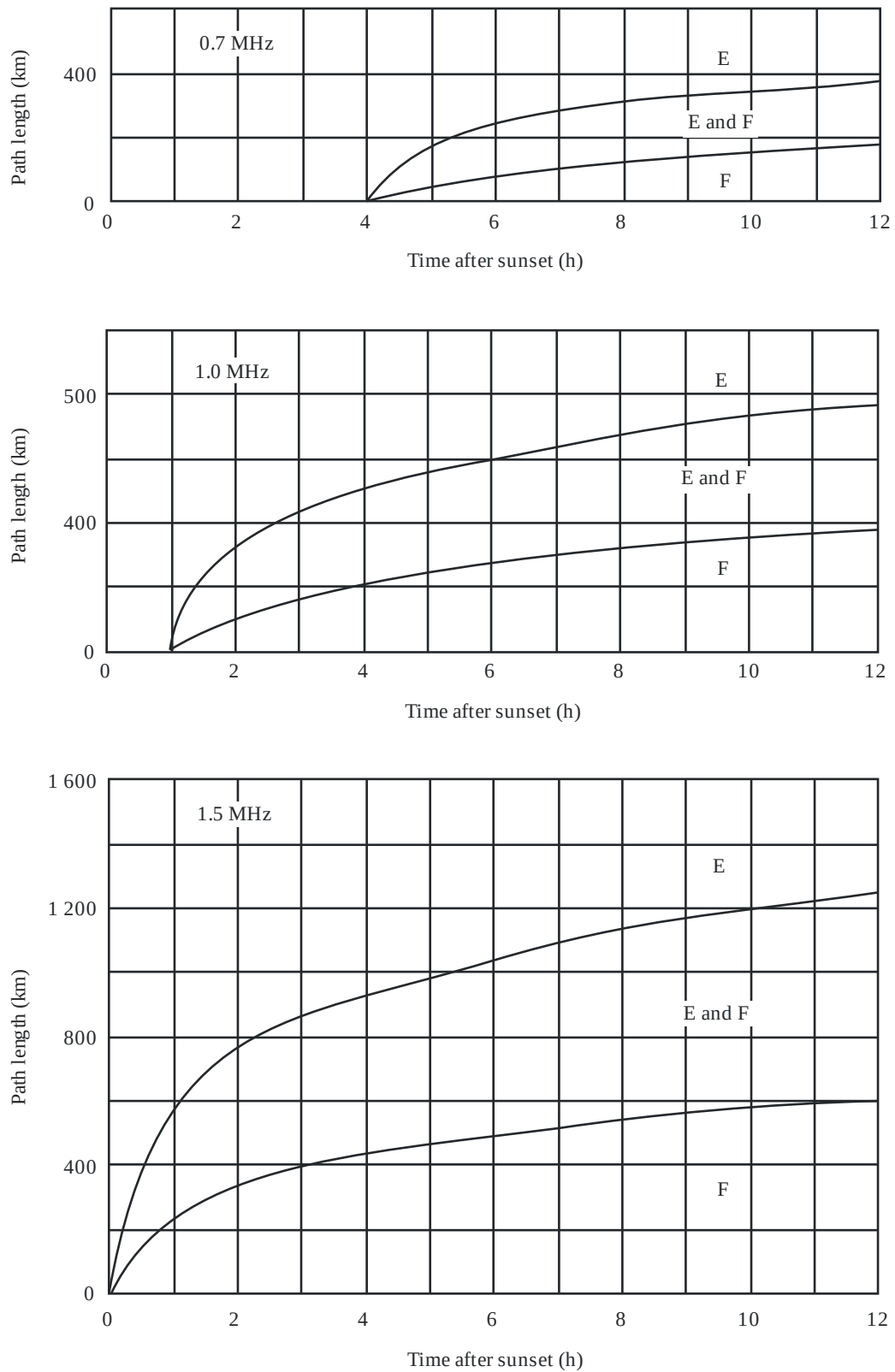
3 Multipath time spread

Using the above simple propagation models, Fig. 2 shows the expected median field strengths and relative time delays for three ranges, 100, 200 and 500 km, and two frequencies, 700 kHz and 1 MHz. The field strengths are for 1 kW e.m.r.p. and do not include the effect of the vertical radiation pattern of the transmitting antenna – this may reduce the levels of the sky-wave signals at the shorter ranges.

The mode shown at 0 ms is for the ground wave, and field strengths are shown for three values of ground conductivity; 5 S/m (sea water), 10^{-2} (good ground), and 10^{-3} (poor ground).

The sky-wave components are marked with the relevant mode and the levels approximately represent the median field strengths four hours after sunset at sunspot minimum.

FIGURE 1
Available propagation modes



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