

RECOMMENDATION 734

THE APPLICATION OF INTERFERENCE CANCELLERS
IN THE FIXED-SATELLITE SERVICE

(Question 58/4)

(1992)

The CCIR,

considering

- a) that one of the principal limitations in achieving greater utilization of the RF spectrum and geostationary orbit for the fixed-satellite service (FSS) is mutual interference among satellite networks operating in common frequency bands and serving the same or adjacent geographical areas;
- b) that inter-satellite network interference protection is primarily achieved by earth-station antenna discrimination;
- c) that other techniques such as frequency re-use, improved modulation, higher power satellite transmitters and lower noise receivers may be used to increase communication capacity;
- d) that some of these techniques increase the susceptibility of satellite networks to mutual interference;
- e) that the deleterious effects of some of these techniques may be reduced through the employment of interference cancelling devices;
- f) that the basic principle of interference cancellers is to construct a replica of an interfering signal in both amplitude and phase, and to phase invert the replica and add it to the wanted signal plus interference,

recommends

- 1. that interference cancellers should be used, where cost effective, in satellite communication systems to reduce interference or the effects of interference.

Note 1 – Some examples of interference cancelling techniques are discussed in Annex 1.

ANNEX 1

A survey of interference cancellers for use in the fixed-satellite service

1. Examples of interference cancellers

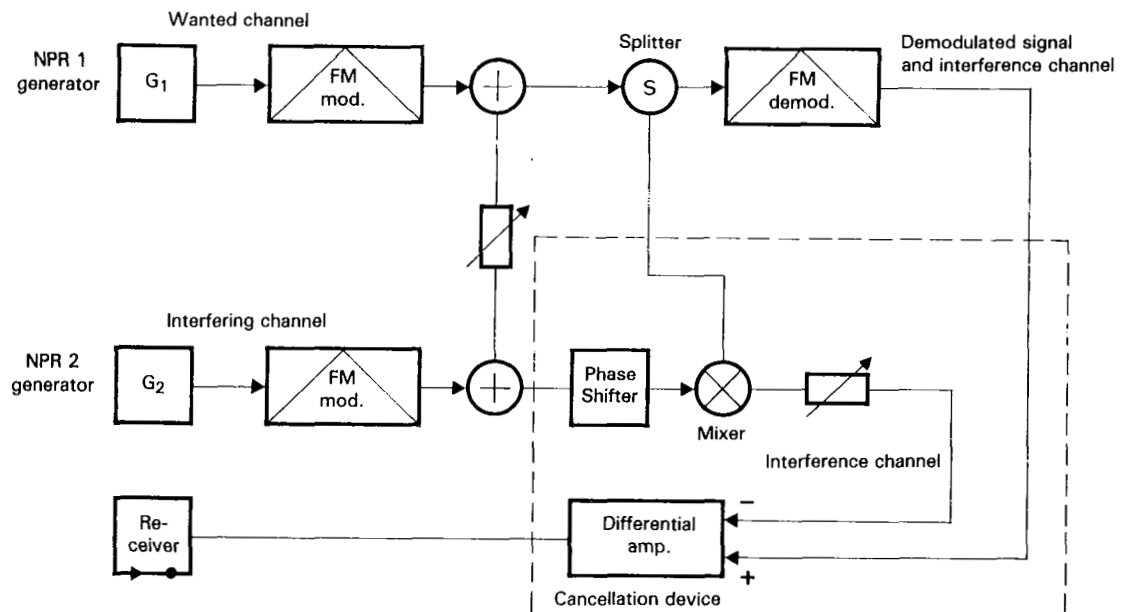
A few examples of these techniques reported in the technical literature are described below. The results obtained by the various investigators were in the absence of any significant thermal noise.

1.1 Baseband interference cancellers

For angle-modulated carriers, a method of interference cancellation at baseband has been achieved by mixing wanted and interfering RF signals into the experimental system depicted in Fig. 1. It should be noted that this approach requires that the interference be received directly as the input for the interfering channel. This can be achieved by having a separate antenna directly facing the interference source. The interference signal is mixed with the wanted carrier at RF or IF. The low frequency components resulting from this process were shown to be the replica of the

baseband interference. Cancellation was achieved by subtracting this replica from the demodulated baseband signal plus interference. Laboratory tests showed this method reduced interference by about 15 dB for a wide range of operating parameters.

FIGURE 1
Block diagram of test set-up



In cases where a separate interfering signal is not available for purposes of control or reference, another technique has been proposed for angle modulation signals. In this approach, the information contained in the envelope waveform of the combined wanted and interfering carriers is used to reconstruct the baseband interference. For effective cancellation, the interference source should be separated from the wanted carrier by the sum of the highest modulating frequencies. Analysis and experiments revealed that the detected envelope of the desired carrier plus the interfering carrier is equal to the demodulated interference component shifted by plus or minus 90° . Once identified, the interference can be removed by subtraction. As much as 15 dB of interference reduction was achieved for a range of tested parameters (frequency separation, carrier-to-interference ratios, and modulation indices). The best results occurred at the lower modulation indices and larger carrier frequency separations.

For frequency modulation (FM) signals where the interfering signal is small and cannot be received separately, it is possible to detect the interference at baseband with a crystal detector. A pure FM signal has a constant envelope and the addition of interference results in amplitude modulation which can be detected, and thus removed by subtraction. However, in laboratory tests, this technique was successful in cancelling only those interference components which had not experienced spectral foldover. Since only the first order component can be assured of cancellation, the interference must be small compared to the wanted FM signal.

The higher order terms become troublesome if the interference power is significant. They limit the degree of interference cancellation which can be realized in a baseband cancellation technique since the phasing required to cancel the first order term is not the same as that required to cancel the higher order terms. A preferable approach in these circumstances is to cancel interference at RF or IF prior to demodulation, where all orders of the baseband interference spectrum are suppressed.

1.2 *Cancellation at IF*

Another technique investigated for FM systems was to subtract the IF or RF spectra of an interfering signal prior to the receiver demodulator as shown in the test set-up of Fig. 2. It was assumed in this case that the interfering signal was available separately. It should be emphasized that the auxiliary channel (interference only) required "virtually identical" down conversion and filtering as the main channel (wanted signal plus interference). Also, the electric lengths for the interference signal in the two channels had to be nearly identical in order that the modulation on the two signals at the cancellation point was coherent. Phasing of the cancellation signal was refined with a variable phase shifter. Test results showed that the IF interference spectrum was reduced by approximately 25 to 30 dB across the IF filter bandwidth. The advantages of this technique were:

- simplicity,
- first order and higher order terms are cancelled simultaneously,
- cancellation was possible with any value of C/I ,
- lower impulse noise was experienced compared to baseband cancellation methods.

1.3 *Interference suppression bridge*

Another passive technique, demonstrated in laboratory tests, uses a bridge network to suppress the interfering signal at the receiver with an auxiliary signal derived from an interference channel. A simplified block diagram of this set-up is shown in Fig. 3. Ideally, the bridge circuit output phase angle must remain at 180° and the power amplitude must remain equal to the interference across the desired frequency band and continuously with time. The objective of the test was to determine the performance of the system for various phase angle and power amplitude errors generated by the bridge.

Tests were conducted using a signal tone at approximately 3 807 MHz and interfering signals at $3\,809 \pm 4.5$ MHz and 3 950 MHz. Suppression of the interfering signals from 15 dB to 50 dB was achieved with this technique, the latter associated with relatively narrow band interference signals under clear weather conditions.