RECOMMENDATION ITU-R F.454-1*

PILOT CARRIER LEVEL FOR HF SINGLE-SIDEBAND AND INDEPENDENT-SIDEBAND REDUCED-CARRIER SYSTEMS

(1970-1978)

The ITU Radiocommunication Assembly,

considering

a) that although for conventional radiotelephone systems a level of −26 dB appears, theoretically, to be adequate, operational experience shows that significant improvements in operational time are secured with higher levels;

b) that, for radiotelephone systems employing a frequency-modulated control channel, further protection of the pilot carrier is necessary to ensure end-to-end circuit gain stability;

c) that on currently operated multi-channel radiotelegraph systems a level of −26 dB is, both theoretically and in operational experience, inadequate to ensure reliable action of the automatic frequency control system down to the failure point of the telegraph channels;

d) that a standard level of reduced pilot carrier for all single-sideband and independent-sideband emissions would be operationally advantageous,

recommends

1. that a standard pilot-carrier level of −20 dB ±1 dB relative to transmitter peak envelope power be adopted for all fixed service single-sideband and independent-sideband reduced-carrier HF radio emissions.

ANNEX I

SIGNAL-TO-NOISE RATIOS IN SIDEBAND AND CARRIER CHANNELS

1. Channels with conventional terminals

The minimum usable signal-to-noise ratio of a channel depends on its function. With a conventional terminal, only the speech channel and carrier channel need be considered while in the case of Lincompex equipment the control signal channel must be considered as well.

The carrier branch provides both automatic frequency control and automatic gain control functions. When the signal-to-noise ratio in the carrier branch is approximately 10 dB on an r.m.s. basis, the noise peaks will exceed the carrier peaks. Then large perturbations or even reversals of carrier phase will result so frequently as to impair operation of the automatic frequency control. This may be taken as the failure point of the carrier branch inasmuch as the automatic gain control is somewhat less affected by noise. The noise bandwidth of the carrier branch of a receiver varies among individual designs; for example in the United States of America it is commonly 35 Hz while in the United Kingdom it is 70 Hz and receivers used in the Netherlands, France and Japan have intermediate bandwidths.

The minimum usable speech-to-noise ratio depends on the type of terminal equipment used. For conventional terminals under stable circuit conditions a value of 15 dB corresponds to marginally commercial quality (see Recommendation ITU-R F.339). If these conditions and the foregoing ratio are assumed, the corresponding carrier-to-noise ratio can be calculated by taking into account the respective bandwidths of the speech and carrier channel and the mean speech level relative to p.e.p. Although the latter varies among Administrations, as well as the carrier filter noise bandwidth, such a calculation shows that, in the absence of selective fading, a carrier level of −26 dB relative to p.e.p. should be adequate to ensure that the automatic frequency control is not noticeably disturbed by noise before the speech channel of a conventional circuit becomes uncommercial.

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* Radiocommunication Study Group 9 made editorial amendments to this Recommendation in 2000 in accordance with Resolution ITU-R 44.

Recent operating experience in the United Kingdom has shown, however, that if the carrier-to-noise ratio is increased by 10 dB some 5% improvement in commercial channel hours is nevertheless realized.

2. Channels with Lincompex terminals

In a Lincompex system, there is a possibility of inadequate signal-to-noise ratio in the speech channel, in the pilot carrier channel and/or in the control signal channel. The control signal channel has a bandwidth of 200 Hz and the speech bandwidth is correspondingly reduced from the usual 2750 Hz of a conventional circuit to 2450 Hz to accommodate both the speech and control signals below 3 kHz (in accordance with Recommendation ITU-R F.1111).

High noise in the control channel causes the circuit loss to fluctuate. This imparts a subjective "gritty" quality to the speech. The effect becomes excessive for control channel signal-to-noise ratios less than about 14 dB.

A speech-to-noise ratio of 7 dB has been found to represent just marginally commercial quality, taking into account the compandor improvement (see Note 3 to Table I of Recommendation ITU-R F.339).

It can be calculated that the minimum usable signal-to-noise ratios occur approximately together in the speech channel, the control signal channel and the carrier channel.

Thus the protection afforded to the carrier is commensurate with that of the control channel if selective fading is ignored. Nevertheless, the importance of the carrier in controlling the gain stability of up to four channels would appear to demand a higher signal-to-noise ratio, since in the Lincompex system gain stability is directly related to the performance of the automatic frequency control system.

3. Multichannel telegraph systems

The failure of a radiotelegraph channel equipped with automatic error-control facilities is not rigidly definable since it depends on the circuit efficiency that can be tolerated. At low values of circuit efficiency undetected character errors increase significantly and, for this reason, low efficiency circuits are unsuitable for telex operation. For other types of telegraph traffic, however, circuit efficiencies as low as 20% to 30% may be considered tolerable in certain circumstances. However, for the purpose of this assessment, a circuit efficiency of 50% is taken as the failure point. For a dual-diversity system working typical radio conditions, this corresponds to a median signal-to-noise ratio of approximately 8 dB in the telegraph channel, which, in a typical 100-baud system, has a bandwidth of 140 Hz.

According to Recommendation ITU-R SM.326, it is typical of present practice that the mean power of each channel of a multi-channel telegraph system (class of emission R7B or B7B) be given by p.e.p./4n, when $n > 4$. Thus for a representative number of channels (say $4 < n < 10$), the power in a given telegraph channel will exceed that of a pilot-carrier of −26 dB relative to p.e.p. by at least 10 dB. But the carrier channel has an advantage with respect to noise bandwidth of only 3 to 6 dB since the ratio of the telegraph channel bandwidth to the carrier channel bandwidth is typically in range 2 to 4 (corresponding to a bandwidth range of 70 to 35 Hz). Therefore it is evident that the carrier channel will be at a net disadvantage and that a pilot carrier level of −26 dB relative to p.e.p. is inadequate over a wide range of circumstances to ensure reliable action of the automatic frequency control down to the failure point of the telegraph system.

The foregoing discussion makes no allowance for selective fading. It may be noted that in general the telegraph channels ordinarily derive substantial benefit from either space or frequency diversity while the carrier channel does not.