REPORT 946-1*

FREQUENCY-PLANNING CONSTRAINTS ON FM SOUND BROADCASTING IN BAND 8 (VHF)

(Question 46/10, Study Programme 46L/10)

(1982-1990)

1. Introduction

In order to ensure effective planning of sound-broadcasting services in the frequency range 87.5-108 MHz, it may be necessary to take into account certain constraints on the use of frequencies in order to avoid interference to other sound-broadcast transmissions within this band and to ensure compatibility with television broadcasts in the frequency ranges 47-68 MHz and 174-230 MHz.

This Report identifies the various possible interference mechanisms resulting from the technical limitations of receiver design, and also those due to constraints resulting from the transmission of several broadcast programmes from the same site.

A listing of the main interference mechanisms generated in the radio receiver is provided in § 2, and § 3 specifies those which are of importance in planning. No account is taken of interference resulting from radiation of harmonics and intermodulation products at transmitter sites, on the assumption that the broadcaster can take the necessary precautions to reduce such spurious radiation to acceptable levels.

2. Interference mechanisms arising from the characteristics of broadcasting receivers

2.1 *Local oscillator radiation*

In the following, consideration is given only to the case where the local oscillator frequency is 10.7 MHz above that of the wanted transmission, this representing the condition for the great majority of current receivers. The following interference mechanisms may occur:

2.1.1 *Radiation at the fundamental frequency*

Radiation from VHF-FM receivers may affect VHF-FM reception at frequency separations of 10.7 ± 0.2 MHz. This occurs if adjacent receivers are in use, tuned to transmissions separated by this frequency difference.

Radiation from television receivers in the range 47-68 MHz may affect VHF-FM reception. This may occur when the television oscillator frequency, which is equal to the intermediate frequency (IF) plus the frequency of the vision carrier, lies near the carrier frequency of a VHF-FM transmission. VHF-FM frequencies which may suffer possible interference are given in Table I below.

TABLE I

System	Channel	Channel limits (MHz)	Vision carrier (MHz)	IF video channel (MHz)	VHF-FM frequencies which may be interfered with (MHz)
B	3	54 – 61	55.25	38.9	94.1; 94.2
B	4	61 – 68	62.25	38.9	101.1; 101.2
D	R1	48.5 – 56.5	49.75	38	87.7; 87.8
D	R2	58 – 66	59.25	38	97.2; 97.3
I	IB	52.5 – 60.5	53.75	39.5	93.2; 93.3
I	IC	60.5 – 68.5	61.75	39.5	101.2; 101.3

* Sections 2.5 and 3.2.5 of this Report should be brought to the attention of Study Group 8.

2.1.2 *Harmonic radiation*

Second harmonics of local oscillators of VHF-FM receivers may interfere with reception of television on all channels in the range 196-230 MHz. The interfering VHF-FM frequency can be calculated using the formula

$$2(f_{FM} + 10.7) = f_{TV} \qquad \text{MHz} \qquad (1)$$

2.2 *Harmonic conversion*

In a VHF-FM receiver the second harmonic of the local oscillator may combine with television sound and vision carriers in the range 174-230 MHz to produce a frequency difference of 10.7 MHz, thereby causing interference to radio reception. The interfered VHF-FM frequency can be calculated using the formula

$$2(f_{FM} + 10.7) = f_{TV} \pm 10.7 \qquad \text{MHz} \qquad (2)$$

2.3 *Harmonics and intermodulation products generated under overload conditions in the receivers*

High input signal levels can lead to non-linearities in the input stage of receivers, giving rise to the generation of harmonics and intermodulation products. The following cases may occur:

- second harmonics of television transmissions in the range 47-54 MHz fall in the range 94-108 MHz;
- second harmonics of VHF-FM transmissions in the range 87.5-108 MHz fall in the range 175-216 MHz;
- third-order intermodulation products due to reception of more than two VHF-FM transmissions separated by equal frequency spacings occur on the frequencies of these transmissions. For example, with three frequencies f_1, f_2, f_3 such that:

$$f_2 = f_1 + \Delta f\,;\, f_3 = f_1 + 2\Delta f \qquad (3)$$

where Δf is the frequency spacing,

$$\text{then } 2f_2 - f_1 = 2(f_1 + \Delta f) - f_1 = f_1 + 2\Delta f = f_3 \qquad (4)$$

There exist additional possibilities of double or triple beats.

- The second harmonic of an interfering VHF-FH transmission separated by 5.3 or 5.4 MHz from the wanted transmission can combine with the second harmonic of the local oscillator to produce a frequency difference of 10.6 or 10.8 MHz, thereby causing interference to radio reception.
- Two transmissions with a frequency separation of 10.7 ± 0.2 MHz may give rise to interference as a result of intermodulation processes in a receiver.

2.4 *Harmonics of the intermediate frequency*

Non-linearities in the output intermediate frequency stage can produce harmonics of 10.7 MHz. The ninth and tenth harmonics (96.3 MHz and 107.0 MHz respectively) fall within the VHF-FM broadcasting band 8, and interference may result from feedback to the input stages of receivers tuned to these frequencies.

2.5 Image channel interference

The use of a receiver intermediate frequency of 10.7 MHz effectively eliminates the possibility of image channel interference arising from other emissions within the FM sound broadcasting band (87.5 - 108 MHz). However, emissions in neighbouring frequency bands, in particular the aeronautical communications band (118 - 137 MHz), may cause such interference. At critical locations, the field strength at ground level arising from aeronautical emissions may exceed 100 dB(μV/m)[CCIR, 1986-90a].

Since the image channel is some 21.4 MHz above the frequency of the wanted signal, broadcasting reception above about 96.6 MHz is potentially at risk if the approach to an airfield lies over a populated area that is close to the limit of service of a broadcasting station. Whether interference is experienced in practice depends on there being the critical frequency relationship between the broadcasting and aeronautical frequencies and on the operational use of the aeronautical frequency. As the broadcasting and aeronautical frequency plans are not normally coordinated to avoid this critical relationship, it appears desirable to provide a minimum value of some 40 dB of image channel rejection in the design of broadcasting receivers. This would be the most appropriate long-term solution.

3. Relevance of the various interference mechanisms to frequency planning

3.1 *Main constraints*

3.1.1 The use of VHF-FM transmission frequencies separated by 10.7 ± 0.2 MHz in the same area should be avoided to the extent possible (see §§ 2.1.1 and 2.3).

3.1.2 It is common practice to radiate several VHF-FM transmissions from a single site using either a common antenna or separate antennas. In the former case, the minimum possible frequency separation is determined by the design limitations of combiner units.

Today there are combining units which can operate with frequency separations as low as 800 kHz [CCIR, 1986-90b], for unit transmitter powers of 10 KW, while maintaining signal quality and minimizing intermodulation products.

However, for planning purposes in general, the minimum frequency spacings should not be less than 2 MHz, with a reduction down to 1.5 MHz accepted in special cases.

With separate antennas for each transmission, frequency spacings of less than 800 kHz may be feasible in some cases.

3.2 *Constraints of less importance*

3.2.1 It is suggested that those interference mechanisms which depend on the generation of the second harmonic of the unwanted transmission in the VHF-FM receiver need not in general be taken into account in planning. In general, such interference is only likely to occur in areas close to the unwanted transmitter, and the problem may be overcome either with improved receiver selectivity or by providing appropriate filters in the antenna lead. In the case of portable VHF-FM receivers it will often be possible to reduce the probability of overload by retracting the receiving antenna should wanted signal levels allow this.

3.2.2 Although some earlier experience has indicated that significant interference to stereo reception of transmission on 96.3 MHz may result from the mechanism described in § 2.4, a number of European countries now operate such services on this frequency with little complaint. This may also apply to the frequency 107.0 MHz. In the People's Republic of China, these frequencies are used by FM broadcasting service and no interference has been noticed [CCIR, 1986-90c].

3.2.3 The use of VHF-FM transmission frequencies for which the second harmonic of the local oscillator falls within the band occupied by a television transmission operating in the range 196-230 MHz within the same area should be avoided. In view of the severe limitations it would impose on the use of frequencies for the VHF-FM service, it is probably impractical to take this into account in planning (see § 2.1.2). Tests carried out in the People's Republic of China show that this kind of interference is fairly weak and need not be taken into account in frequency planning [CCIR, 1986-90c].

3.2.4 Although the use of equal frequency spacings can in principle cause problems as described in § 2.3 (third inset), one European country provides three stereo transmissions at equal spacings from nearly all sites providing national network services at VHF-FM. It could be desirable to avoid using equal spacings for transmitters listed close to areas of high population density. Tests carried out in a large, industrialized city with a high population density (Shanghai), using a quintuplexer and an equal carrier-frequency spacing of 1 MHz show that the transmission of five monophonic and stereophonic broadcasting programmes with this mode of operation is possible when the radiation power of the five transmitters is not greatly different [CCIR, 1986-90c].

3.2.5 In situations where image channel interference from aeronautical communications is found to be particularly troublesome, consideration may be given to:

a) a change in the frequency of either the broadcasting or the aeronautical assignment which together bear the critical relationship;

b) varying, if at all possible, the operational use of the aeronautical frequency so that emissions at critical locations are largely avoided.

3.3 *Conclusions for the planning procedure*

In the planning procedure the main constraints (§ 3.1) should be taken into account generally. Other constraints may be taken into account only in individual cases.

REFERENCES

CCIR Documents

[1986-90]: a. 10/33 (United Kingdom); b. 10/233 (France); c. 10/91 (China (People's Republic of)).

BIBLIOGRAPHY

CCIR Documents

[1978-82]: a. 10/232 (Yugoslavia (Socialist Federal Republic of)); b. 10/240 (EBU).