REPORT 1018-1*

CO-CHANNEL AND ADJACENT-CHANNEL COORDINATION CRITERIA FOR SIMULTANEOUS USE OF DIFFERENT MODULATION TECHNIQUES IN THE MOBILE SERVICE

(Question 72/8 and Study Programme 7B/8) (1986-1990)

1. Introduction

The United States of America has conducted laboratory and field tests comparing amplitude companded single sideband (ACSSB) to conventional FM for VHF mobile radio. The results of this study are contained in a report issued by the FCC [FCC, 1983]. Some of the information is extracted and included in Figs. 1, 2 and 3. In addition, the National Telecommunications Information Administration [NTIA, 1983] conducted some measurements, and issued a report.

In Canada, ——— a number of laboratory and field tests were carried out on ACSSB systems. These tests demonstrated satisfactory performance with regard to the quality of reception, coverage and immunity to noise. In these tests ACSSB compared favourably with FM [Bischoff and Sieb, 1982; Bonney, 1982].

During the period 1984-1987, ——— subjective and objective laboratory tests of ACSSB systems were carried out by the Communication Research Center, Department of Communications, Canada [Burke and Boucher, 1984]. Intelligibility of voice signals was evaluated for various combinations of wanted and unwanted signals, as a function of frequency separations.

A Canadian experiment was also conducted to identify the possible sharing criteria between frequency hopping (FH) spread spectrum and other mobile services.

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

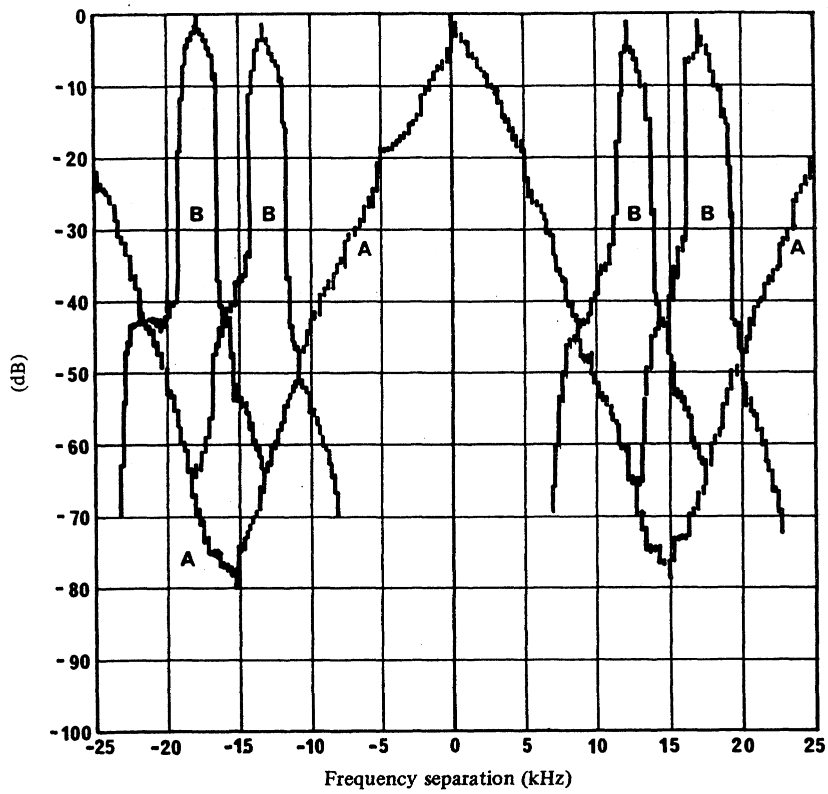

FIGURE 1 – *Superimposed spectrum emissions of FM and ACSSB, 30 kHz spaced FM, with 12.5 kHz offset ACSSB drop-ins*

Curves A: FM
B: ACSSB

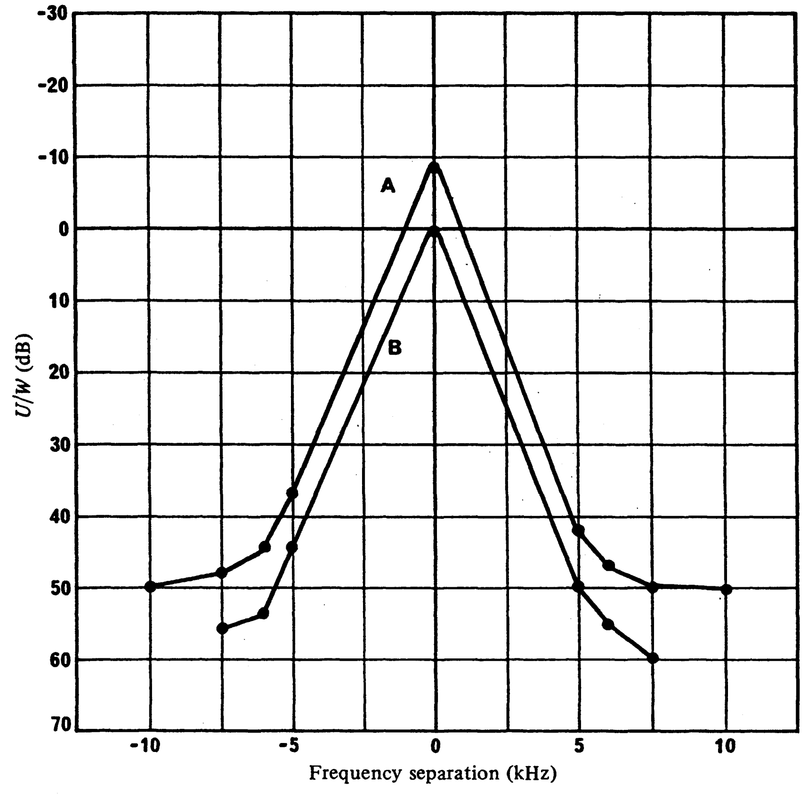

FIGURE 2 – *Unwanted/wanted ratio for ACSSB into ACSSB interference*

Curves A: just noticeable
B: disruptive

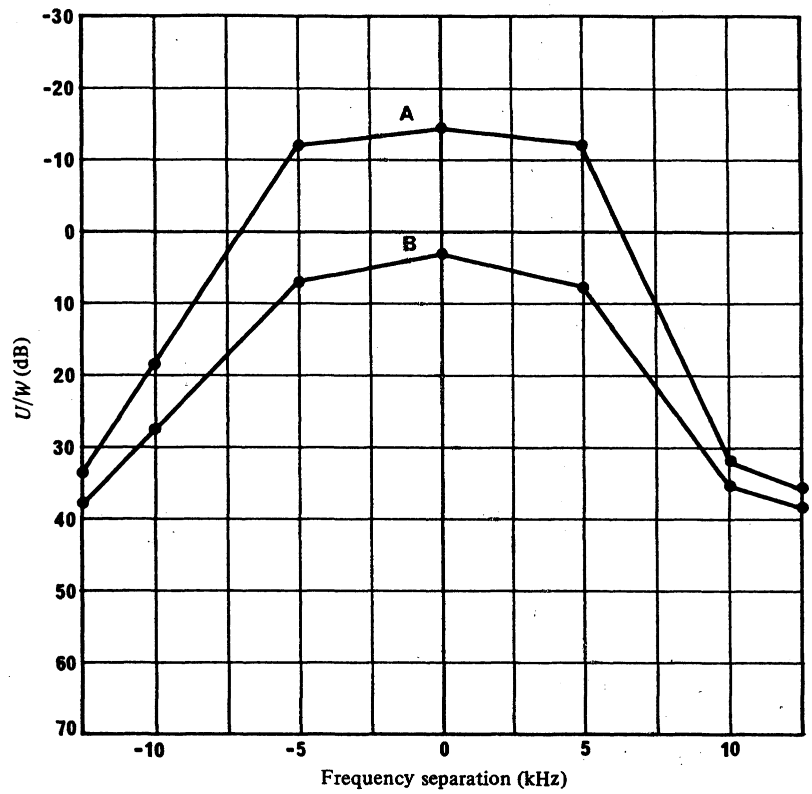

FIGURE 3 – *Unwanted/wanted ratio for ACSSB into FM interference*

Curves A: just noticeable

B: disruptive

2. Results of the United States' tests on ACSSB versus FM

Figure 1 shows superimposed spectrum emissions of FM and ACSSB systems with 12.5 kHz offset ACSSB channels between existing 30 kHz spaced FM channels. This is referred to as ACSSB drop-in channels. This causes degradation of protection to the wanted FM signal because of the full power of the adjacent ACSSB drop-in signal at the band edge of the FM channel. The intermediate frequency (IF) bandpass of typical FM receivers in use today provides only limited attenuation of signals at 12.5 kHz from centre frequency. Therefore, sufficient geographical separation would be necessary in order to place ACSSB channels (drop-ins) between existing FM channels. A typical FM system operating at 25 or 30 kHz spacing can offer in excess of 70 dB adjacent-channel protection to the wanted FM signal. With ACSSB drop-in channels, the adjacent-channel protection to the wanted FM signal could be as low as 40 dB.

The unwanted to wanted (U/W) ratios for an ACSSB signal from an unwanted ACSSB signal are shown in Fig. 2. The data in Fig. 2 were taken at co-channel, ± 5 kHz, ± 6 kHz, ± 7.5 kHz, ± 10 kHz and ± 12.5 kHz offsets. The data taken beyond 7.5 kHz was limited by the test set-up. The U/W ratio may be greater than 50 dB beyond 7.5 kHz. A positive U/W value indicates that the unwanted signal is stronger than the wanted signal.

The U/W ratios for an FM signal from an unwanted ACSSB signal are shown in Fig. 3. The data in Fig. 3 were taken at co-channel, ± 5 kHz, ± 10 kHz, ± 12.5 kHz offsets. The data shown for both tests represent the average values of what the observers individually obtained. The average difference in data logged between observers was less than 1 dB for "just noticeable" and less than 0.5 dB for "disruptive".

To determine the unwanted to wanted ratios, the wanted channel attenuator in the receiver test area was adjusted for the appropriate test level at the receiver. For each test, the unwanted channel attenuator was adjusted by the observer for "just noticeable" interference, and the difference between attenuators recorded. The unwanted channel attenuator was then adjusted by the observer for "disruptive" interference, and the difference between attenuators recorded. This procedure was repeated for all five wanted levels.

Just noticeable was defined as interference which is detectable but would not be observed if the interfering signal was reduced slightly in level (1 dB).

Disruptive was defined as interference which caused some words to be garbled, requiring occasional repeated message transmissions. Using random sentences with an average length of six words, two or more garbled words in three consecutive sentences was the criterion used to require a repeated transmission.

Any channel plan based on the *U/W* ratio will need to take account of the frequency stability of the interfering transmitter, and the victim receiver. The selectivity characteristics of the receiver will also affect the *U/W* ratio. Development and field testing will continue in the United States of America.

3. Results of the Canadian tests on ACSSB versus FM

3.1 *Criteria used for interference protection*

3.1.1 *Interference protection ratio (objective tests)*

The "interference protection ratio" is the ratio (in decibels) of the interfering signal relative to the wanted signal level present at the receiver input that would result in degradation in the SINAD at the receiver from 12 dB to 6 dB. The desired signal was modulated with a 1 kHz tone while the interfering signal was modulated with voice.

3.1.2 *Disruptive interference (subjective tests)*

"Disruptive interference" is that level of interference which will result in some words being garbled, requiring some occasional repeat of message transmission. Both wanted and interfering signals are modulated with voice.

3.1.3 *"Disruptive interference ratio" (subjective tests)*

The "disruptive interference ratio", with the wanted signal level adjusted to the same level as the 12 dB SINAD, is the ratio of interfering signal relative to the wanted signal that would result in disruptive interference conditions.

3.2 *Results for ACSSB to FM and FM to ACSSB interferences*

The critical values of relative interfering signal strength to produce objective and disruptive interferences for the ACSSB and FM units are summarized in Table I. Figures 4 and 5 show the results for disruptive and objective interferences, respectively.

TABLE I

Interference	Frequency Separation (kHz)	Objective Interference Protection Ratio (dB) (desired channel modulated with 1 kHz tone)	Disruptive Interference Protection Ratio (dB) (desired channel modulated with voice)
ACSSB to FM	7.5	3	4
	12.5	45	42
	15.0	60	57
	20.0	72	73
FM to ACSSB	7.5	26	28
	12.5	63	57
	15.0	72	70
	20.0	83	80
	25.0	85	87

3.3 *Results for ACSSB to ACSSB, and FM to FM interferences*

The results of the tests for objective and disruptive interference protection ratios for ACSSB to ACSSB and FM to FM interferences are given in Table 2. Figures 4 and 5 show the protection ratio (dB) for subjective disruptive and objective interferences, respectively.

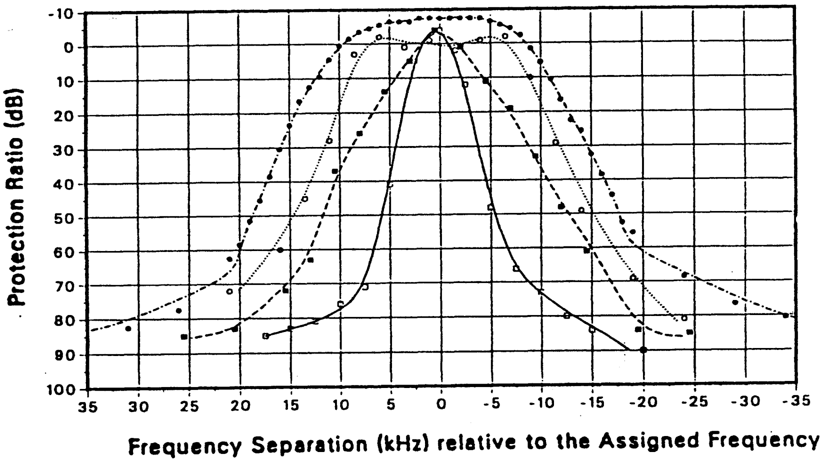

FIGURE 4

Objective 12 to 6 dB SINAD with Voice Interfering

LEGEND

▫ ACSSB into ACSSB
▪ FM into ACSSB
• ACSSB into FM
• FM into FM

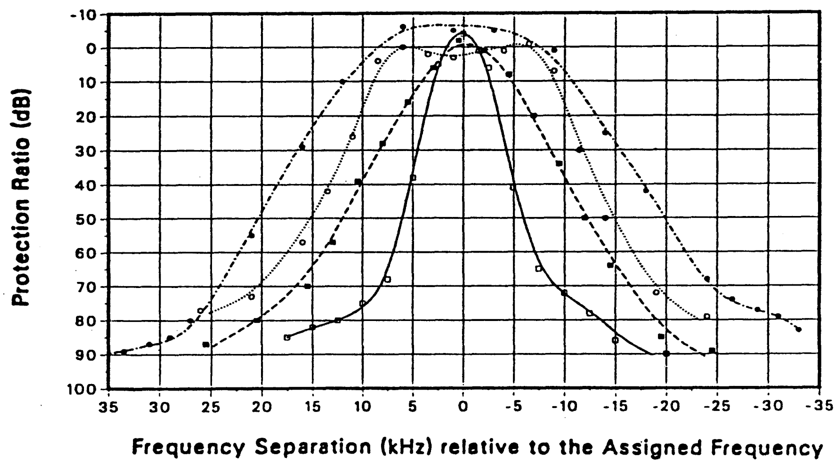

FIGURE 5

Subjective Disruptive Interferences

LEGEND

▫ ACSSB into ACSSB
▪ FM into ACSSB
• ACSSB into FM
• FM into FM

TABLE II

Interference	Frequency Separation (kHz)	Objective Interference Protection Ratio (dB) (desired channel modulated with 1 kHz tone)	Disruptive Interference Protection Ratio (dB) (desired channel modulated with voice)
FM to FM	11	9.5	10
	15	30.5	29
	20	62.5	55
	25	77.5	73
	30	83.0	87
ACSSB to ACSSB	2.5	5.0	5
	5.0	41.0	38
	7.5	71.0	68
	12.5	81.0	80
	15.0	83.0	82
	17.5	85.0	85

4. Canadian measurements of protection ratios from frequency (FH) hopping spread spectrum

Measurements were conducted to identify co-channel interference criteria applicable to the land mobile service operating in the 30-50 MHz band. Three commercial FM receivers, having channel spacings of 20, 50 and 25 kHz respectively, were used in the measurements. Signal-to-interference (S/I) protection ratios for co-channel operation were measured using the just perceptible (JP) and non-intelligible (NI) interference criteria which are respectively about equivalent to the MINIT and 0.3 AI, as defined in Reports 526 and 525. The results of these measurements are reported in detail in Report 826.

The experimental evidence indicates that large propagation losses are required to protect an FM receiver against the just perceptible level of FH co-channel interference. On the other hand surprisingly small propagation losses are required to protect against the non-intelligible harmful interference level. Moreover, considering that present land mobile users of the 30-50 MHz band use analogue transmission techniques, an interference of 10 ms duration, such as the one used in the Canadian experiment, will not be annoying if it does not occur too often. For a given land mobile channel, interference from one source was present on average 0.4% of the time so that a land mobile system (analogue voice) can tolerate a greater number of FH sources, the maximum number being determined by the desired grade of service.

This experiment did not attempt to evaluate the impact of FH interference on digital systems nor did it study the relationship between the number of FH interference sources and the degradation of a land mobile signal.

It should be noted that the degradation is additive, in the sense that the simultaneous operation of n frequency hopping transmitters will increase the duty cycle of the interference by a factor n. Finally, values given by Recommendation 478 have to be kept in mind (spurious emissions on discrete frequencies are limited to 2.5 µW or to 70 dB below the carrier power).

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