

RECOMMENDATION ITU-R S.671-3

NECESSARY PROTECTION RATIOS FOR NARROW-BAND SINGLE
CHANNEL-PER-CARRIER TRANSMISSIONS INTERFERED
WITH BY ANALOGUE TELEVISION CARRIERS

(Question ITU-R 50/4)

(1990-1992-1993-1994)

The ITU Radiocommunication Assembly,

considering

- a) that narrow-band SCPC carriers are sensitive to the interference caused by analogue television carriers, especially when such TV carriers are only modulated with energy dispersal signals at the television frame rate;
- b) that interference from FM-TV into SCPC transmissions is generally a determining factor in the coordination of closely spaced satellites;
- c) that the calculation methods required for determining the level of permissible interference in such cases are unique to this class of signals;
- d) that the uniqueness of this situation is recognized in Appendix 4 of the Radio Regulations,

recommends

1. for the purposes of calculating the permissible levels of interference between analogue television and narrow-band SCPC carriers, the protection ratio of SCPC carriers interfered with by analogue TV carriers modulated only by energy dispersal at the TV frame rate, be calculated from the following:

- 1.1 for 64 kbit/s SCPC, without forward error correction (FEC);

$$C/I = C/N + 6.4 + 3 \log \delta - 8 \log (i/10) \quad \text{dB}$$

- 1.2 for companded frequency modulation (CFM) SCPC;

$$C/I = 13.5 + 2 \log \delta - 3 \log (i/10) \quad \text{dB}$$

where:

- C/I : ratio of the interfered with SCPC carrier power to the total carrier power of the interfering dispersed TV signal
- C/N : operating carrier-to-noise power ratio of the SCPC carrier which corresponds to a BER of 1×10^{-6}
- δ : ratio of the occupied bandwidth of the SCPC carrier to the TV peak-to-peak deviation due to dispersal
- i : the total allocated pre-demodulation interference power in the SCPC bandwidth, consisting of the interference power contributed by the TV carrier as well as the noise-like interference coming from other interfering carriers (see Annex 1), expressed as a percentage of the total pre-demodulation noise power ($10 \leq i \leq 25$);

2. that the following Notes should be regarded as part of the Recommendation:

Note 1 – The interference criteria in § 1.1 and 1.2 are applicable for interfering TV signals using frame rate energy dispersal only.

Note 2 – The formulae in § 1.1 and 1.2 are correct on the assumption that the interference determined by the relative power value i is caused by a TV carrier I and noise-like interference I_N , for a ratio $I_N/I = 2.5$ and for a power spectral density of the noise-like interference of -62 dBc/Hz.

Note 3 – To protect 64 kbit/s SCPC carriers having FEC coding at rates between 1/2 and 7/8 using soft decision Viterbi decoding, the following expression may be used:

$$C/I = C/N + 9.4 + 3.5 \log \delta - 6 \log (i/10) \quad \text{dB}$$

This interference criterion is valid for interfering FM-TV signals modulated only by a dispersal signal.

Note 4 – Significant additional protection for narrow-band SCPC carriers can be obtained if they are appropriately offset in frequency from the centre frequency of the TV carrier. This applies, in different degrees, both when the TV carrier is modulated with live programme material and otherwise and in such cases the effect of power spectral density of FM-TV carriers should be taken into account for determining the interference at frequencies outside the energy dispersal bandwidth.

Note 5 – Further study is needed to determine the level of additional protection which can be realized when the TV carrier is modulated with live programme material or otherwise.

Note 6 – Annex 1 contains methods for performing the calculations which utilize the protection ratios in § 1 and the results of measurements in support of both § 1 and 2.

Note 7 – Further study is needed to develop appropriate interference criteria for interfering FM-TV carriers with a line rate energy dispersal or a composite line rate and frame rate dispersal.

ANNEX 1

Calculation of protection ratio for FM-TV interference into single-channel-per-carrier transmissions in networks of the fixed-satellite service

1. Interference in uncoded 8-bit PCM 4-phase PSK single-channel-per-carrier transmissions

One of the most common carriers in use is 8-bit PCM 4-phase PSK (QPSK) SCPC at 64 kbit/s and the establishment of an interference criterion is based on the following considerations.

Monitoring of TV transmissions in the INTELSAT system indicates that TV carriers are modulated by video signals or test patterns most of the time and that for only very short periods the TV carriers are modulated by energy dispersal signals (EDS) alone. These periods are of the order of 0.6% of the total transmission time. The average length of such periods is about 5 min. The longest continuous such period was found to be about 18 min. Thus, the probability of simultaneous occurrences of two or more such interferers is very small.

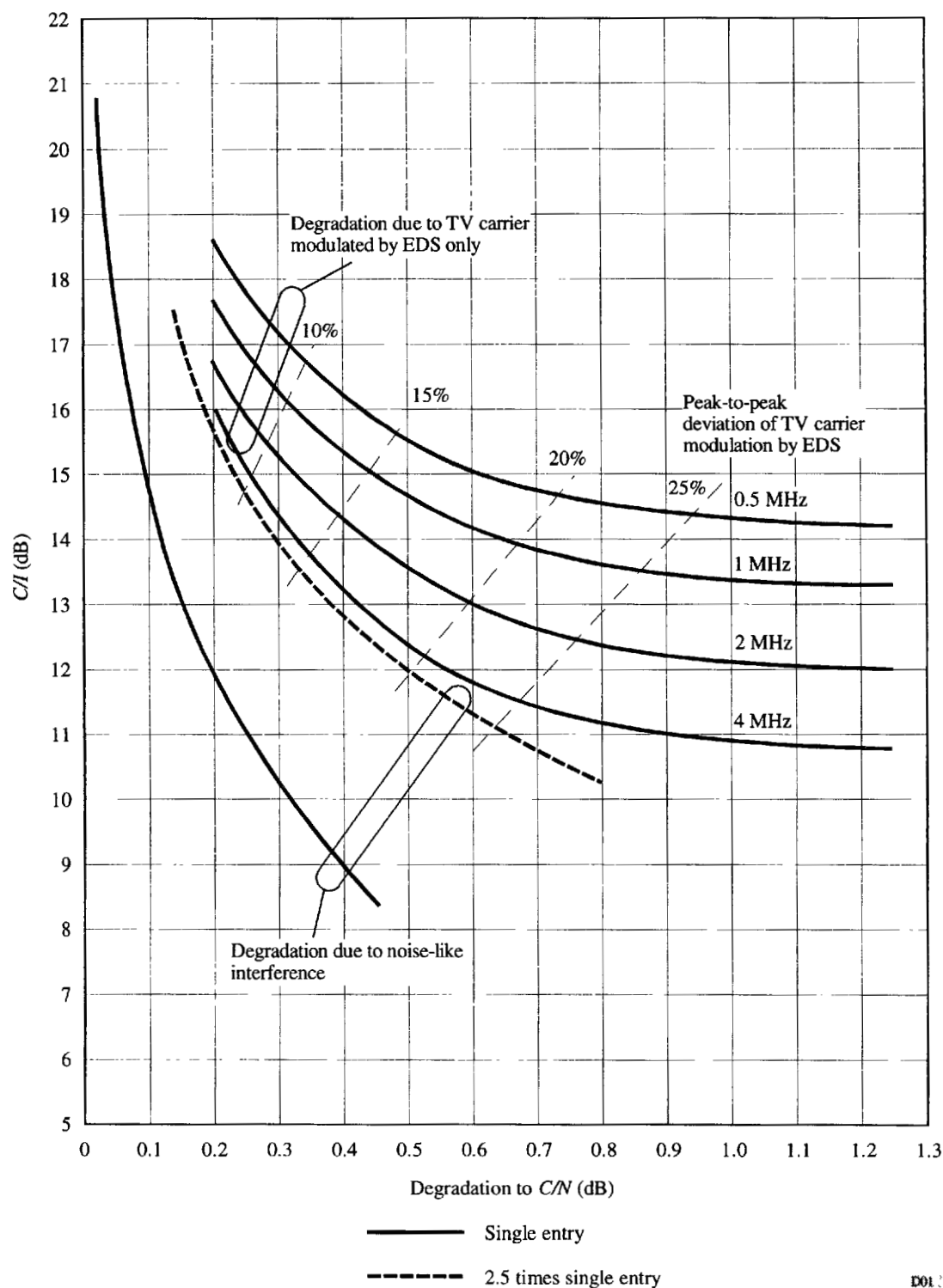
Additional measurements are needed to examine the validity of these statistical results in other satellite systems.

To establish a criterion to be used for protecting the uncoded SCPC/QPSK (64 kbit/s) transmissions, one TV carrier modulated with EDS alone is assumed to be present all of the time (one such entry representing time addition of all such interfering signals from different satellites). This type of interference is assumed to coexist with other noise-like interferers. Therefore, the total pre-demodulation interference noise allowed by Recommendation ITU-R S.523 should be divided between these two dissimilar types of interference.

A model has been developed to derive the apportionment of the total allowed interference between the two types of interferers. The model assumes a contribution coming from an energy dispersal modulated TV carrier and a noise-like contribution which is equal to 2.5 times the single entry interference. The noise-like single entry interference is assumed to originate from a modulated carrier, whose spectral density (power in a bandwidth of 1 Hz relative to the total carrier power) in the proximity of the carrier frequency is –62 dBc/Hz. This value is appropriate for representing a high density FM carrier or a modulated TV carrier.

The following laboratory measurements were made. The SCPC transmission was operated at different carrier-to-noise ratio values above $C/N = 14.6$ dB ($E_b/N_0 = 12.3$ dB) which corresponds to $BER = 10^{-6}$. Then, the energy dispersal modulated TV interferer was added and the value of the carrier-to-interferer carrier power was recorded which restored the BER to 10^{-6} . The results are presented in Fig. 1 for different peak-to-peak energy dispersal signal deviations. In the same figure, the relationship between the noise-like interference C/I (for both single entry and total noise-like interference) and degradation is shown.

FIGURE 1
 C/I vs degradation of C/N ratio



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