

REPORT 807-3*

UNWANTED EMISSIONS FROM BROADCASTING-SATELLITE
SPACE STATIONS**

(Question 1/10 and 11, Study Programme 2E/10 and 11)

(1978-1982-1986-1990)

1. Introduction

Space stations in the broadcasting-satellite service may radiate high levels of e.i.r.p. and consequently the level of the unwanted emissions may produce interference in networks using adjacent and harmonically related bands for other services. This Report considers unwanted emissions from space stations operating in all bands allocated to the broadcasting-satellite service. In particular, some provisional results of studies are given in this Report regarding unwanted emissions from a broadcasting-satellite space station at the lower and upper edges of the 12 GHz band.

2. Possible sources of unwanted emissions from broadcasting satellites

The sources of unwanted emission into adjacent bands from a broadcasting-satellite transponder operating near the edge of a broadcasting-satellite frequency band are:

- radiation due to frequency conversion;
- third-order intermodulation products caused by insufficient suppression of signals in adjacent channels in the satellite transponder branching network;
- thermal noise power generated by the satellite transponder;
- spreading of the signal spectrum due to non-linearities.

In the following, an attempt is made to deduce the variation of the spectral power flux-density (PFD) as a function of frequency difference from the channel centre. The absolute values of the spectral PFD are related to the maximum PFD required for television broadcasting as given, for example, in Report 215.

Another possible source of unwanted emissions, in this case, beyond adjacent bands, is a harmonically related spurious emission from a broadcasting satellite.

2.1 Spurious emission due to frequency conversion

Spurious emissions generated by the frequency conversion process and the local oscillator source need to be taken into account in the implementation of BSS systems.

Tables I and II show for example the down-link frequencies that would be affected by high order frequency conversion products (up to the 10th order) for specific translation frequencies for Region 2. Similar factors also apply in general to Regions 1 and 3.

* This Report should be brought to the attention of Study Group 1 and the IEC.

** Unwanted emissions consist of spurious emissions and out-of-band emissions. See Nos. 138, 139 and 140 of the Radio Regulations.

Considering the effects of interference caused by spurious components radiated from one BSS channel into another, the protection margins inherent to the BSS down-link plan should not be significantly degraded by such implementation factors. This is only likely to be a significant factor for interference from a co-located satellite, and in the case of certain values of frequency translation between a feeder link and its associated down link. In Regions 1 and 3, taking into account possible power differences between down-link carriers and the possibility of multiple interfering signals, an appropriate limit for the total spurious emission power radiated from any BSS satellite channel falling within any down-link channel is of the order of 55 dB below that of the main carrier; i.e. the carrier from the channel causing the interference. This figure is readily realizable, for example, in the case of a satellite using a 5.6 GHz frequency translation in the Region 1 and 3 Plan with a single frequency conversion stage. Dual frequency translation will reduce the level of in-band spurious emissions. Such techniques can be used if required. The interference level actually required to protect other channels from this source of interference requires further study.

2.2 Intermodulation products caused by insufficient suppression of signals in adjacent channels

With a carefully designed branching filter inserted at a relatively linear portion of the transponder, it should be possible to suppress the signal in the adjacent channels so that the intermodulation products falling into the adjacent band are of an acceptable level.

2.3 Unwanted emission due to thermal noise power generated by the broadcasting-satellite transponder

Thermal noise in the down link is caused by interaction of the thermal noise and the RF carrier in the high-power amplifier due to non-linearity, by amplification and transmission of receiver noise, and by retransmission of received feeder-link noise.

Figure 1 represents the calculated results [CCIR, 1974-78a] for the thermal noise spectral PFD as a function of frequency. The two curves shown refer to different filtering conditions as noted in the figure.

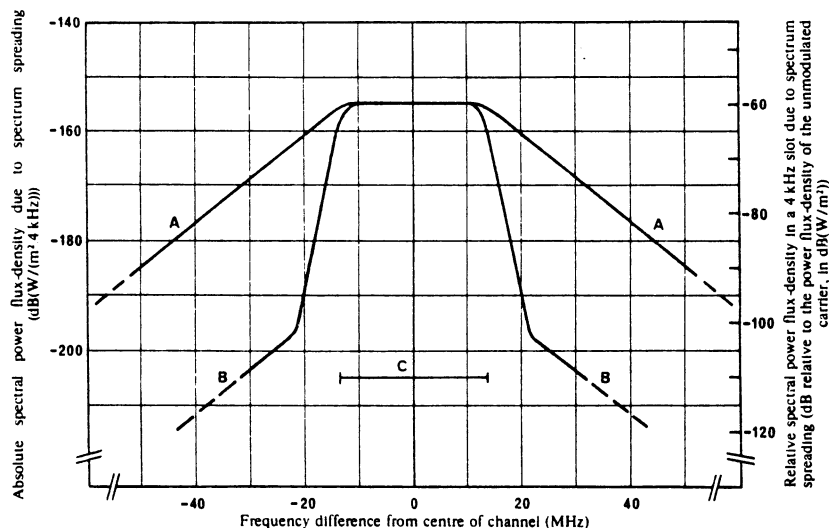


FIGURE 1 — Typical envelopes of the thermal noise power spectrum radiated by the high-power output amplifier of a broadcasting satellite

Curves A : Transponder with typical filtering

B : Estimated performance of transponder with additional filter before power amplifier

C : Nominal channel bandwidth (27 MHz)

Note. — The spectra shown by curves A and B assume the presence of an rf-carrier corresponding to a power flux-density of $-94 \text{ dB(W/m}^2\text{)}$ at the centre of the beam area and a carrier-to-noise power ratio of about 20 dB at the transponder output. In the absence of a carrier, the thermal noise spectrum envelopes increase by about 9 dB.

2.4 Spreading of the spectrum of the radio-frequency signal due to non-linearities

Band limiting on the feeder link and in the transponder leads to carrier envelope variations at the input to the transponder high power amplifier. This is typically a saturated amplifier which causes AM/PM conversion, so the envelope variations will generate RF intermodulation products, some of which will fall out of band. The transponder output filter is likely to have limited loss, so it will be unlikely to be very effective in removing out-of-band intermodulation products near to the band edge.

This intermodulation will be reduced by increasing the bandwidth of the feeder link and of the transponder preceding the high power amplifier, but this will increase the system noise bandwidth (see § 2.3).

The actual spectrum radiated by the satellite largely depends upon the television signal transmitted. In Fig. 2 computer calculated results on this subject [CCIR, 1974-78a] are presented for illustrative purposes. The signal used in the calculations of Fig. 2, curve B, was a television test signal in line 330, with a peak-to-peak deviation of 13 MHz. The signal used in the calculation of Fig. 2, curve A, consisted of 100% saturated colour bars. It should be noted that such a signal is not used in normal broadcasting. A sound sub-carrier with a peak-to-peak deviation of 5.6 MHz was associated with both television signals.

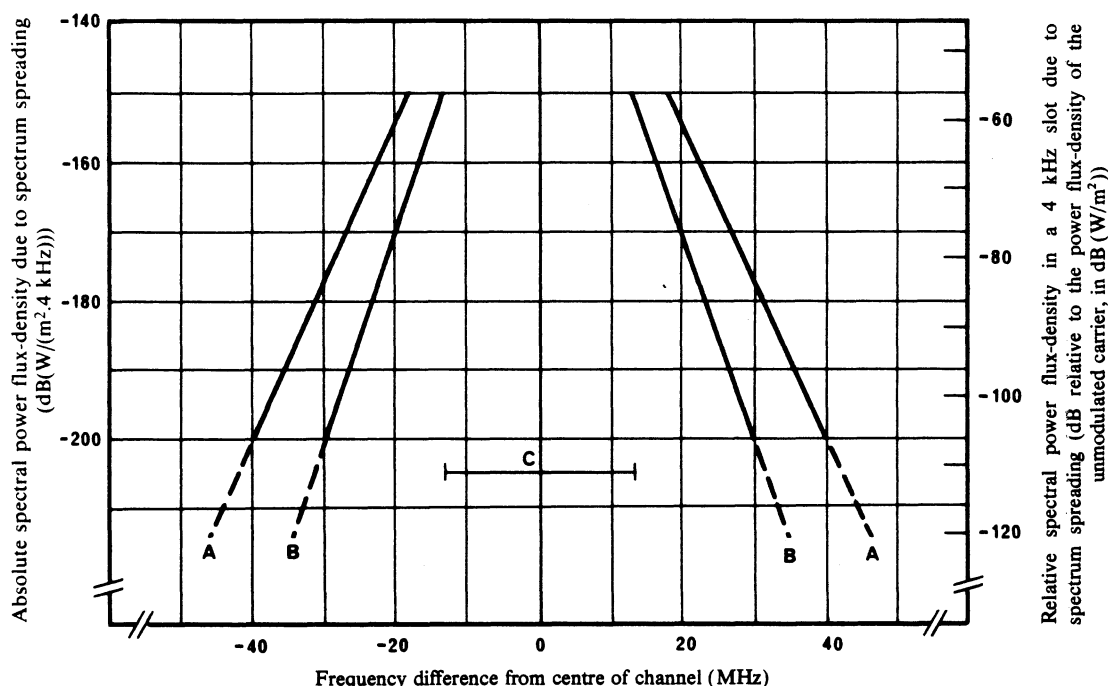


FIGURE 2 – Typical out-of-band envelopes of the radio-frequency spectrum radiated by a television broadcasting satellite

Curves A: envelope for 100 per cent colour-bar baseband signal, modulator AC coupled

B: envelope for line 330 insertion test signal, modulator AC coupled

C: nominal channel bandwidth (27 MHz)

Note 1. – For the left-hand scale, it is assumed that the e.i.r.p. of the satellite corresponds to a power flux-density of $-94 \text{ dB(W/m}^2\text{)}$ at the centre of the beam for an unmodulated carrier.

Note 2. – Minimum energy dispersal of $\pm 7.9 \text{ kHz}$ is assumed.

Note 3. – Pre-emphasis according to Recommendation 405 is assumed.

Additional data showing power spectral density envelopes of television signals based upon laboratory measurements in the United States of America [CCIR, 1978-82a] are shown in Annex I. The signal used in these measurements was an FM carrier with a digital (4-PSK) audio sub-carrier (693 kbit/s data rate at a sub-carrier frequency of 5.5 MHz) with a 75% NTSC colour bar. Measurements for both 18 MHz and 27 MHz bandwidths were made with several different signal deviations (including over-deviation). No energy dispersal waveform was used, nor was any significant RF filtering applied.

2.5 *Spurious emissions due to harmonics*

Annex II notes the harmonics of the various bands allocated to the broadcasting-satellite service and other space services which operate at those frequencies. Studies in the USA have shown that if spurious emissions at harmonics of the fundamental frequency are of the order of 60 dB below the level of the fundamental interference to other services operating at these frequencies may not be significant [CCIR, 1978-82b].

General criteria for protection include: power level, fraction of total sky covered and percentage of time exceeded. Protection is usually achieved by geographical sharing; "line-of-sight" sharing is difficult, but maximum allowable line-of-sight e.i.r.p.s are given in Fig. 3.

The likelihood of harmful interference to the services shown in Annex II has not been assessed except for the case reviewed in § 3.3. Further study is necessary.

3. **Protection of other services from unwanted emissions**

Guard bands necessary to protect the services operating in adjacent bands from unwanted emissions of 12 GHz broadcasting satellites in Regions 1 and 3 are discussed in § 3.9 of Annex 5 to Appendix 30 (ORB-85) to the Radio Regulations.

For space stations in the broadcasting-satellite service in other bands, adjacent services may similarly be protected by establishing appropriate guard-bands. The width of these guard bands will depend on future decisions concerning the minimum levels to be protected, on current filter technology (e.g. roll-off in dB/MHz) and on the bandwidth of the emission from the broadcasting-satellite service.

Also, the width of the guard-bands depends upon equitable application of the principle of sharing the burden of protection, that is, services in adjacent bands should employ designs affording a maximum feasible protection from interference outside the bandwidth required for satisfactory service (see for example No. 301 of the Radio Regulations).

Studies in the USA have shown that unwanted emissions immediately outside the allocated band can be reduced by filters with a roll-off of, for example, 2 dB/MHz, which could continue to an attenuation of 80 dB, depending on filter design, but such attenuation may not be realized at frequencies far removed from the carrier.

3.1 *Fixed-satellite service*

Report 712 addresses the protection of fixed-satellite earth stations operating in adjacent bands against unwanted emissions from 12 GHz broadcasting-satellite space stations and gives the values of maximum allowable power flux-density (PFD) at the edge of the band that would produce no more than 500 pW_{0p} of interference in the worst channel of an FDM-FM carrier in the fixed-satellite service whose space station is co-located and serves the same area.

At 12.5 to 12.75 GHz, a value for a specific FSS system is shown as $-171.2 \text{ dB(W/(m}^2 \cdot 4 \text{ kHz))}$. No such limit is defined for the 12.1 to 12.2 GHz frequency band.