Use coaxial filters to reduce interference

Public safety base stations in rural communities sometimes are subject to interference when co-located dispatching radios are used simultaneously. Simple filters can help as temporary remedies and to isolate causes.

By Donald E. Koehler

Inexpensive phasing harnesses described in the July 1992 issue* brought to mind another use for reactance in coaxial cables—coax stub filters.

Using stub filters can save money that otherwise might be spent on commercial filters when they are used temporarily while an interference problem is investigated. Let's review some uses for stub filters and general interference troubleshooting for the field technician.

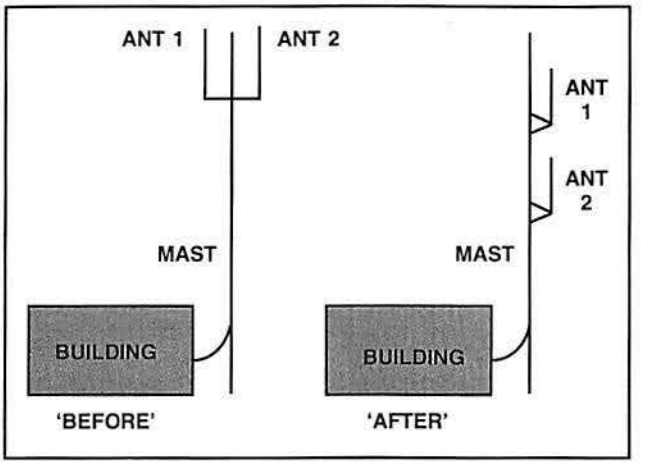

Figure 1. One possible interference solution is to stack the offending antennas vertically a few feet apart, one over the other and on a common mast or mount to provide as much as 20dB of attenuation.

Public safety agencies in rural communities often face equipment problems, budget limitations and staff shortages. Although many agencies operate successfully under austere conditions, reducing costs reflects positively on the service they provide. Many small communities operate two-way radio, paging and dispatching functions from a single facility or room. Police officers, firefighters, ambulance crews and even, in some cases, road maintenance workers are centrally controlled and dispatched from these facilities.

In most cases these services operate radios on different frequencies or band segments in the VHF and UHF spectrum. Simultaneous use of these radios can result in interference.

Before purchasing what may be an expensive commercial filter to remove an offending signal, try a few virtually cost-free remedies.

'Free' remedies

First, check for bad coaxial cable and connectors.

On low-cost systems, the temptation to skimp on coax or fittings during installation may have been too great to resist. Stacking the offending antennas vertically a few feet apart, one over the other and on a common mast or mount, can provide as much as 20dB of attenuation. (See Figure 1 above.)

Ensuring that the ground system is a continuous, unspliced conductor run to a common tie point helps to eliminate possible common mode interference sources. This tie point must be connected to a low-resistance ground.

Double-check this ground point with a temporary ground rod and spectrum analyzer if you do not have a dedicated ground tester. You may see that the ground isn't *clean*. If so, the external ground and tie point can be replaced or serviced.

If the interference persists after trying these less expensive remedies, try the stub filter.

Filtering

Interference problems often are solved with a commercial tunable cavity or with crystal bandpass filters.

When the interference is limited, intermittent or when it appears on a single channel, a lower-cost option is available. The use of a coaxial cable stub filter may reduce the interference sufficiently. In addition, it may be used temporarily to reduce the problem until a commercial filter can be installed.

Once in a while, the stub filter is enough to fix the problem.

The coaxial stub filter is used as a receive notch filter. The filter attenuates the undesired signal, allowing the desired RF energy to reach the radio set.

Although assembling the stub filter is easy, tuning the filter to the correct frequency requires a spectrum analyzer and tracking generator or signal generator. A small amount of math allows you to cut the filter to an approxi-

*"Combining and Phasing Land Mobile Base Antennas" by Brian Henderson, P.Eng.

Koehler is a technical writer; technical resource researcher; and computer, communications and database specialist for Hartec Management Consultants, Anchorage, AK.

mate length. Then, the test equipment helps you to trim the filter to the exact length of coaxial cable needed.

The formula for a quarter-wavelength of cable is as follows:

$$L = (246)(VF)/f$$

where

L = length in feet

f = frequency in MHz

VF = the cable's velocity factor.

Multiply L by 12 to convert the cable measurement to inches.

Table 1 on page 14 gives the velocity factors for common types of cable.

If a quarterwave coaxial stub is left open, it appears as a series resonant circuit. When measured with a tracking generator and spectrum analyzer at its resonant frequency, the stub exhibits a low reactance.

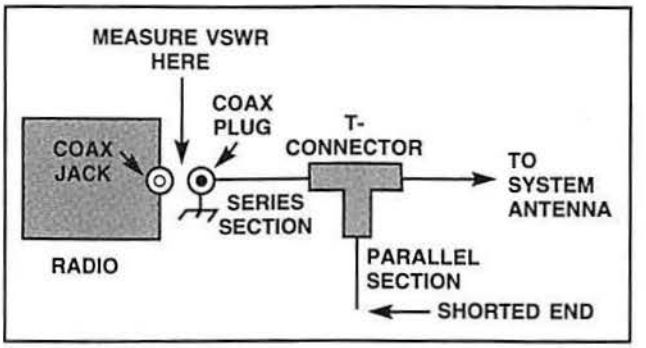

Figure 2. The shorted stub coax filter looks like a T with one upper arm broken off. The two coax 'sections' are cut to length using the formula in the text.

When one end of the same stub is short-circuited and the stub is re-measured in the same way, it appears as a parallel resonant circuit. The shorted stub then exhibits a high reactance at its resonant frequency.

Thus, the shorted stub can be used to eliminate interference.

Making the filter

To make a shorted stub coax filter, assemble a coax "section" with a connector at each end and another "section" with a connector at one end only. Using the formula to calculate the approximate length for the desired frequency, cut two "sections" of 50Ω coaxial cable.

Assemble connectors on both ends of one measured piece of cable. This "section" of cable with two connectors is used to attach the filter to the communications equipment.

On the other measured section, assemble only one connector. These two sections mate to a T adapter. First, attach the cable with two connectors to one end of the coax T fitting, leaving the other two sides open. Then, take the cable with only one connector and connect it to the bottom of the T fitting, 90° from the first.

The result should look like a T with one upper arm broken off. (See

Figure 2 on page 13.)

Tuning the filter

To tune the stub filter, use a spectrum analyzer, a tracking generator or signal generator, and a calibrated cable. The calibrated cable is the one you normally use with the spectrum analyzer; it is a cable known to be *flat*, that is, without significant attenuation, in the filter's operating frequency range.

Attach the filter cable to the spectrum analyzer. Attach the calibrated cable to the open end of the filter T fitting from the tracking or signal generator and look at the notch produced by this filter arrangement as displayed on the analyzer. With filters I have built using this method, the notches are both deep and easy to see.

To adjust the filter exactly to the interfering frequency, trim the bottom of the stub on the filter. Remember, the interfering signal is the one to notch out, so the filter should be made so it causes no problems on the transmit frequency. Check the antenna cable SWR at the radio, ahead of the filter, just to be sure.

Table 1—Common coaxial velocity factors.

CABLE	VELOCITY FACTOR	TYPE
RG-8X	75	Foam
RG-8	66	PE
RG-8	80	Foam
RG-58	66	PE
RG-58	79	Foam
RG-58A	66	PE
RG-213	66	PE
RG-214	66	PE

As you tune the filter, take a moment to look at the difference opening and shorting the trimmed end of the filter makes on the spectrum analyzer display. If you have the time to spare, remove the other cable (the one with the double connector that you assembled) and see the difference it makes.

These two pieces of cable make up both series and parallel resonant sections of the filter. Testing these cables makes a good training demonstration for students or new technicians who cannot quite grasp the concept of resonance.

Coaxial stub filters are not intended to replace commercial, tunable filters; nevertheless, most technicians carry enough surplus parts in the field to make this kind of a filter as a temporary remedy for an interference problem.

This type of filter has been used several times to put an airfield communication system back on line while the cause of interference was being determined.

The coaxial stub filter sometimes can be used to demonstrate to a customer that a communications problem is external to the system. Moreover, a stub filter can provide a temporary solution to the problem before a purchase order is signed.