HOMING IN

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S-Meters

How well does your two meter FM transmitter hunting setup work when the signal is really weak? Getting an accurate bearing with a beam or quad is tricky when the signal just barely breaks the squelch. Such situations are common at the beginning of hunts, particularly after you leave the high elevation of the starting point.

Today's VHF and UHF rigs are very sensitive, but their S-meters are not. The S-meter takeoff point must be at an early stage in the IF chain to minimize saturation effects and give maximum dynamic range (which is none too high anyway). So the typical S-meter doesn't start upscale until the signal is about 10 dB above the threshold of detection.

There have been a lot of hunts where I've gone well over halfway to the hidden T before getting S-meter readings good enough to use for bearings. Without meter indications, the only way most hunters can get a bearing is to find the squelch break points and average between them. This method is often inaccurate due to flutter and local noise conditions.

The better equipped you are to get bearings on weak carriers, the better your chance of winning the hunt. Wouldn't it be great if there were a way to indicate the strength of signals that are too puny to move typical S-meters? There is!

Squelch Secrets

Ever notice that the squelch on your VHF-FM rig opens properly on stations that are too weak to read on the S-meter? That's because the squelch senses the signal level in the IF differently from the way that the S-meter does this. If the squelch worked like the S-meter, it would be very insensitive and unreliable. Instead, the squelch uses the "quieting" effect that occurs on even the weakest FM or CW signals.

Because of the very high gain of the IF stages in an FM receiver, the FM detector stage (the discriminator) outputs a high level of random noise when it's not receiving a signal, sometimes as great or greater than the peak audio level of typical signals. Most of the noise is at high audio frequencies, well above the passband of the speaker amplifier. When any carrier-type signal (such as FM) comes in, even if it is very weak, this noise is quieted. The stronger the signal, the greater the quieting.

Figure 1 shows the output stages of a typical FM receiver. Signal pickup for the squelch comes directly from the discriminator and passes through an audio high-pass filter. The system senses the supersonic noise components instead of the voice range audio, then amplifies and rectifies the noise. Next, a logic circuit decides if there is enough quieting to represent a signal. If so, the squelch gate connects the discriminator audio through a low-pass filter (the de-emphasis network) to the speaker amplifier. In many radios, the squelch control varies the gain of the noise amplifier, as in Figure 1. In other sets, such as the Kenwood TR-7950, the squelch pot is part of the logic.

WA6DLQ's Noise Meter

Why not meter the squelch detector? Great idea! The rectified noise is a very sensitive indicator of the relative strength of feeble signals.

There are two methods for metering noise on ham VHF-FM transceivers. The easiest way is to find a takeoff point in the receiver where there is a DC voltage proportional to the noise, then amplify that voltage to drive a meter. That's what Vince Stagnaro WA6DLQ did with his TR-7950 two meter rig. It's practical for other rigs, too.

WA6DLQ's meter box features a switch, S2 (see Figure 2) to make the unit either a noise meter or an external S-meter that tracks the one in the TR-7950. With this system, you hunt weak signals using the noise meter then, when the signal gets to near full quieting, switch to the S-meter position and use your dashboard meter instead of the small one on the transceiver.

The collector of transistor Q12 in the TR-7950 is an ideal noise meter pickoff point. With no signal, rectified noise turns Q12 on hard, resulting in Q12 collector voltage near zero. As the signal level rises toward full quieting, the drive to Q12 decreases until it is at cutoff, and the collector voltage rises to about +7.3 volts. The S-meter tapoff for the TR-7950 comes from TP3, which varies from 0 volts with no signal to +1.6 volts at full scale.

The meter amplifier unit is basically a straightforward DC gain stage using the National LM324 quad op amp, U2. (See Figure 2.) This chip is ideal because it works when input voltage is near zero, with no need for a negative supply voltage. Be sure to strap and ground the unused sections, as shown.

Easy-To-Find Parts

Most parts for this project are carried at Radio Shack. L1–L2 and C1–C4 are filters to keep RF out of the radio and meter circuitry, and can be omitted if there

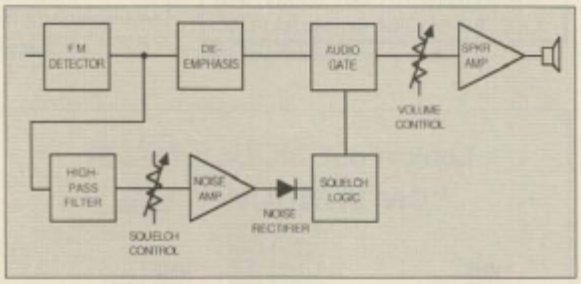

Figure 1. Block diagram of a portion of a typical VHF-FM receiver, showing the discriminator, audio, and squelch.

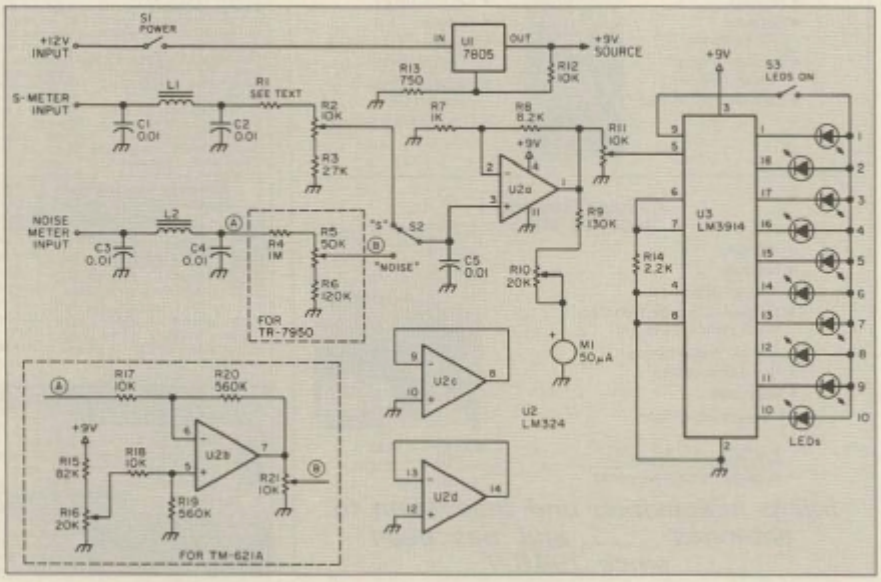

Figure 2. Schematic diagram of WA6DLQ's noise meter and external S-meter circuit for use with the Kenwood TR-7950 and TM-621A transceivers.

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are no such RFI problems in your setup. You can make L1 and L2 by winding 50 turns of #26 wire on an Amidon T-37-2 (red) toroidal core. M1 is a 50 microampere lighted meter for nighttime use. R1 is 18k for the TR-7950.

An optional LED bar graph indicator (U3 and associated components) tracks the 50 microamp meter movement. The LEDs are handy for checking noise or signal level out of the corner of your eye on night hunts. Use a variety of colors to aid visibility if you wish.

Vince built his meter amplifier on a predrilled grid board, Radio Shack part number 276-158. There's plenty of room to add other goodies, such as the internal attenuator from the March 1989 "Homing In" column. Use sockets on the ICs for ease of setup and troubleshooting. Make the three connections from the radio to the box (S-meter, noise meter, and ground) with ribbon or other multiconductor cable.

Metering a Dual-Bander

Hunts on 220 MHz are gaining in popularity, as are dual-band rigs such as the Kenwood TM-621A. WA6DLQ recently got one and modified his noise meter box for use with it. The TM-621A is a very compact unit with surface-mount components. I suggest you get the service manual for it, or any other rig you wish to modify, to aid in locating tap-off points.

Noise meter input on the TM-621A comes from signal SQ-1 at the connector on the main board. With no signal, there are 0.6 volts present at SQ-1, dropping to 0.55 volts with the squelch open. This shift is much smaller and of opposite polarity to the shift in the TR-7950, so an amplifier/inverter stage is used. U2b and associated components in the inset box in Figure 2 replace R4–R6, connecting at points A and B.

Tap off signal SQ-1 without disturbing the delicate surface mount PC boards by removing the proper pin from that connector, soldering the added wire to the pin, and then reinstalling the pin into the connector and plugging it back in. S-meter pickoff for the TM-621A is at test point TP-1, which has +4.85 volts at full scale. TP-1 sticks out of the two meter board in the TM-621A. R1 in the meter amp is changed to 120k because of the higher signal level.

Checkout and Operation

For initial checkout, leave U1 and U2 out of the sockets. Apply +12 volts input, close S1, and measure the voltage at the output of regulator U3. If it's not close to +9 volts, change R13 as necessary. For the TM-621A, adjust R16 for 0.6 volts at the tap of the pot. Connect +9 volts to U2-1 with a clip lead and adjust R10 for exactly full scale on M1.

Now, turn off the power, remove the clip lead, and install U1 and U2. Set S2 to the "S" position, and apply a strong on-frequency signal to the receiver. Adjust R2 for exactly full scale on M1. Adjust R11 until all except the last LED comes on, then slowly increase R11 until that last LED just comes on.

Set S2 to the NOISE position and adjust R5 or R21 for exactly full scale on M1, with the strong signal still applied. For the TM-621A, remove the signal and adjust R16 to zero the meter. Repeat the adjustments of R21 and R16 if necessary.

For hunting, adjust the squelch control in the rig to get a near zero reading on the noise meter when there's no signal coming in. Weak signals will then move the noise meter upscale. You'll be amazed how easy it is to get bearings on them! Switch to the S-meter position as signals become stronger and the noise meter tops out.

Remember: I said that there are two methods for noise metering. If you can't find a good DC take-off point in the squelch circuit of your particular VHF-FM receiver model, you can use the second method. Tap off the noise at the discriminator and build an external high-pass filter, noise amplifier, rectifier, and meter amplifier. It's easier than it sounds. A schematic and full details are in the T-hunt book. (Moell and Curlee, *Transmitter Hunting—Radio Direction Finding Simplified*, TAB Books #2701, p. 156. Available from Uncle Wayne's Bookshelf.)

How do you hunt when the hider is varying the transmitter power, making both the S-meter and noise meter bounce around like crazy? You'll want RDF equipment that does not depend on signal amplitude to obtain bearings. We'll discuss such units in the next column. 73