Co-channel interference: How bad is it?

By Harold Kinley, CET

With the overcrowded land mobile radio frequency spectrum, interference has become the rule, rather than the exception.

Years ago, it was common for land mobile radio users to operate strictly carrier squelch. Although some users still get by with carrier squelch systems, their numbers are dwindling rapidly, and the time is fast approaching when it will be virtually impossible to operate without some kind of coded squelch system, digital or tone.

Classes of interference

Basically, interference can be classified as either of two types, *nuisance* or *destructive*.

Nuisance interference is heard in the absence of desired signals, but it does not significantly degrade the desired signal.

Destructive interference causes serious degradation to or even blocks the desired signal.

Although a coded squelch system does alleviate most of the *nuisance* interference problems, it is *not* the great panacea that it is perceived to be by most non-technical, and even some technical, people. It does nothing to alleviate problems caused by destructive types of interference.

Even nuisance interference can become harmful if allowed to go *untreated*. For example, a user who is constantly annoyed by noise or other undesirable signals often will turn down the radio's volume control or adjust the carrier squelch control to the maximum position, thus seriously desensitizing the receiver to even the desired signal transmissions.

At this point, the nuisance interference has become harmful. A coded squelch system is the logical solution to this type of interference.

There is not much use in crying to the FCC about nuisance interference *unless* it is caused by an improperly or illegally operating transmitter that you can identify. You will not get much sympathy, especially if you are operating carrier squelch only.

Destructive interference is another matter.

Normally, great care is taken by the duly authorized frequency coordinators to eliminate or greatly reduce the likelihood of interference between two users operating on the same frequency.

In spite of the best efforts to avoid interference between co-channel users, problems often occur. Most of the

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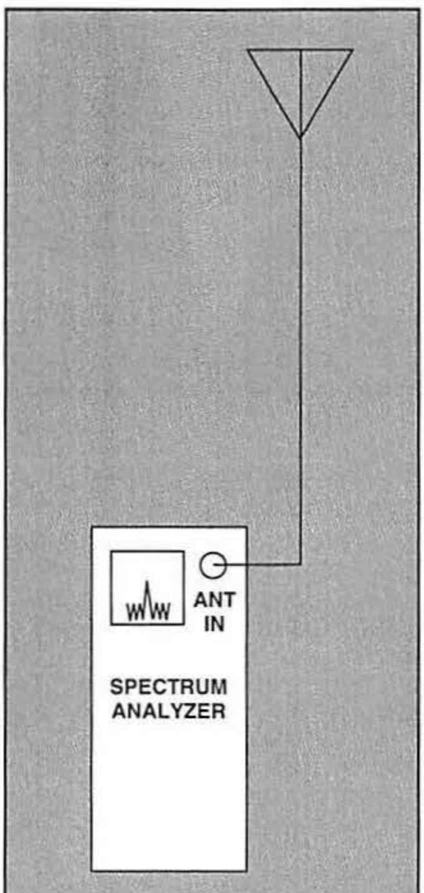

Figure 1. This simple setup can be used to measure the offending interfering signal's amplitude. The spectrum analyzer must be capable of *absolute* (dBm) measurement and not the simple *relative* dB indications on some imitation spectrum analyzers that are a part of some service monitors.

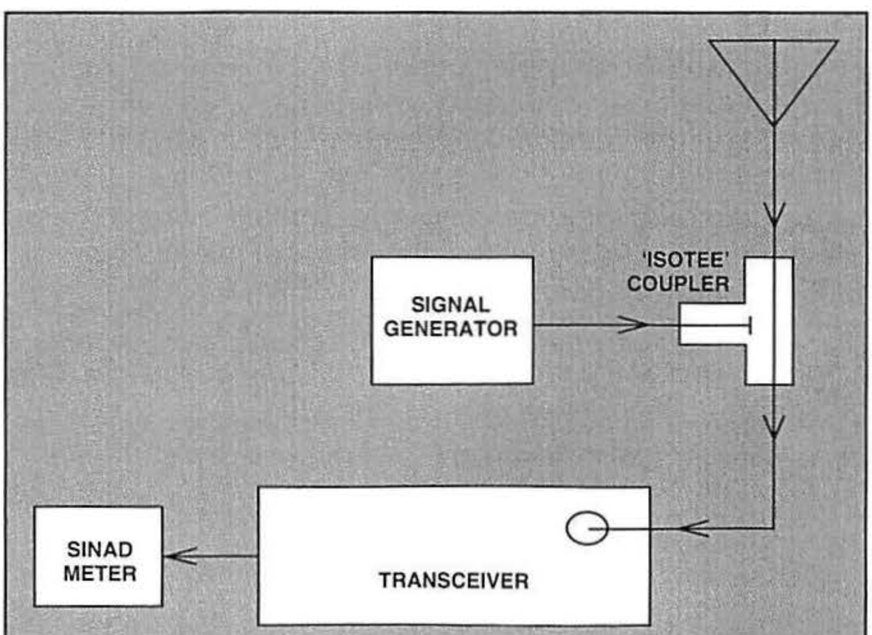

Figure 2. This setup can be used to measure the actual amount of degradation that the interfering signal causes to the desired signal. For example, suppose that in the absence of the interfering signal, a generator output level of −60dBm is required to produce the 12dB SINAD level. Also suppose that in the presence of the interfering signal, the generator output must be increased by 20dB to −40dBm to return the SINAD meter reading to 12dB SINAD. This means that the interfering signal is *degrading* the desired signal by 20dB.

Formula 3

$$\mu V/m = \text{antilog}\left[\frac{20\log(\mu V) - G_R + 20\log F + L_L - 32}{20}\right]$$

Formula 4

$$\mu V/m = \text{antilog}\left[\frac{dBm - G_R + 20\log F + L_L + 75}{20}\right]$$

where

μV = signal level at receiver input in microvolts

dBm = signal level at receiver input in decibels above 1mW

G_R = antenna gain of the receiving antenna in dBd

L_L = line loss in decibels

F = frequency in MHz

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problems are of the nuisance type and can be solved by using different codes on coded squelch systems.

Compromising solutions

With destructive interference, a different approach is required. The best method of combatting co-channel destructive interference is for the two co-channel users to meet and to work out an arrangement that is mutually beneficial and acceptable to both parties.

Some of the factors that might be adjusted to minimize interference include the antenna height, antenna gain, antenna orientation, transmitter and antenna location, and transmitter power. It may be necessary to try a combination of several of these methods to effect a satisfactory solution.

Last resort

Obviously, if all else fails, it will be necessary to request intervention from the FCC.

Such a request should be avoided if at all possible. If it is necessary, then you should be well prepared with documentation to show that the other party is indeed causing destructive interference to your radio system.

Logs showing dates and times of the destructive interference might prove helpful. Tape recordings of transmissions being blocked by the offending signal are useful in proving a case of blocking or serious degradation of the desired signal.

You should have plenty of recorded signal level readings on different dates and times for the FCC's examination and consideration.

Signal level measurements

The simplest method of measuring the offending signal's level is to use a spectrum analyzer as shown in Figure 1 on page 8.

Most spectrum analyzers measure signal level in dBm units. If you want to convert dBm units to microvolts, use the following formula:

$$\mu V = \text{antilog}\left[\frac{\text{dBm} + 107}{20}\right]$$

(1)

Example: Suppose, using the setup in Figure 1, the signal level was found to be −90dBm. Substituting into the formula, we have:

$$\mu V = \text{antilog}\left[\frac{-90 + 107}{20}\right]$$

$$= \text{antilog}\left[\frac{17}{20}\right]$$

$$= \text{antilog}\ [0.85]$$

$$= 7.08\mu V$$

(2)

This is the signal level at the spectrum analyzer input, and it would be the same at a receiver input.

Receiver method of measurement

Another way to determine the signal level at the receiver input (when metering points are provided) is to check the meter reading at the IF metering point with the signal on the air.

Record the meter reading for reference. Then, connect a signal generator to the receiver input and adjust the generator level to produce the same meter reading. Read the signal generator level in microvolts or dBm. This is the signal level of the interfering signal.

Converting to μV/m

To convert the signal level at the receiver input in microvolts or dBm to *field strength at the antenna* in microvolts per meter (μV/m), use formula (3) or formula (4), as appropriate, in the box on page 46.

Example: The signal level in microvolts at the receiver input is 1.5μV. The antenna gain is 6dB, and the transmission line loss is 3dB. The frequency is 160MHz. What is the field strength at the antenna in microvolts per meter?

Solution: Use Equation (3) and substitute:

Formula 5

$$\mu V/m = \text{antilog}\left[\frac{20\log(1.5) - 6 + 20\log(160) + 3 - 32}{20}\right]$$

$$= \text{antilog}\left[\frac{3.52 - 6 + 44.08 + 3 - 32}{20}\right]$$

$$= \text{antilog}\left[\frac{12.6}{20}\right]$$

$$= \text{antilog}\,[0.63]$$

$$= 4.27\mu V/m$$

If the signal level at the receiver input were in dBm, you would use Equation (4) on page 46 to find the field strength in microvolts per meter at the antenna.

To determine how much the interfering signal is degrading the desired signal, use the equipment setup shown in Figure 2 on page 8.

The *isotee* is a homemade coupling device that is very lossy and has a negligible loading effect on the line. It is made by removing the center pin from a T-connector, cutting it off short and then reinserting it into the T-connector.

Then the female-female UHF adapter is attached to the T-connector. Because the T-connector's pin has been cut off, no direct contact is made between the double-female UHF adapter (barrel) and the T-connector; nevertheless, RF leakage within the connector provides some degree of coupling with considerable isolation between the signal generator and the line. Similar isolation couplers can be made with other types of RF connectors.

Measurement procedure

(1) With no incoming signal from the antenna and with the signal generator set to the correct frequency and modulated at ±3kHz deviation, set the generator level to produce 12dB SINAD. Record the generator level in dBm. (It will take a high signal level to produce 12dB SINAD because of the loss or isolation of the isotee.)

(2) Wait for the interfering signal to make an appearance. When the interfering signal appears, increase the signal generator level to return the SINAD meter reading to 12dB SINAD. Record the new signal generator level.

(3) The difference between the generator levels in steps 1 and 2 in decibels is the amount of degradation the interfering signal is causing to the desired signal.

If your radio system operates at consistently stronger signals than the *minimum usable signal level* (12dB SINAD), then you might choose a higher input level as the reference. For example, 1μV might be a good choice if your signals are always this strong. Of course, the measurement would indicate less degradation at 1μV than it would at the 0.3μV level, for instance.

This information should help you to establish the magnitude or the severity of the interference problem. The severity of the interference may vary from day to day and time of day. If the problem occurs frequently and with severe degradation, it can render your radio system very unreliable.

But before taking your case to the FCC, arm yourself with information and documentation.