SECTION 1B: PRINCIPLES AND TECHNIQUES FOR SPECTRUM PLANNING, AND SHARING AND UTILIZATION

RECOMMENDATION 337-3

FREQUENCY AND DISTANCE SEPARATIONS

(Question 72/1)

(1948-1951-1953-1963-1970-1974-1990-1992)

The CCIR,

considering

a) that, in the more usual cases, the primary factors which determine appropriate frequency or distance separation criteria include:

– the signal power and spectral distribution required by the receiver;

– the power and spectral distribution of the interfering signals and noise intercepted by the receiver;

– the distance dependence of the transmission losses of the radio equipments;

b) that transmitters, in general, emit radiations outside the frequency bandwidth necessarily occupied by the emission;

c) that many factors are involved, among which are the properties of the transmission medium (which are variable in character and difficult to determine), the characteristics of the receiver and, for aural reception, the discriminating properties of the human ear;

d) that trade-offs in either frequency or distance separations of the radio equipments are possible,

recommends

1. that the frequency-distance separations of radio equipments should be calculated by the following method:

1.1 determine the power and spectral distribution of the signal intercepted by the receiver;

1.2 determine the power and spectral distribution of the interfering signals and noise intercepted by the receiver;

1.3 determine the interactive effects among wanted signals, interference and receiver characteristics for various frequency or distance separations by using the basic equations of Annex 1 along with, if necessary, simple approximations to the integral expressions;

1.4 determine, from these data, the degree of frequency or distance separation that will provide the required grade of service and the required service probability. Account should be taken of the fluctuating nature both of the signal and of the interference, and, whenever appropriate, the discriminating properties of the listener or viewer;

1.5 determine the appropriate CCIR propagation model to be used;

2. that, at every stage of the calculation, comparison should be made, as far as possible, with data obtained under controlled representative operating conditions, especially in connection with the final figure arrived at for the frequency or distance separation among radio equipments.

ANNEX 1

This Annex describes basic equations which quantify the interactive effects among wanted signals, interference, and receiver characteristics for various frequencies and frequency distance separations. The measures are:

– frequency dependent rejection (FDR) which is a measure of the rejection produced by the receiver selectivity curve on an unwanted transmitter emission spectra;

– frequency distance (FD) which is a measure of the minimum distance separation that is required between a victim receiver and an interferer as a function of the difference between their tuned frequencies;

– relative radio-frequency protection ratio *A* (see Recommendation 560) which is the difference, expressed in decibels, between the protection ratio when the carriers of the wanted and unwanted transmitters have a frequency difference of Δf and the protection ratio when the carriers of these transmitters have the same frequency.

The frequency distance and frequency dependent rejection are measures of the interference coupling mechanism between interferer and receiver and are the basic solutions required for many interference evaluations. They aid in the solution of co-channel frequency sharing and adjacent band or channel interference problems by providing estimates of the minimum frequency and distance separation criteria between interferer and receiver which are required for acceptable receiver performance.

The interference level at the receiver is a function of the gains and losses the interference signal will incur between the source and the receiver and is expressed by:

$$I = P_t + G_t + G_r - L_b(d) - FDR(\Delta f) \quad \text{dB} \tag{1}$$

where:

P_t : interferer transmitter power (dB)

G_t : gain of interferer antenna in direction of receiver (dBi)

G_r : gain of receiver antenna in direction of interferer (dBi)

$L_b(d)$: basic transmission loss for a separation distance d between interferer and receiver (dB) (see Recommendation 341)

and:

$$FDR(\Delta f) = 10 \log \frac{\int_0^\infty P(f)\,\mathrm{d}f}{\int_0^\infty P(f)\,H(f + \Delta f)\,\mathrm{d}f} \tag{2}$$

where:

$P(f)$: emission spectra density generally normalized to unity maximum power spectral density (W/Hz)

$H(f)$: receiver selectivity

$$\Delta f = f_t - f_r$$

where:

f_t : interferer tuned frequency

f_r : receiver tuned frequency.

The *FDR* can be divided into two terms, the on-tune rejection (*OTR*) and the off-frequency rejection (*OFR*), the additional rejection which results from off-tuning interferer and receiver.

$$FDR\,(\Delta f) = OTR + OFR\,(\Delta f) \qquad \text{dB} \tag{3}$$

where:

$$OTR = 10 \log \frac{\int_0^\infty P(f)\,\mathrm{d}f}{\int_0^\infty P(f)\,H(f)\,\mathrm{d}f} \tag{4}$$

$$OFR\,(\Delta f) = 10 \log \frac{\int_0^\infty P(f)\,H(f)\,\mathrm{d}f}{\int_0^\infty P(f)\,H(f+\Delta f)\,\mathrm{d}f} \tag{5}$$

The on-tune rejection also called the correction factor, can often be approximated by:

$$OTR \approx K \log \left(\frac{B_T}{B_R}\right) \qquad B_R \leq B_T \tag{6}$$

where:

B_R : receiver 3 dB bandwidth (Hz)

B_T : transmitter 3 dB bandwidth (Hz)

K = 10 for non-coherent signals

= 20 for pulse signals.