An Active Attenuator for Transmitter Hunting

Here's an innovative approach to transmitter hunting that eliminates the use of traditional passive attenuators to control the strength of the received signal. With this *active* attenuator, you'll be able to home in on your target with greater precision!

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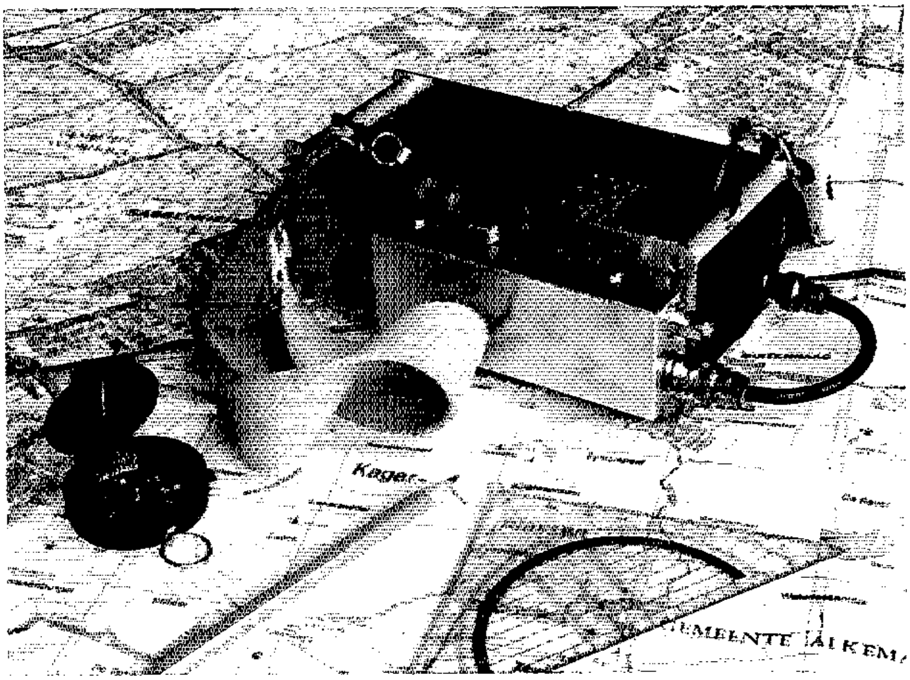

During a transmitter hunt, the strength of the received signal can vary from roughly −120 dBm at the starting point, to 0 dBm when you're very close to the transmitter. To find the transmitter, your receiver must be capable of providing accurate signal-strength readings throughout the hunt. Most hand-held transceivers provide a signal-strength indicator (either a meter or an LCD bar graph) with a usable range of −120 to −90 dBm. Although this may be fine for normal operating, it's totally inadequate for transmitter hunting!

Inserting a passive attenuator between the antenna and the receiver reduces the received-signal strength. By selecting various levels of attenuation, you'll see peak signal readings as you search for your target. More precise readings and greater ease of use would result if the attenuation was *continuously variable*. However, the usefulness of a variable attenuator is limited by how well the receiver is shielded. Modern hand-held transceivers often lack adequate shielding, allowing strong signals to effectively "leak around" the attenuator. This can result in significant directional errors.

I've designed an active attenuator that achieves continuously variable attenuation by mixing the received signal with a signal from a simple oscillator circuit. This process creates mixing products above and below the input frequency. The spacing of the closest products from the input frequency is equal to the local oscillator frequency. If the input signal is at 146.52 MHz, for example, and the oscillator is running at 500 kHz, the closest mixing products will appear at 147.02 and 146.02 MHz. By increasing or decreasing the oscillator signal, the strength of the mixing product signals decreases or increases according to the *conversion loss* of the diode mixer.

By monitoring the mixing products, you can obtain accurate headings even in the presence of a strong received signal. As a result, any hand-held transceiver—regardless of how poor its shielding may be—can be used for transmitter hunting.

Varying the level of the oscillator signal provides the extra advantage of controlling the strength of the input signal as it passes through the mixer. So as you close in on your target, you have the choice of monitoring and controlling the level of the input signal or the product signals—whichever provides the best results. (Although I used 2-meter frequencies in the previous example, the attenuator will function elsewhere in the VHF or UHF range.)

Circuit Description

The heart of the oscillator circuit is Q1, a 2N2222A transistor (see Fig 1). Trimmer capacitor C1 adjusts the oscillator's operating frequency. Oscillator frequency stability is only a minor concern; a few kilohertz of drift is tolerable.

Q1's output is fed to an emitter-follower buffer comprised of Q2, a 2N3904 transistor. R6—a linear-taper potentiometer—controls the oscillator signal level present at the cathode of our mixing diode, D1. D1 and coupling capacitor C7 are in series with the signal path from the antenna input to the attenuator output.

I must admit that my oscillator/mixer design may seem unorthodox. In my initial attempts to design an active attenuator, I tried the conventional approach using a doubly balanced mixer with the prescribed 5-mW local oscillator drive, matching pads, filters and so on. My conclusion was that this simple circuit has all the necessary performance features, is easy

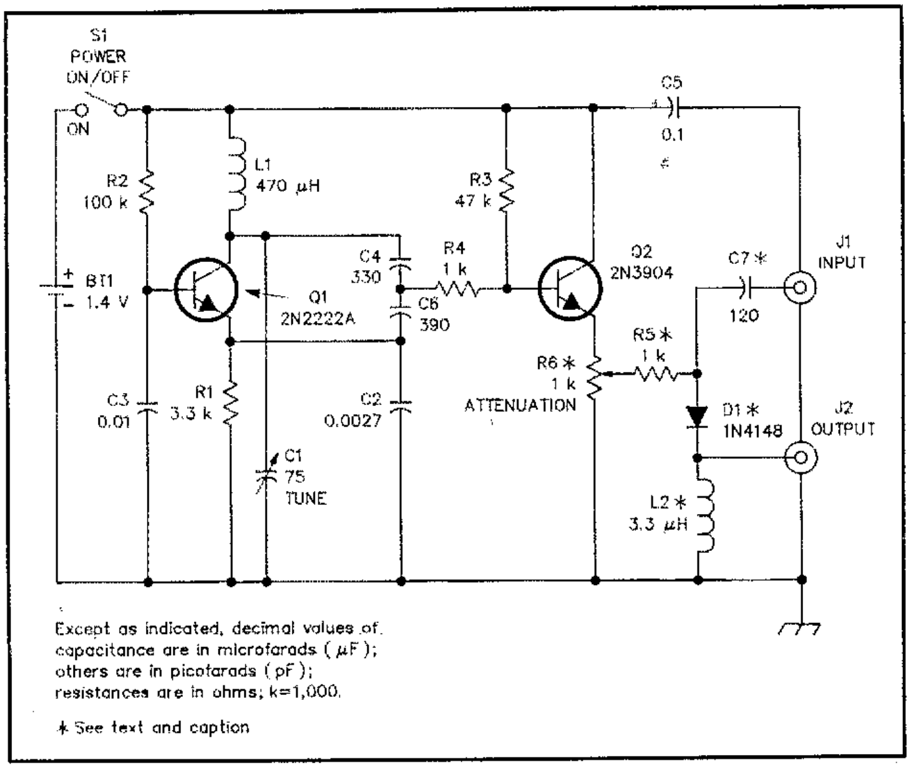

Fig 1—Schematic of the active attenuator. Resistors are ¼-W, 5%-tolerance carbon-composition or film. R6 is mounted on the wall of the metal enclosure. (The author used a slide control at R6; a rotary control is also suitable.) R5, C7, D1 and L2 are connected between the input/output connectors, ground and R6.

BT1—Alkaline hearing-aid battery. Duracell SP675 or equivalent.
C1—75-pF miniature foil trimmer.
J1, J2—BNC female connectors.
L1—470 μH-RF choke.
L2—3.3 μH-RF choke.
R6—1 kΩ, 1-watt, linear taper (slide or rotary).
S1—SPST toggle.

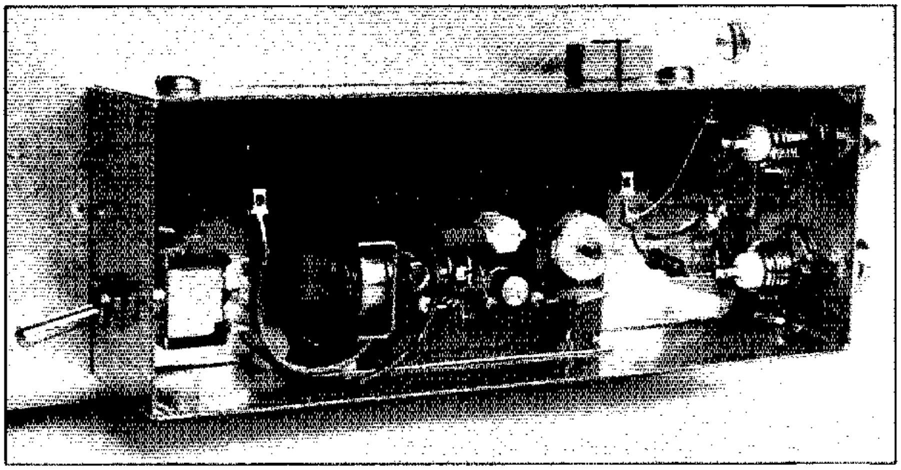

Fig 2—An interior view of the active attenuator. Note how C7, D1 and L2 are mounted between the BNC connectors. R5 (not visible in this photograph) is connected to the wiper of slide pot R6.

to build and consumes little power. In fact, its power source is a tiny 1.4-volt hearing-aid battery!

Construction

I've designed a small PC board for the oscillator and buffer circuits. The etching template and parts overlay are available from ARRL Headquarters.[1] To further simplify assembly, a circuit board is available from FAR Circuits.[2]

I mounted the PC board within a tin-plated enclosure using female BNC connectors for the input and output (see Fig 2). My enclosure was designed to accommodate a slide potentiometer, R6. Other potentiometers and enclosures can be used as well. C7, D1, L2 and R5 are installed with point-to-point wiring between the BNC connectors and the potentiometer. S1, an SPST switch, is mounted on the rear wall of the enclosure.

BT1 is held in place by a piece of **U**-shaped tin plate (see Fig 3). This plate is the positive terminal and it's soldered to the PC board with four pieces of #18 wire. The negative terminal consists of a piece of spring bronze that's soldered to the underside of the PC board. When the battery is inserted into the holder, the spring clip holds it in place.

To make the entire system as portable as possible, I bolted the attenuator box to the side of a **U**-shaped aluminum carrying case in which the transceiver is mounted face up. Two bars are attached to the case and holes were drilled in the middle of each bar. The holes serve as attachment points for a camera belt. These belts are generally available in photographic supply shops.

Tuning the Attenuator

The example at the beginning of the article assumed that the oscillator was operating at 500 kHz. This would place the closest mixing products 500 kHz above and below the true transmitter frequency. Most hams will find that this is a convenient arrangement, but the oscillator can be tuned to other frequencies as well. The frequency you choose will depend on local operating conditions. If VHF/UHF activity is high in your area, it may be to your advantage to choose an oscillator frequency that will create products in clear portions of the band.

You can tune the oscillator with a frequency counter, or with the help of a strong signal of known frequency (it helps to enlist the aid of a friend for this procedure). Connect a short piece of wire to J1 and connect your hand-held transceiver to J2. Select a simplex receive frequency that matches the frequency of your friend's transmitter. Ask your friend to make sure the transmitter is operating at its lowest power output setting. (Better yet, attach the transmitter to a dummy antenna.)

With the attenuator on, adjust R6 to obtain a midscale reading. Now switch your receive frequency to one of the mixing product frequencies. Carefully tune C1 and adjust R6 until you hear the mixing product. Watch your signal-strength meter and tune C1 for maximum reading. If the circuit is performing normally, you should be able to switch to the other mixing product frequency and hear a signal there as well.

Using the Active Attenuator

If your receiver or transceiver features memory functions for frequency selection,

[1]Notes appear on page 95.