HAM RADIO

Improving Reception In Crowded VHF/UHF Bands

By Joseph J. Carr, K4IPV

When I first got into ham radio many years ago, the VHF and UHF bands from 50 MHz (6 meters) and up were darn near dead. You could tune for an hour or more and not hear another station on "two," at least in some areas.

In those days, we used a motley collection of home-brew equipment (a 2-meter downconverter ahead of a 14- to 19-MHz general-coverage shortwave receiver, for example), Heath "Benton Harbor Lunch Boxes" (a low-power rig with a squawking super-regenerative receiver), and Gonset Communicator II/III rigs. The latter were the cream of the crop for many of us. They used a moderately low-power transmitter based on the 2E26 tube (little brother to the 6146B) and a real super-heterodyne receiver. Tuning the transmitter was aided by a "magic eye" tube on the Communicator II (closing the eye was peaking the RF), or by a small relative RF-output meter on the Communicator III.

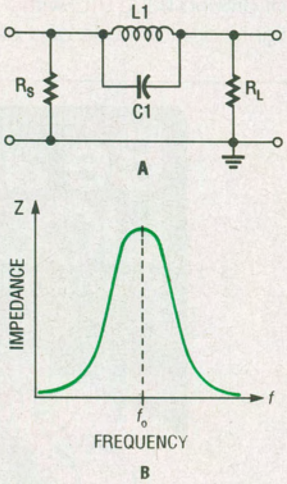

Fig. 1. A parallel-resonant wave trap (A), which has a very high impedance at its resonant frequency, will block the offending signal when placed in series with the signal line. Its impedance curve is shown in B.

Regardless of the rig, we could tune for a long while and not hear any other station, especially out west where amateur stations were fewer and further between than in the east. Even in Virginia, I can recall when two or three contacts was a good night on two-meters.

Another limitation on VHF/UHF operation was that it was essentially line of sight. In other words, signals propagated only a little ways beyond the horizon—however that is defined given the heights of the antennas of the two stations. Operation was what we now call *simplex* (improperly, by the way), with stations either receiving and sending on the same frequency, or on inverted frequencies (*i.e.*, I might use *f*1 for transmitting, and *f*2 for receiving, while you would use *f*2 for transmitting and *f*1 for receiving). The latter mode was used because we tended to have tunable receivers, but crystal-controlled transmitters.

But that changed radically. About 25-years ago, Ken Sessions and a bunch of other W6-land amateurs started the repeater revolution. In repeater systems, all users, whether mobiles, portables, or fixed stations, use the same pair of frequencies; call them *f*1 for transmitting and *f*2 for receiving. A repeater station would have exactly the opposite arrangement: *f*1 for receiving and *f*2 for transmitting.

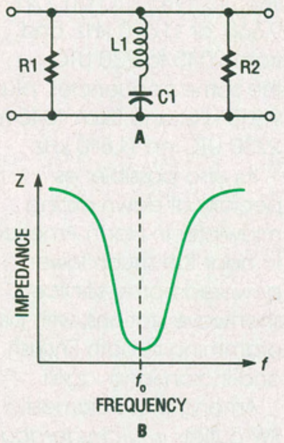

Fig. 2. A series-resonant wave trap (A), which has a low impedance at its resonant frequency, will snuff the offending signal when shunted across the line. Its impedance curve is shown in the illustration in B.

In that arrangement, an automatic (or semi-automatic, since there was a control operator) repeater would pick up weak signals from all users, and retransmit them on a frequency that they could all hear. In that way, a repeater that was properly sited (a high antenna located on a hill or tall building) would allow hams to communicate over a much larger range than would normally be possible with simplex operation.

Today, there are not only 2-meter repeaters, but they are also on the other VHF/UHF bands as well. Repeaters are operated by amateur-radio clubs, as well as many hundreds of individuals, all across the country. It is almost impossible to drive somewhere without being within range of some ham-band VHF/UHF repeater.

All of that VHF/UHF operation is heartening, and it helps us to maintain our

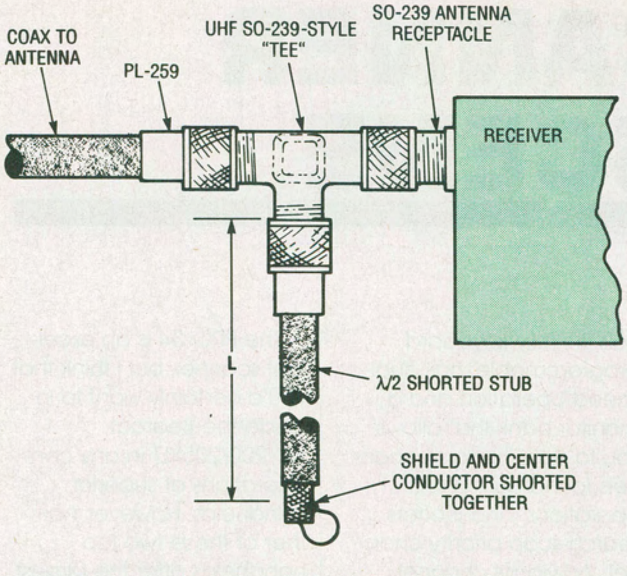

Fig. 3. With a half-wavelength shorted stub, like this one made from coaxial cable, connected at the antenna input of the receiver, the load impedance will be "reflected" every half wavelength along the line. When the line is exactly an electrical half wavelength, the input impedance looking into the line is the same as the load impedance.

bands in a hostile "grab-em" environment (and believe me, dear ham, commercial interests covet our bands). But there is a little problem with all of that activity: interference. The most obvious interference is co-channel mush; *i.e.*, when another station attempts to use the same frequency or frequency pair and it results in what the CB'ers call being *stepped on*. There is little we can do about that, save coexist.

Another form of interference is intermodulation. That's when two signals are mixed together in a non-linear circuit, resulting in a complex output-frequency spectrum that contains the sum and differences of the original frequencies, plus the sum and differences of all of their significant harmonics. The general formula is:

$$f_{\text{out}} = mf1 \pm nf2$$

where $f1$ and $f2$ are the two interfering frequencies, f_{out} is the output frequency spectrum, and m and n are integers (1, 2, 3, and so on). In other words, equation 1 tells us that there can be an immense number of possibilities.

For example, suppose you are not too far from an FM-broadcast station on 105.1 MHz. Further, suppose that there is a local repeater on 146.94, and a landmobile transmitter on 462.24 MHz. The third harmonic of the FM station is $mf1 = 3 \times 105.1 = 315.3$ MHz. The harmonic can be generated in your receiver front-end because of overload, even when the original signal is clean. When the third harmonic is mixed with the 462.24-MHz signal, the difference frequency is 462.24 MHz − 315.3 MHz = (you guessed it!) 146.94. In other words, you would hear one or both signals on the two-meter repeater frequency.

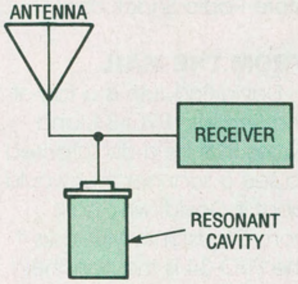

Fig. 4. In UHF systems, a cavity resonator—which acts very much like a shorted, half-wavelength stub—can be used to eliminate an offending signal.

In some urban and suburban areas, that situation is further complicated by dozens, scores, and even hundreds of transmitters in relatively small areas.

WHAT TO DO?

How can you keep that situation under control? Well, one thing is to buy a good receiver with a wide dynamic range (providing freedom from overload) and a tuned (selective) front-end. After that's done, however, some people will still suffer intermodulation problems. There are still some neat tricks for them, all of which involve eliminating one or both of the offending frequencies from the receiver.

One solution that is useful on six-meters (the FM-broadcast band) and on two-meters, if done right, is the wave trap. Figure 1 shows a parallel-tuned wave trap, while Fig. 2 shows a series-tuned wave trap. A parallel tuned circuit has a very high impedance at its resonant frequency, so it will block the offending signal when placed in series with the signal line. On the other hand, the series resonant circuit has a low impedance at its resonant frequency, so will snuff the offending signal when shunted across the line. Keep the following rules in mind: a parallel trap is in series with the signal line and a series trap is in parallel with the signal line.

Another option is to use a half-wavelength, shorted, transmission-line stub (like that shown in Fig. 3) across the antenna line at the an-

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tenna input terminal of the receiver. In any transmission line, the load impedance will be "reflected" every half wavelength along the line. When the line is exactly an electrical half wavelength, the input impedance looking into the line is the same as the load impedance.

In the half-wavelength shorted stub, the *load impedance* is zero ohms because of the short circuit. That zero-ohm impedance is reflected every half wavelength, so appears across the input end of the line. Thus, because the physical length that creates an electrical half wavelength is frequency dependent, the "short" appears only at the resonant half wavelength of:

$$L_{\text{inches}} = 5904\ V/\ f_{\text{MHz}}$$

where L_{inches} is the length of the transmission line in inches, f_{MHz} is the offending frequency in MHz, and V is the velocity factor of the transmission line (use 0.66 for polyethylene line, and 0.80 for foam line). Always use the same type of line for the stub that you used for the transmission line.

The Optoelectronics APS-204 six-octave, tunable, bandpass filter maintains a constant 4-MHz bandwidth over a range of 20 to 1000 MHz.

In UHF systems, you can also use a tuned cavity (Fig. 4). They act very much like a shorted, half-wavelength stub at a single frequency, and can be tuned. A tuned cavity can be bought commercially by some repeater operators, but they are very expensive. They are also sometimes available on the surplus market and at hamfests. Older editions of *The Radio Amateur's Handbook* and *The Radio Amateur's VHF Manual* (both ARRL publications) had instructions for building your own, so a little research might yield good results.

Another pricey, but otherwise attractive, solution is the new Model APS-204 bandpass filter (from Optoelectronics, 5821 N.E. 14th Avenue, Fort Lauderdale, FL, 33334; Tel. 305-771-2050). That high-Q, six-octave, tunable bandpass filter maintains a constant 4-MHz bandwidth over a range of 20 to 1,000 MHz. It's an active filter, so it produces no insertion loss—the normal bane of filter users. Don't bother asking about the APS-204 unless you can go the price: $995. I suspect that repeater operators with a real problem will find it cheap, however, because many of the other solutions to severe problems cost a similar amount, or more. ■