BUILD A HIGH-GAIN RHOMBIC TV ANTENNA

This easy-to-build antenna offers high gain, good directivity, wide bandwidth–and costs less than $10 for parts.

BY GEORGE L. MONSER

THE rhombic is a nearly ideal TV antenna. It's easy to build and install, provides good reception, and costs less than $10 in materials. If you live in a house with a nonmetallic roof and are located in a medium signal-strength area (with a rather clear "shot" to the transmitter), it can be installed without support masts. The rhombic can also be shaped to the roof contour so it will not detract from the house's appearance. High gain (up to 14 dB), broad bandwidth, and good directionality are characteristic of the rhombic's performance.

About the Rhombic. The rhombic is a long-wire antenna in the shape of a rhombus, with sides usually greater than three halves of a wavelength (Fig. 1). In this configuration, it is a nonresonant antenna with a resistive termination. The presence of the resistor converts the rhombic into a unidirectional antenna with the favored direction looking toward the termination. (Unterminated rhombics are bidirectional). This is desirable in most situations since many viewers want to receive signals which are all transmitted from the same high antenna site. The legs of the antenna are formed from foam-filled 300-ohm twinlead, because the use of multiple conductors increases the gain and bandwidth of the antenna.

Both the leg length *l* and the "tilt angle" θ are variables, and the rhombic's overall gain depends on this combination and the angle at which the signal approaches the antenna. The dimensions (*l* and θ) can be chosen either to give maximum gain and directivity or to fit certain physical constraints (like the shape and size of your roof!). In general, maximum gain is found as θ increases. The gain of a diamond-shaped rhombic (θ = 65°) is

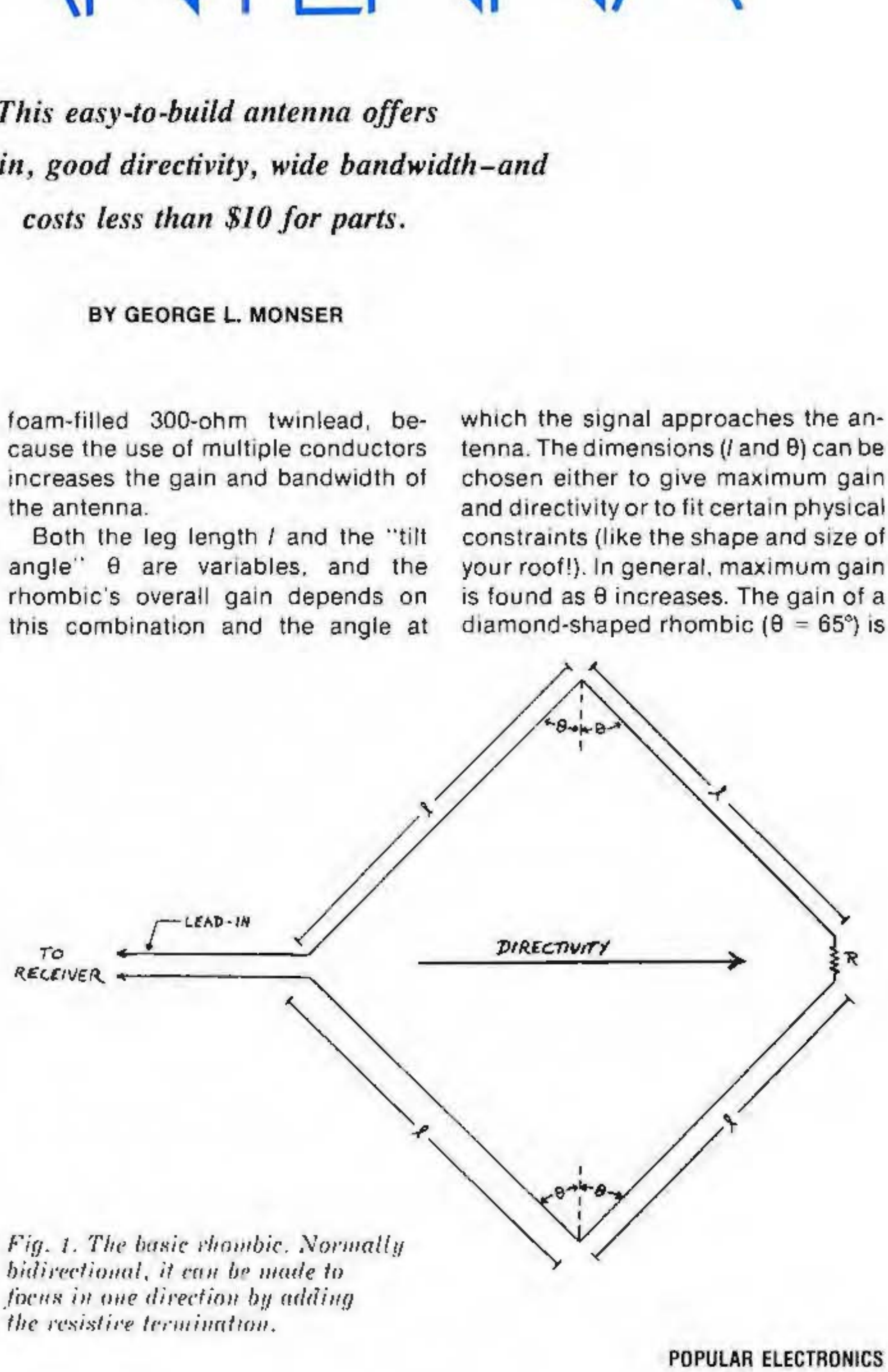
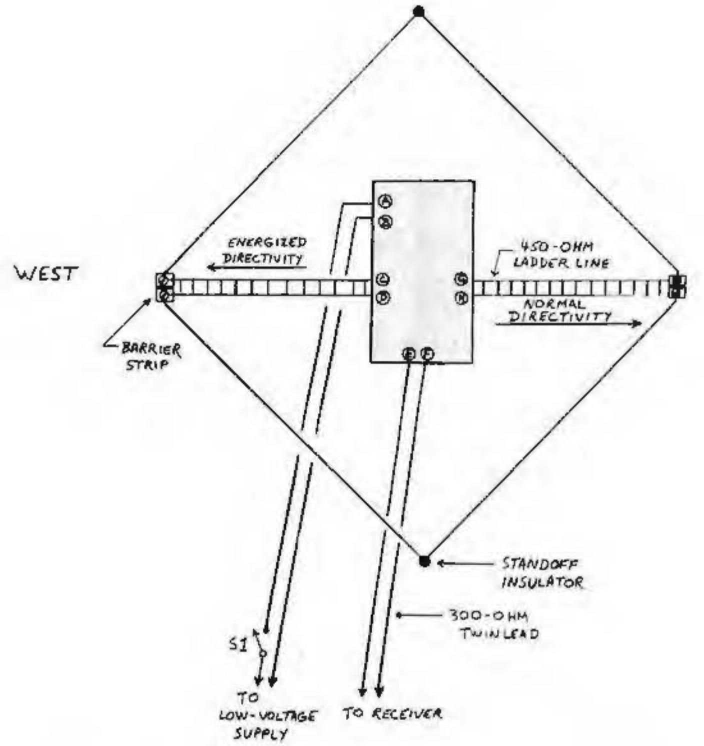


Fig. 1. The basic rhombic. Normally bidirectional, it can be made to focus in one direction by adding the resistive termination.



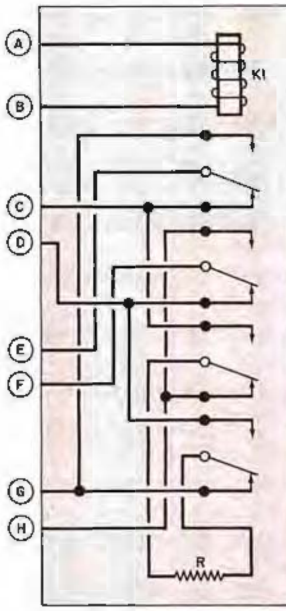


Fig. 2. At left is switchable rhombic antenna. Shaded area is relay switching circuit above. Switching feed and termination changes direction.

about twice that of a square antenna ($\theta = 45°$).

Feedpoint impedance poses an important question—what type of transmission line should be used with the rhombic? The antenna's impedance is not a constant value over variations in frequency, and the physical dimensions have some effect. A square antenna has an impedance of 600 to 800 ohms, while smaller values of θ mean it will generally lie between 450 and 600 ohms.

Most TV receivers, on the other hand, have an input impedance of 300 ohms, and most TV transmission line is of the 300-ohm twinlead variety. This means that, if 300-ohm line is used to bring the signals down to the receiver, an SWR will develop on the line. Some signal loss will exist because of the reflections induced by the impedance mismatch. It's not all that bad, since the greatest SWR you're likely to encounter is 2.7:1. This corresponds to a signal loss of about 25%, or 1.25 dB—which will not really be noticed.

Multidirectional Rhombics. If you want to receive stations from more than one direction, you will either have to put up a few unidirectional rhombics or resort to a switching scheme such as that shown in Fig. 2. In this case, we want to receive signals coming along one axis of the rhombic (see arrows). Most of the time, we listen to station X, whose broadcasts come in from the east. So, we leave *S1* open and relay *K1* de-energized. The antenna favors signals facing east, since that's where the termination (*R*) is with respect to the feedpoint.

Now, let's say that there's a good program on station Y's channel, whose signals come in from the west. Closing *S1* will energize the relay coil, reversing the feed and termination points. The antenna thus "looks" west. Although only two directions are realized in this design, it's possible to use a more complex switching system to include the other two corners of the rhombic. This would allow selection of each of the four cardinal directions (with respect to the antenna). If you want to use this relay switching technique, it's advisable to have a low-capacitance relay mounted in a weather-sealed box to avoid excessive signal loss. Also, for safety's sake, use a low-voltage ac or dc relay coil and good outdoor wire between the coil and voltage source.

Antenna Design. The first step in designing the rhombic is to decide what channels you want to receive, the relative location of their transmitting antennas with respect to your home, and the physical layout of the installation site. (In this article, we assume the antenna is mounted horizontally on

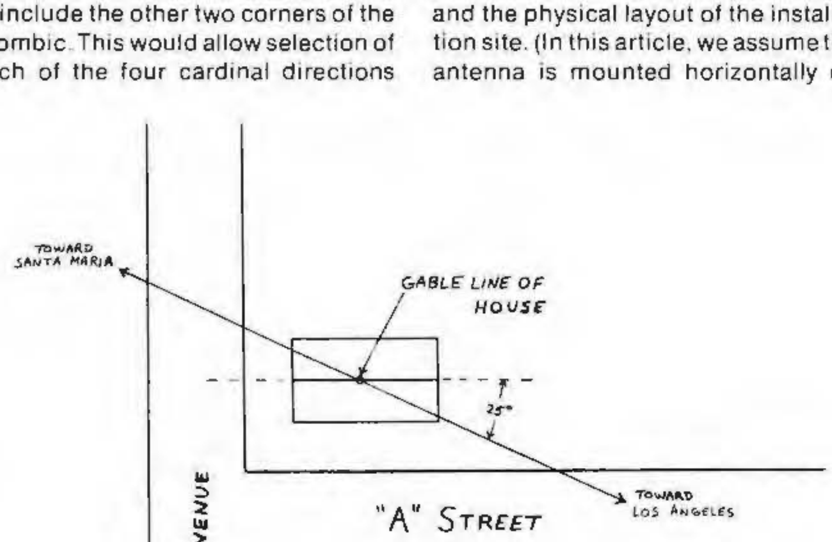


Fig. 3. The angle between the transmitter and house gable line determines rhombic design.

the pitched roof of a wood-frame house.)

For optimum results, three basic designs are described, covering the vhf LO, vhf HI, and uhf bands. The vhf LO antenna measures 25 feet (7.6 m) on a side, and covers channels 2 through 6 and the FM broadcast band. The vhf HI design, spanning channels 7 through 13, has legs one-third the length of those for vhf LO. For the uhf channels (14 through 83), a rhombic that is 55 inches (139.7 cm) on each side is recommended. One rhombic can be installed within another with a different cant to receive higher channels from another direction.

Once you have chosen which size(s) you want to use, locate your reception site and the transmitting antenna on a state or city map. Determine the alignment of your house with respect to the station locations as shown in Fig. 3. In our example, we want to receive stations in Los Angeles and Santa Maria. These roughly lie along the same line, at a 25-degree angle from the gable line of the house. If the angle to the station exceeds 30°, it's best to use the square rhombic (θ = 45°). But we are within the limit for a diamond-shaped antenna, and we'll take advantage of its higher gain to get the distant (100 miles) signals. A vhf LO band antenna will be set up.

Construction. First, we cut a 100-ft. (30.5-m) length of foam-filled 300-ohm TV twinlead in half. A few inches of the insulation are removed at each end of the twinlead segments, and the bared wires are twisted together and soldered. Then, install 3½-inch (not critical, larger units can be used) standoff insulators at the four corners of the rhombic design. Slip the twinlead segments through standoffs 1 and 3 until they are halfway through. The free ends of the twinlead are now connected to individual terminals on two barrier terminal strips, which are secured with nylon rope to standoffs 2 and 4. Install relay *K1* and the terminating resistor in a small weatherproof box near the center of the antenna. Weatherproof all connections with epoxy or a commercial preparation made for this purpose. The terminating resistor should be either 470- or 680-ohm, half-watt carbon types. Experiment with the two values and choose the one that gives best reception.

The geometry and physical installation of the rhombic may have to be tailored to your location. Use Figs. 4 and 5 as guides—but by all means experiment. Try to keep all leads to the relay short, and have the 300-ohm line take off at right angles to the gable line.

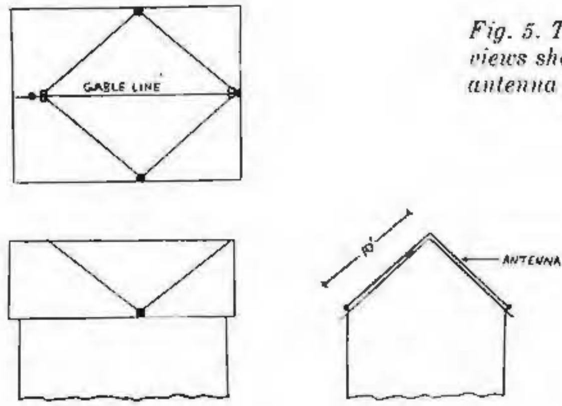


Fig. 5. Top, side, and edge views show how to install antenna on a pitched roof.

Performance. How well the rhombic performs is pretty much a function of the leg length and the tilt angle. For the antenna described, about 6 dB of gain is realized on channel 2, rising to about 14 dB on channel 6 and the FM broadcast band. If the vhf HI-band rhombic is built along the same lines, the gain would be 6 dB on channel 7 and increase to 11 dB on channel 13. The uhf model would deliver about 7 dB gain on channel 14, rising to 12 dB on channel 83. (These figures are referenced to a dipole, and are approximate.) With the rhombic aimed toward the channel(s) of interest, the antenna should yield better results than a 5-element yagi beam mounted at the same height. While reception won't be quite as good as that experienced with the multi-element, long-boom commercial antennas, the rhombic will deliver amazing results—considering that it was built for less than $10!

Other Uses for the Rhombic. Though we have described a rhombic for the TV bands, there's no reason why it can't be adapted for SWL, CB, amateur and vhf monitor use. The only major modifications would be in size. At lower frequencies, a larger antenna (and mounting area) would be needed. Remember though, that hf rhombics (14 MHz and below) can be unwieldy. A matching network would also be required to step down the high impedance of the rhombic feedpoint to the low-impedance, unbalanced inputs and outputs of communications receivers, transceivers, and transmitters. For more design information on this high-performance antenna, see "The ARRL Antenna Handbook" or other reference works on antennas. ◈

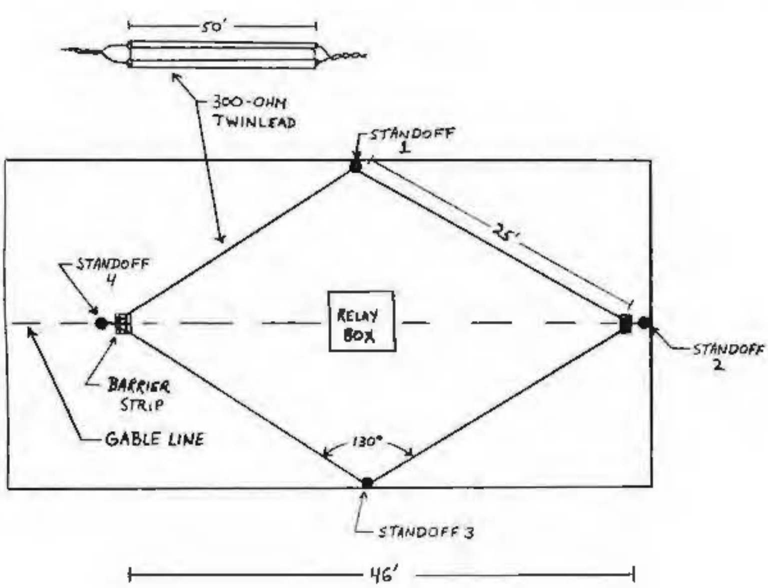


Fig. 4. Installation on a pitched wooden roof. TV insulators support the rhombic about 3" off the roof.