The VBW-1 Antenna: A "VHF Broadband Wonder"

Here's an easy to build, almost omnidirectional, broadbanded antenna covering 25 to 110 MHz. It's a nice, very low-cost weekend project for beginners and experts alike.

By Arnie Coro, CO2KK*

Ever wondered if an easy-to-build *broadband* VHF antenna really exists? Have you asked yourself if, in addition to being broadbanded, that antenna will also provide almost omnidirectional coverage? Finally, if you found that "broadband VHF wonder," could it pick up both vertically and horizontally polarized waves?

If someone came along with a "YES" to all three questions, I'm sure many VHF enthusiasts would keep on reading, and then begin to collect the materials to start building. Well, keep reading and start building! This article is about a very simple and effective general purpose antenna—developed after a lot of rooftop and backyard real-life experiments—and it answers those questions with a resounding "yes," "yes," and "yes"! This easy-to-duplicate omnidirectional antenna covers from 25 to 110 MHz, and it picks up both horizontally and vertically polarized signals equally. I call it the VBW-1, for *VHF Broadband Wonder*.

Uses for the VBW-1

I use my VBW-1 for a wide variety of purposes, such as monitoring the 27-MHz band for *E*-skip openings, working mode A 10-meter downlink satellites, scanning the 30- to 50-MHz band, monitoring 6 meters, and watching TV channels 2 to 6, *plus* listening to FM stations right to the end of the FM broadcast band! But it's not just a receive antenna. The VBW-1 also lets you *transmit* on the 11-, 10-, and 6-meter bands. And, as an extra bonus, it's a very quiet antenna (see "Don't Be Surprised").

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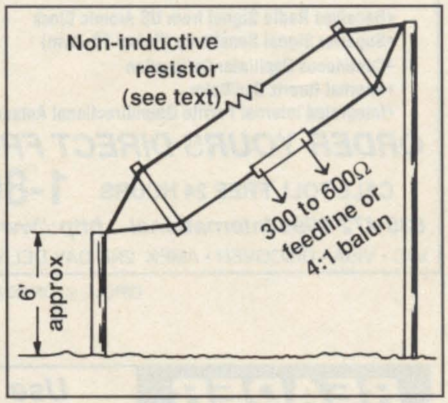


Figure 1. The VBW-1 antenna is a modified version of the Terminated Tilted Folded Dipole (TTFD or T2FD) antenna developed nearly 50 years ago by W3HH, and popularized in a CQ *magazine article in 1951. See text for construction details.*

Operating Theory

The VBW-1 is a modified, scaled-up-in-frequency version of the well-known TTFD, or *Terminated Tilted Folded Dipole* antenna, now so popular among commercial users of the High Frequency (HF) spectrum from 3 to 30 MHz. (For more on the background and theory of both the TTFD and the VBW-1, see "The Theory Behind the Antenna.")

Basically, it consists of a dipole antenna with its ends folded back over themselves (with separation) and *connected to each other in the center* through a non-inductive resistor. The antenna is then mounted at a 20 to 40° angle relative to the ground (see Figure 1). HF communications system operators need this kind of skywire to fully exploit the fast frequency changing capabilities of the newer breed of professional grade transceivers.

Build Your Own VBW-1

The exact dimensions for the VBW-1 are as follows:

1. Overall length: 4 meters or approximately 13 feet;

2. Separation between the upper and lower elements: 20 centimeters or approximately 8 inches.

Use #14 or #12 PVC-covered wire to build a folded dipole, then break it in two halves as shown in Figure 1. The next, very easy step is to attach *two* center insulators, one at the top of the folded dipole and the other at the bottom. I've made the insulators with PVC pipe, acrylic plastic, or polyethylene taken from the center of a coaxial cable from which the copper wire was removed by heating. Insulators should be about 10 centimeters, or approximately 4 inches, long.

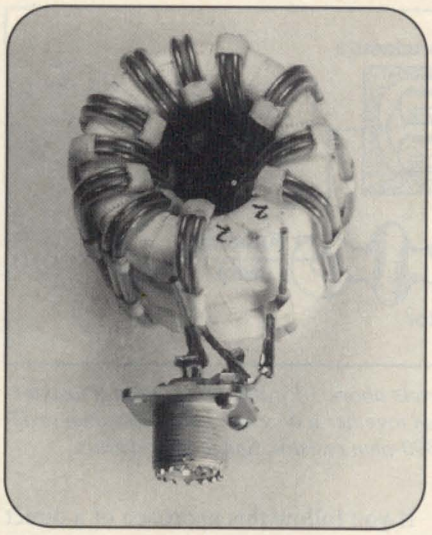
On the top insulator, you must install a *non inductive* resistor or group of resistors, which bridges across it, providing *resistive loading* to the antenna (more about this later). The bottom insulator is used to attach the feedline, as you would with any other dipole antenna. In the case of the VBW-1, it may be fed in several different ways (we'll cover that also in more detail later).

Don't Be Surprised...

...if your VBW-1 provides good reception at much lower frequencies than its 25-MHz design limit.

In practice, this antenna is capable of providing good reception down to around 12 MHz with an additional bonus: The VBW-1 is a very *quiet* antenna system. Especially when fed via a 6:1 balun and low loss coaxial cable, it picks up much less noise than a standard horizontal dipole cut for a specific frequency. This is a big advantage for those of you having to deal with noisy locations.

Tests performed at my downtown QTH showed that reception of the RS10 and RS12 satellites on 29 MHz was much better when using the VBW-1, thanks to a big improvement in signal-to-noise ratio over the previously used half-wave dipole cut for 10 meters. I was so pleased with the VBW-1's reception of the satellite downlink signals that I haven't used the 10-meter dipole again! Also, using the VBW-1 for transmitting with a wide range antenna tuner showed that it also radiated a useful signal on the 24- and 21-MHz bands, but at a reduced overall efficiency. Nevertheless, it could be pressed into service as a standby or emergency 12- or 15-meter antenna if the need should arise.



You can use 75-ohm coax as a feedline to the VBW-1 if you couple it to the antenna through a 4:1 balun like the one shown here, producing a 300-ohm match at the feedpoint.

Standard antenna construction practice calls for careful cleaning of all wires before connecting them. All connections must be soldered, using 60/40 rosin core solder—and make sure to use enough heat so that no cold-soldered joints will show up! Use a 100- to 150-watt soldering iron or a small butane torch. All soldered connections must be weather-protected using silicone sealant to prevent humidity from reaching into the wires and causing corrosion. Use high quality end insulators. Ribbed polyethylene types are ideal, but you may use any good insulating material to homebrew your own.

Spreaders Make It Look Nice

I recommend using insulating spreaders to keep the upper and lower wires of the VBW-1 at a uniform distance from each other. There's no need for the spreaders themselves to be uniform, however. You may build your own spreaders from PVC plastic pipe, fiberglass rods, polyethylene from the center of coaxial cables, or any other high-quality insulating material. Use no less than two insulating spreaders on each side of the antenna to prevent sagging; but I don't recommend using more than three on each side, as they do make a small contribution to increased antenna loss.

I attached the antenna elements to the spreaders with small pieces of plastic-covered hookup wire tied through holes I drilled in the spreaders.

This construction technique was used by old timers to make their two-wire transmission lines long before the first coaxial cable was ever manufactured!

Building the Load Resistor

The VBW-1's load resistor must be non-inductive, and its power dissipation needs will depend on your transmitter's maximum power output and operating mode. According to some of the antenna literature that I reviewed, the value of the load resistor in the HF version of the TTFD seems to be quite critical: 390 ohms for a 300-ohm feeder, 500 ohms for a 450-ohm feedline, and 650 ohms for a 600-ohm line.

For a *receive only + QRP transmit* "VBW-1," I use a pair of 2-watt, 680-ohm carbon resistors connected in parallel to form a 4-watt-dissipation, 390-ohm, *almost non-inductive* resistor (see Figure 2). With this load resistor, you can run up to a maximum of 10 watts transmitter carrier output power to the VBW-1 on the 27-MHz CB band (assuming it's legal to do so where you live), 10 meters, and 6 meters. This 10-watt figure refers to a full-time carrier mode such as AM, FM, or RTTY. On SSB, with its lighter duty cycle, you may run about 20 watts PEP without overheating the load resistor.

For higher power outputs, you must configure a 390- to 400-ohm resistor which is capable of dissipating about one third of your transmitter output power if it operates on a full carrier 100% duty cycle mode. This is done by connecting a combination of series and parallel 2-watt carbon resistors, which may be easily calculated following Ohm's Law.

During my experiments with the VBW-1, I've operated on 6 meters using about 75 watts CW to the feedline. The load or terminating resistor used was a series-parallel combination that gave me 24 watts of dissipation and a resistance value very close to 400 ohms (see "Calculating and Building the Terminating Resistors"). No signs of overheating or damage to the resistors were observed after lengthy periods of CW tests, which, of course, I ran on an unused frequency and with the 6-meter band closed!

Feeding the VBW-1

There are several different ways of feeding this antenna. My 4-meter overall length VBW-1 can be fed directly with low-loss 300-ohm parallel line (twin-lead) and connected, for example, to the 300-ohm input of a TV set. This is the way I use one of these antennas for monitoring the low-band TV channels while

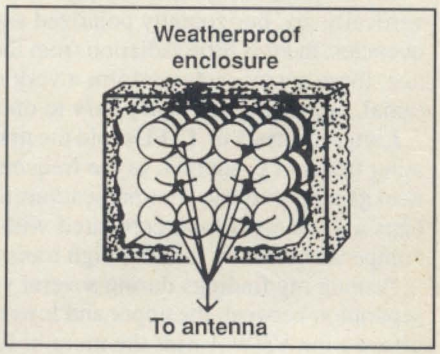


Figure 2. For receiving or for low-power transmitting, the terminating resistor at the top of the antenna may be as simple as two 2-watt, 680-ohm resistors used in parallel and placed in a weatherproof box for protection.

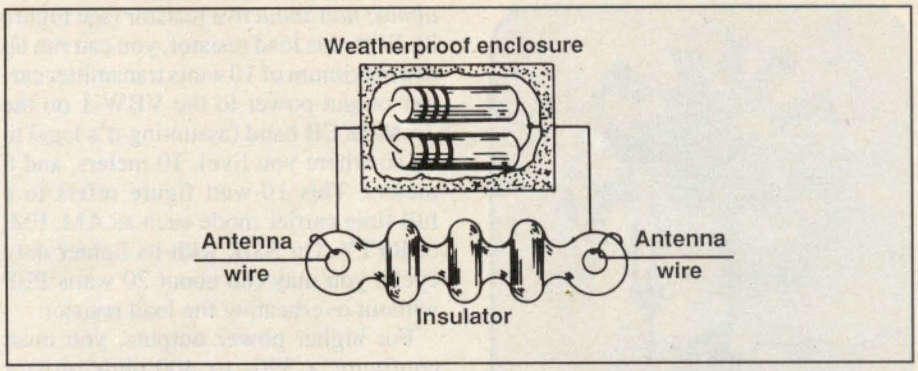


Figure 3. If you're using the VBW-1 at power levels above 10 watts, you'll need a heavier-duty terminating resistor. Here, the author has tied together a dozen 2-watt, 4700-ohm resistors in parallel to form a single, 24-watt, 390-ohm resistor. See text for details.

"Install your VBW-1 antenna as high and in the clear as possible. Note that, because this is a tilted antenna, it must be mounted at a 30° to 45° angle!"

searching for elusive sporadic-*E* openings. By the way, in this configuration, the VBW-1 also makes an excellent emergency TV antenna!

Another option is to use 450-ohm, open-wire ladder line, or, in fact, any open-wire line within the impedance range of 200 to 600 ohms. It won't make much difference, especially if you use (as I do) a simple antenna matching system or tuner.

If you follow this approach of a direct feed with a parallel line of any type, then you must install some kind of balanced to unbalanced coupling and matching system between the antenna feedline and the radio equipment. This is because practically all existing radio equipment uses coaxial cable inputs and outputs. You may use a 4:1 balun, when feeding via a 300-ohm line, directly matching a 75-ohm coaxial cable input. Or the open-wire line may be matched via a simple antenna tuner, providing either a 75- or 50-ohm unbalanced output to the equipment. The connection from the antenna tuner to the receiver, transmitter, or transceiver is then made via a short length of coaxial cable.

I use the antenna tuner approach as it's easy to build and provides an excellent match to the VBW-1 as well as additional harmonic suppression when I transmit with it. The antenna tuner also provides increased selectivity at the input when receiving, which is important when using any broadband antenna system.

Another way of feeding the VBW-1 is via a specially built 6:1 balun, connected right at the antenna terminals to a 75-ohm

The Theory Behind the Antenna

The TTFD, or Tilted Terminated Folded Dipole, was invented by G. L. Countryman, W3HH, in the 1940s and was tested in actual practice during the early 1950s. It was described by its inventor as a "squashed rhombic" because it used a terminating resistor, like the terminated rhombic unidirectional broadband antenna also popular at many professional communications installations.

The theoretical design first appeared in *QST* in 1949 (see "Resources"), but was little noticed by hams. A practical antenna based on that theory was first published in *CQ* in 1951 and quickly became very popular. For some reason, though, W3HH never published the theoretical analysis which led to his design, so the way by which he arrived at the dimensions of the original prototype TTFD remains a mystery. As John Heys, G3BDQ, says in the "Transmitting Loops" section of his book, *Practical Wire Antennas*,

> ...it bears a superficial resemblance to an ordinary folded dipole, but its dimensions, the use of a non-inductive terminating resistor and the all important 20 to 40 degrees tilt result in an aperiodic or non-resonant, vertically polarized radiator, that has a frequency ratio of at least 4:1.

My findings are that, at the higher end of the HF spectrum and lower VHF frequencies, the antenna tends to pick up both vertically *and* horizontally polarized signals with near equal strength. Although its critics point out that, at some specific frequencies, there is little radiation from the antenna and much power is wasted at the terminating resistor, the fact is that, in practice, these antennas do perform a very useful service, providing HF transmitting stations with a low cost, almost omnidirectional, broadband and fairly easy to match system.

Longtime users of TTFDs told me that efficiency was lower compared to a standard half-wave dipole cut for a specific operating frequency, but that, as the frequency went up, the TTFD's efficiency also took an upward swing, making it a very practical general purpose communications antenna. The price you have to pay for the broadbanded, single feedline antenna is perhaps a 1- to 5-dB loss, compared with a half-wave dipole cut to the operating frequency—something that could easily be compensated for by running high transmitter power.

Among my findings during several years of experimental work with the VHF versions of the antenna was the fact that the separation between the upper and lower wires of the folded dipole had to be slightly more than what was used at HF frequencies. So the VBW-1 uses the more or less standard formula for the length of the antenna 100/freq in MHz, or approximately one-third of a wavelength at the lower operating frequency, while the separation formula is modified from the 3/freq in MHz used on HF to 5/freq in MHz, which seems to offer much better overall SWR performance from 25 to 110 MHz. The results of those formulas are in meters, but you may convert them to feet by simply multiplying the metric results by 3.28. Don't worry about rounding off the numbers; this antenna is not too critical with regard to its dimensions!

Calculating and Building the Terminating Resistors

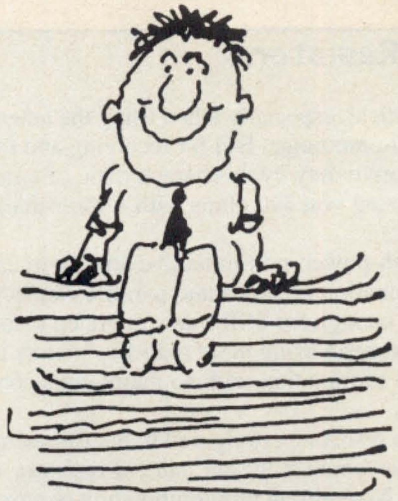
The value and power dissipation ability of the terminating resistor in the VBW-1 is critical, especially when using the antenna with a high-power transmitter. Ideally, the resistor value should be in the 390- to 400-ohm range. But for receiving and for transmitting with up to about 10 watts of carrier power, with the usual transmit and receive duty cycle characteristic of amateur radio, a pair of 680-ohm, 2-watt carbon film resistors will provide a nice match (giving you 340 ohms with 4 watts dissipation, as shown in Figure 2).

If you need to run higher power, you may follow two approaches: 1) try to obtain a high-power, non-inductive resistor of 25, 50, or even 100 watts dissipation and 400 ohms; or 2) make one yourself using a combination of series and parallel connected, 2-watt carbon film resistors. For 25 to 30 watts dissipation, which will be more than enough for SSB transmitters up to the 100-watt class, a combination group of 12 resistors of 2 watts each is used. I don't recommend using more than 12 resistors in the termination for the VBW-1, as it will be very difficult to achieve a low inductance termination with so many units connected in a series-parallel combination.

My favorite arrangement is made from 12 carefully selected 4700-ohm, 2-watt carbon resistors, configured in the following way: Connect the resistors in parallel pairs. They will form 2350-ohm, 4-watt units. Now connect the six pairs of resistors in parallel to form a single 390-ohm resistor with 24-watt dissipation ability (see Figure 3). Assembling this combination requires good layout work and careful soldering. The resistors must also be protected from the weather, something which is fairly easy to do by placing them in a plastic container, leaving enough room for ventilation since the resistors do heat up in operation, especially while running on AM, FM, or RTTY modes.

The references at the end of this article will provide additional information on how to make the terminating resistors for HF-range TTFD antennas.

coaxial cable downlead. When using this second approach, you may get away without the antenna tuner or antenna matching unit. Perhaps the SWR figures obtained while transmitting on the 27-, 28-, or 50-MHz bands will fall below the critical 2:1 ratio normally accepted as the upper limit for solid state finals. But that's something I can't tell you for sure as it will depend on many external factors, such as the location of your antenna and the nature and distance of nearby objects. So, my advice is to use the VBW-1 with an antenna tuner, regardless of whether you're feeding it directly via a balanced transmission line or are using a balun at the antenna terminals and a coaxial cable downlead. (*For more on using*



What You've Told Us...

The questions in our July survey were the same as those asked last June, and the results, by and large, have been remarkably consistent. Among the people who responded to the survey, 86% said that their issue of *CQ VHF* was addressed to them, and, of those, 94% said it was a subscription copy. The postal service is doing its job quite well, as 99% of you said your issue arrived on time.

Most of you still seem happy with what you're reading in *CQ VHF* (whew!): 77% of you say the magazine meets your needs; 69% feel it meets the needs of newer hams, and 47% say it meets the needs of experienced hams—interesting that neither of those numbers is as high as the one that *really* counts, whether the magazine is right for *you*.

Just over half of you (56%) would like to see more beginner-level technical articles and projects (check out our two antenna projects this month); 42% would like more operating-related articles (OK, tell us what *you're* up to!) and the same number say "it ain't broke, don't fix it!" Twenty-eight percent want more high-level technical articles and projects, and 23% want more news/opinion related articles.

Thanks for keeping us posted on what you'd like to see in *CQ VHF*. We'll do our best to keep the magazine full of interesting and educational articles.

This month's winner of our free one-year subscription for replying to our June survey is F. W. Hollenbeck of Lambertville, Michigan. Thank you again for your responses.

75-ohm feedline with "50-ohm" ham gear, see Arnie's article, "Yes, All My Coax Cables are 75 Ohms," in the July, 1997, issue of CQ VHF.*—ed.)*

Installing Your VBW-1

Follow standard antenna installation practices and *please be extremely careful.* **Stay away from power lines, don't work alone, and follow all safety rules.** I spent two weeks in bed last year after falling from my roof while performing antenna work by myself in violation of established safety procedures. *Don't do antenna work if there is the slightest chance of a thunderstorm anywhere nearby.* And if you *do* see a dangerous cloud, **STOP** and **GO DOWN**.

Install your VBW-1 antenna as high and in the clear as possible. Note that, because this is a *tilted* antenna, it *must* be mounted at a 30° to 45° angle! My tests showed that, from 25 to 110 MHz, it works best at a height of no more than about 6 meters (20 feet) above the ground or roof. The ideal tilt angle is as close as possible to 45°. Although some publications specify 40° as the optimum figure, in practice I couldn't really find a measurable difference between a 40° and a 45° tilt angle with my experimental setups! The prototype VBW-1 seems to work nicely at a 30° degree tilt, and it still performed rather well at a 20°slope, too. *(Countryman's original design called for a slope of approximately 30°.—ed.)*

When I installed the antenna horizontally, the SWR curve showed much bigger "bumps" than when it was properly tilted. I didn't test the antenna in a completely vertical position because it was too difficult from a mechanical point of view, requiring no less than a 5-meter length of insulated mast, which was not available. In further tests, moving the antenna around the compass showed *some* directional effects; in other words, the VBW-1 seems to be slightly directional, or show a small amount of gain, in the direction in which it is tilted when using a metal mast or tower to support it. This is something that may be put to good use in some cases. And yes, you're right: the VBW-1 requires only *one* mast, which is yet another advantage over other similar broadband systems.

In Closing

My eight years of experience with this antenna have shown that it's an excellent all-around performer, much quieter than any other broadband antenna that I've ever tested, very easy to build, and even easy to repair in case of any breakdowns. Plus, as some of my friends who are familiar with it point out, it's nice to have that feedline in the shack, as you can test almost anything by simply connecting it to the VBW-1. ■

Resources

For more information on the TTFD (Terminated Tilted Folding Dipole) antenna, you'll have to do some serious digging. But here's a selected bibliography if you really want to learn more about this antenna:

1. "An Experimental Allband Nondirectional Transmitting Antenna," by G. L. Countryman, W3HH, *QST*, June, 1949, p. 54.
2. "Performance of the Terminated Folded Dipole," by G. L. Countryman, W3HH, *CQ*, Nov., 1951, p. 28. (*This is the article that first brought the TTFD to wide attention.—ed.*)
3. "More on the T2FD," by G. L. Countryman, W3HH, *CQ*, Feb., 1953, p. 28
4. "The T2FD," by Donald L. Stoner, W6TNS, *CQ* (Novice column), June, 1957, p. 92.
5. *CQ Antenna Roundup*, 1963 pp. 68 and 70 (a reprint of #3).
6. *Practical Wire Antennas*, by John D Heys, G3BDQ, Radio Society of Great Britain (RSGB), 1989, pp. 46–49.
7. *Radio Communications*, July, 1986 "Technical Topics" by Pat Hawker, G3VA, p. 113.
8. *Update*, 24 January 1986 West Kent Amateur Radio Society England.
9. "Broadbanding the Dipole" in "Technical Topics," *Radio Communications*, RSGB, June 1987.
10. "Improved HF broadband wire antenna" Drs. Brian Austin and A. P. Fourie, *Electronic Letters*, 12 March, 1987, pp. 276-277.