Homebrew Doppler Radar

No, you're not going to watch incoming weather fronts with this simple radar, but it can still be a lot of fun to build and operate.

The guts from a radar detector, a radar door opener, or even a Gunnplexer can easily be made into a nice little Doppler radar. In Photo A, you see two of my simple radars (plus a muffin fan). The small unit has been used for many small demonstrations and will pick up your hand or a metal object at a few feet. The larger unit is the veteran of dozens of presentations. It will pick up a baseball at 30 feet or a walking person out to 50 feet. But these are all fun to experiment with.

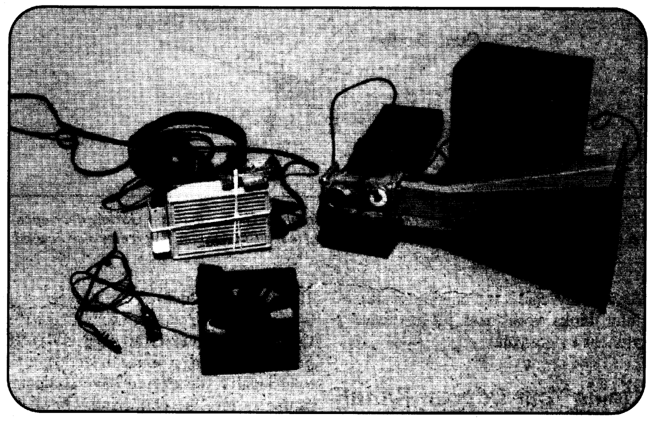

Photo A. Two of the Doppler radar units I've built for demonstrations, along with a muffin fan which I also use in radar demos. Read why in the text. (All photos by the author)

A Little Theory

A basic Doppler radar only detects a moving target (weather radars are more complex Pulse-Doppler radars so they can detect both range and motion). We can actually think of these radars as SWR meters. But instead of measuring the reflections in a piece of coax, we're going to measure the reflections in a piece of free space. As the target moves, the reflected waves go in and out of phase. Every time the target moves 1 wavelength (about 3 centimeters) one sine wave is generated in the detector diode.

To do this, we just put an audio amp on the detector diode (Figure 1) and listen to the SWR of the antenna change as objects move around the antenna. The audio tone of the target as it moves is about 12 Hz/mph. A person walking towards your radar generates about a 30-Hz tone. But their arms and legs are moving at different speeds, so a far more interesting mismash of sounds comes back. Cars at highway speeds generate about an 800-Hz tone. But most signals are pretty low in frequency, so it's a good idea to use a speaker with good bass response.

Building a Simple Doppler Radar

In Figure 2, we have the system diagram for a simple Doppler radar, and a schematic in Figure 3. The audio amp is not critical: I have used stereo amps (phono inputs work well), RadioShack telephone listener amps like the 43-2318, or you can use your favorite LM386-based audio amp circuit. Again, most any old audio amp will work.

In fact, none of the parts used are particularly critical. The capacitor on the mixer diode can be most anything between 1 and 50 µF. Since there are only .7 volts on the mixer diode, the voltage rating of the coupling caps isn't important, either. The 1K resistor can actually be anything between 500 ohms and 10K ohms. If you're trying to get the last inch out of your radar, you can play with the value a bit, but 1K works fine.

On the transmitter side, the 33-ohm resistor is typical for radar detector guts. If you have one of the units from a security system, this may need to be decreased to 10 or 20 ohms. The .1-µF capacitor keeps the Gunn Oscillator from breaking into low frequency oscillation., and values between .02 µF and .2 µF can be used. One value that *is* important: The voltage rating needs to be more than 12 volts and the leads must be kept very short; this is a bypass cap and bypass caps like short leads. Many surplus Gunn oscillators already have a bypass cap on the Gunn

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By Kent Britain, WA5VJB (wa5vjb@cq.net)

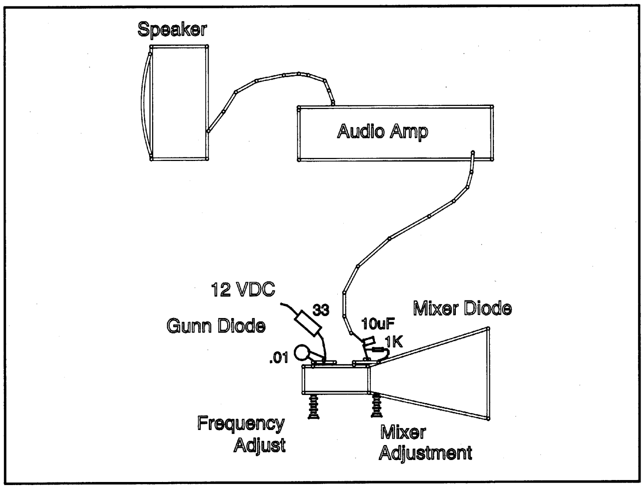

Figure 1. Basic setup of a Doppler radar built around a Gunn oscillator. Garage door openers and the guts of police radar detectors (retuned to the 10-GHz ham band) may also be used.

"A person walking towards your radar generates about a 30-Hz tone. But their arms and legs are moving at different speeds, so a far more interesting mismash of sounds comes back. Cars at highway speeds generate about an 800-Hz tone."

diode. Hey, that's the one the manufacturer thinks works best. I'd just leave it alone if I were you.

Using Your Doppler Radar

If you are using a door opener or some other security device radar, then the radar is already tuned to and licensed for 10.525 GHz, which is handy because it doesn't take much to retune it into the 10-GHz ham band (10.0 to 10.5 GHz). If you're modifying a police radar detector, then legally you should have someone retune in into the ham band. Oh yeah, while you're at it, add a CW key and send your call letters every 10 minutes. This will also keep the FCC happy.

The frequency of the Gunn diode is controlled by a tuning screw in the back cavity of the radar (see Figure 1 again). In front of the mixer diode is another tuning screw. This screw controls how much of the reference wave is reflected back into the mixer diode. A good target for tuning the mixer adjustment is to point your radar at the moving blades of a fan and adjust for the loudest signal.

A Little More Theory

Figure 4 illustrates the Inverse Cube Law. As an RF signal travels twice as far from the transmitter, it spreads out twice as much. But it doesn't just spread out in one direction. It spreads out twice as much up and down, *and* it spreads out twice as much left and right. So as the signal travels twice as far, it's 1/4 as strong. Want to

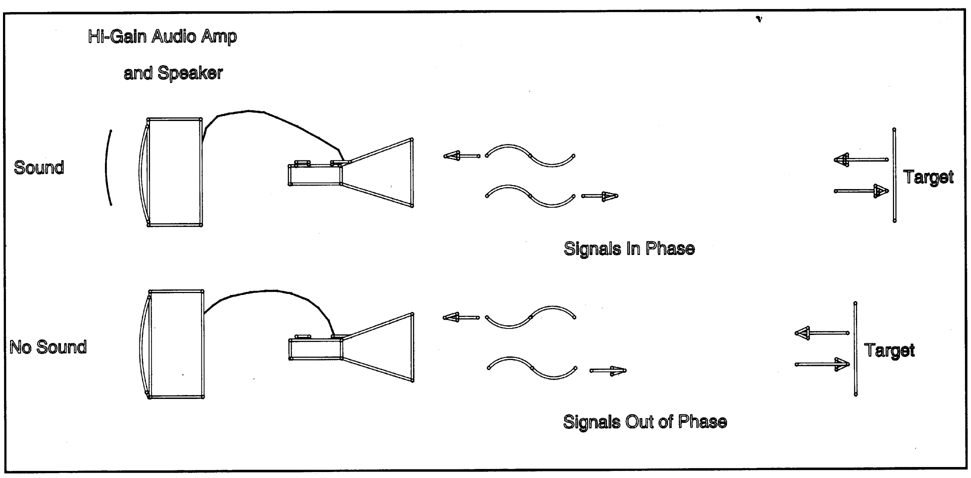

Figure 2. System diagram of how a Doppler radar responds to motion. When signals in both directions are in phase with each other, you'll hear a sound through the speaker; when they're not, you don't. The pitch of the sound varies with distance, direction, and speed.

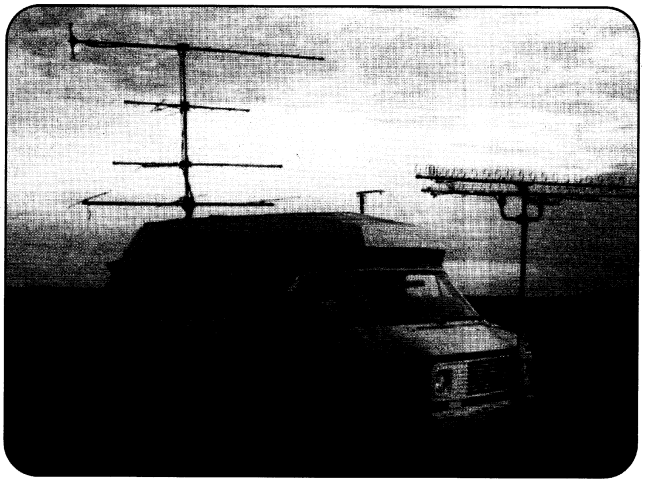

Photo B. WB5VYE's VHF/UHF/microwave rover van. The loop Yagis in front are for the microwave bands.

talk twice as far? You need four times the power (this is for line-of-sight paths). When a radar reaches out twice as far, the signal hitting the target is 1/4 as strong. As the reflection travels back, the *reflection* is now 1/4 as strong. This gives you 1/4 of 1/4 the original signal. That's 1/16 as much signal. So if you want to double the range of a radar, you need 16 times more power! Want you radar to reach out four times as far? Upgrade power by a factor of 256! Bigger antennas really help—you can count the extra gain of the antenna on both transmit and receive—but it's going to take some serious upgrades to this system to reach out miles.

Let's use car headlights as an example. On a clear moonless night, you can see a car stopped on the side of the road in the glare of your headlights at what, 300 feet? Maybe 400 feet? Yet if a car is coming the other way with its headlights on, you

> ***"You can also do your own 'stealth' experiments. See how far away you can detect a piece of flat metal. Now see how far away you can detect a piece of fiberglass, a piece of plastic, or a piece of wood."***

can see its headlights coming from miles and miles away. So if that headlight is used for communications, its range is miles and miles, but if that same headlight is used as a radar, the range is only a few hundred feet. Same way with these low power Doppler radars. We can talk several miles with a pair of these units, but as a radar, range is quite short.

Have Fun with the Truckers!

So what can we do with these? I'll skip over my daughter's award at a science fair with one of the Doppler radars, but they're really fun to play with. The little ones will pick up a baseball at 10 feet, the bigger ones out to 30 feet. Wiggle your fingers near the horn, it sounds pretty neat. One Dallas ham enjoyed listening to road noises as he drove down Highway 635. He said the underpasses sounded particularly interesting. I think he also enjoyed sending CQ to the truckers' "Fuzz Busters."

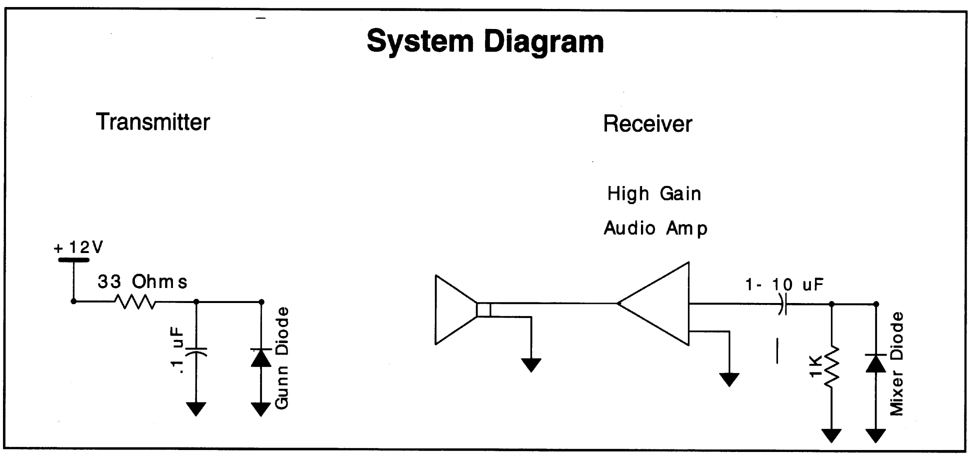

Figure 3. A schematic diagram of a Doppler radar system. None of the component values are critical (see text), so it is really a pretty easy "junkbox" project.

Photo C. N5QGH and his 47-GHz station. QGH was active on 10, 24, and 47 GHz, plus laser, during this year's ARRL 10 GHz Contest.

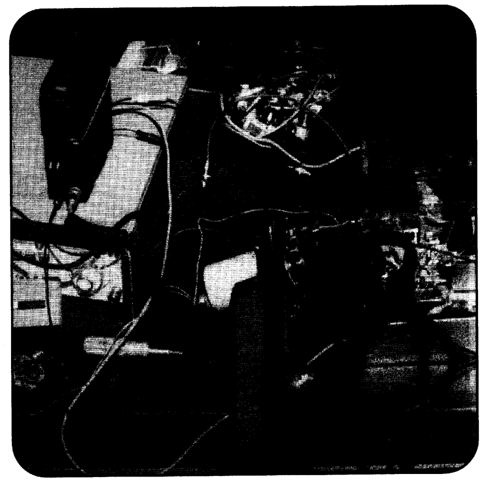

Photo D. The author's 24- and 47-GHz stations. Aren't they neat, compared to what you saw in Photo C?

Back in Photo A, you see a small muffin fan I use in my radar demos. Ever wonder why stealth aircraft have the blades of their jet engines buried deep inside the airframe? Try pointing your personal radar at a fan and see what I mean. And yes, I use a plastic bladed muffin fan.

You can also conduct your own "stealth" experiments. See how far away you can detect a piece of flat metal. Now see how far away you can detect a piece of fiberglass, a piece of plastic, or a piece The results may surprise you!

Next time I'll explain why you're detecting what you're detecting. And we'll cover some simple laser communications systems. Have fun experimenting.

Photo Gallery

No particular stories here—just some interesting pictures of various hams' microwave setups. In Photo B, you'll see WB5VYE's VHF/UHF/microwave Rover setup for contesting. Photo C shows N5QGH and the 47-GHz station he used during the recent ARRL 10 GHz Contest (which is actually for 10 GHz and up). The station was active on 10, 24, and 47 GHz, and on laser. Finally, we have in Photo D my own exquisitely neat 24- and 47-GHz stations. But they work, and that's what counts! ■

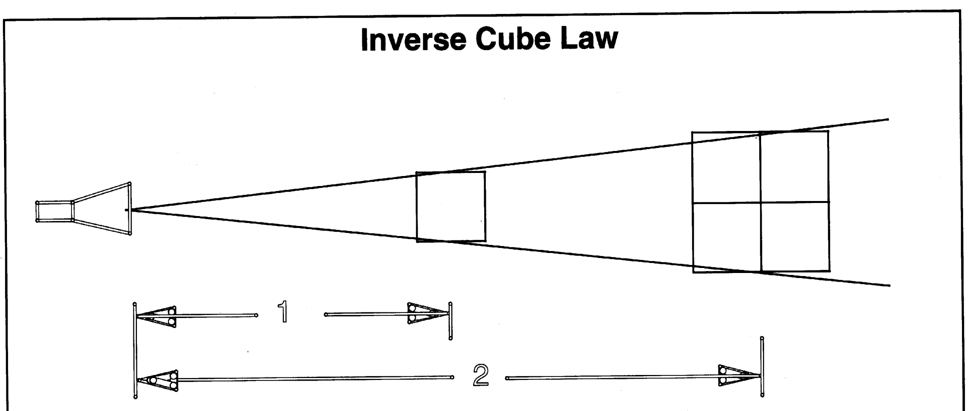

Figure 4. An illustration of the Inverse Cube Law. As a signal doubles its distance from its source, it doubles in both height and width, making the signal at the twice-as-far point only 1/4 as strong as the first point of measurement. If it's then reflected back to the source, it arrives with only 1/16 the strength with which it left.

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