

Broadband Transmitting Wire Antennas for 160 through 10 Meters

A traveling-wave antenna offers some attractive qualities for your station: a 50-Ω feedpoint at ground level, no tuner required, horizontal and vertical radiation components, no radials, nothing in the air but wire, and flexible size and height requirements.

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Does it sound too good to be true? Well, if you need a high-gain, directive antenna, this is *not* it. If you are looking for a general-purpose, simple, all-band radiator, however, a terminated wire may be your answer. There are many designs for resistively loaded dipoles and verticals, but I decided to design a wire antenna that covers 1.8 to 29.7 MHz with a low SWR and provides maximum radiation in all directions on all bands. There were to be no drooping feed lines or other heavy components in the wire, so it would be easy to support with ropes.

In this article, I am going to describe two designs that have resistive terminations at the end (on the ground). They require one or two support points, no more than

120 feet apart (as little as 30 feet apart if you omit 160 and 80 meters). Because the ends are on the ground, safety is a concern. If there is a possibility that someone might touch the wire while you are transmitting, slip a 10-foot piece of small-diameter PVC tubing over the wire ends at ground level and cover the connection terminals.

This antenna has been analyzed for support heights from 30 to 70 feet, although other heights are possible. Since this is not a resonant antenna, you can adjust its size

to fit your property. It is not necessary to have both ends at the same height. As you might suspect, lower and shorter wires reduce efficiency and raise takeoff angle.

Terminated wires are part of a class of antennas called *traveling wave* antennas, in which the current is approximately constant along the wire (any length). Such antennas have been with us since the dawn of Amateur Radio but may not have reached their full appreciation until personal computers came of age. For a dipole, one of a

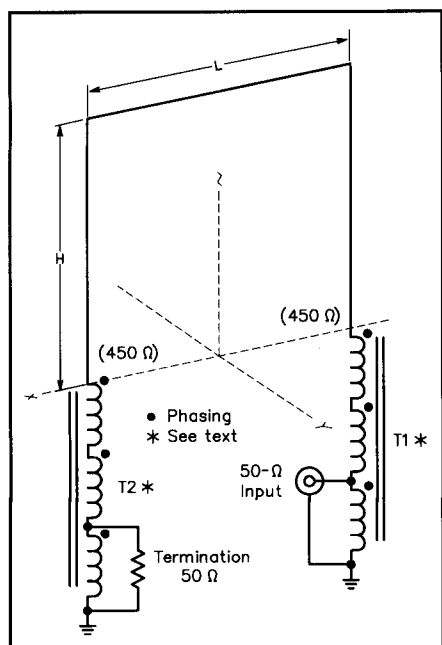


Figure 1—An end-fed, end-terminated TW antenna.

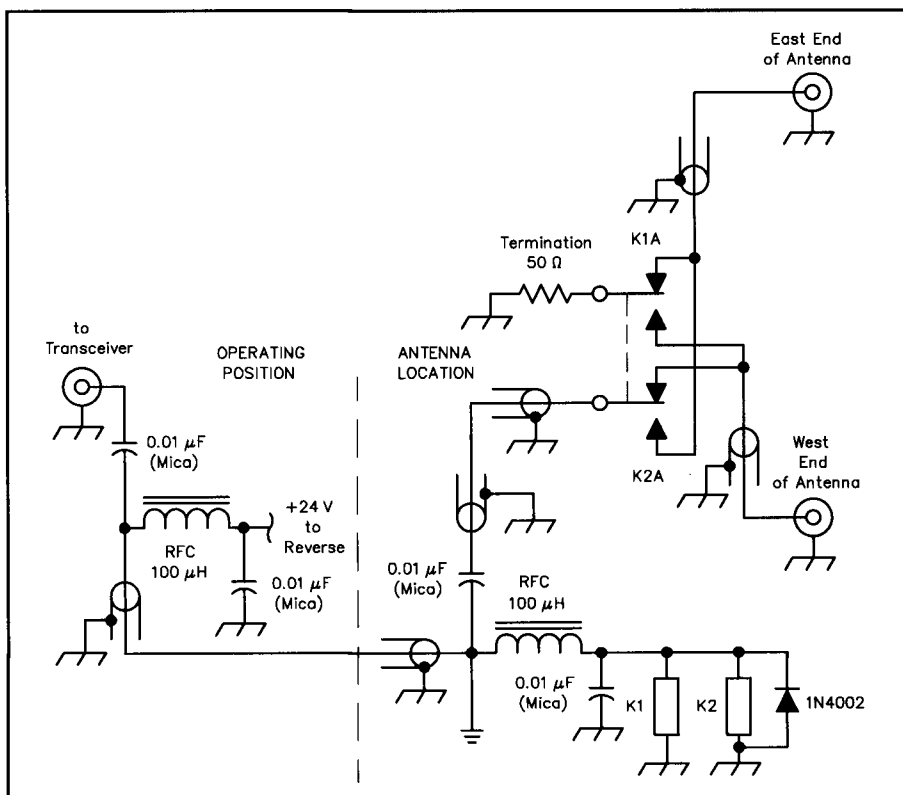


Figure 2—Relay-switching a TW antenna's pattern. RF chokes and blocking capacitors let the feed line carry the relay power.

Table 1
Impedance and SWR for a Typical TW Antenna (50 × 50 ft)

	Frequency (MHz)								
	1.8	3.8	7.2	10.1	14.2	18.1	21.2	24.9	28.5
R (Ω)	662	551	497	346	531	487	433	461	393
X (Ω)	-15	-49	33	-99	-97	-125	-61	-141	-151
SWR	1.47	1.25	1.13	1.44	1.29	1.32	1.16	1.36	1.50

Reference: 450 Ω

Table 2
Calculated Efficiency (%) Versus Antenna Dimensions

Height (ft)	Length (ft)	Frequency (MHz)								
		1.8	3.8	7.2	10.1	14.2	18.1	21.2	24.9	28.5
30	30	0.44	7.4	40.8	33.9	47.6	47.6	48.9	59.9	67.2
30	60	1.1	11.5	28.9	41.4	48.0	57.5	58.9	67.8	67.9
30	90	1.8	11.7	26.0	35.2	53.1	60.4	64.9	68.0	68.5
40	40	1.3	17.3	39.1	39.2	47.1	55.9	67.7	63.9	68.4
40	80	2.9	18.4	37.4	47.6	56.0	65.2	65.7	63.9	67.0
40	120	4.5	15.1	39.6	51.6	55.8	66.8	68.9	66.4	68.3
50	50	3.0	26.7	39.5	50.3	53.3	62.7	67.5	67.9	66.9
50	100	6.2	23.3	45.5	51.6	63.4	67.3	64.1	64.9	64.3
50	120	7.1	20.8	44.6	53.3	62.6	66.2	63.9	64.9	65.4
60	60	5.9	34.2	37.1	45.5	63.6	66.9	67.2	63.1	68.5
60	120	10.2	26.7	45.1	53.4	63.8	66.0	68.7	67.7	72.4
70	70	9.9	36.5	40.6	51.7	60.4	66.5	62.3	67.9	68.6
70	120	13.8	32.2	46.1	57.7	66.8	68.2	66.6	70.8	70.5

SWR less than 1.5:1 for all dimensions listed.

Table 3
Calculated Efficiency (%) Versus Antenna Dimensions for Sloping TW Antenna

Height (ft)	Length (ft)	Frequency (MHz)								
		1.8	3.8	7.2	10.1	14.2	18.1	21.2	24.9	28.5
30	60	0.10	2.3	20.9	36.1	40.9	45.0	47.9	47.9	49.0
30	90	0.06	3.9	27.3	44.0	42.8	45.6	47.1	51.7	50.8
30	120	0.14	5.1	24.5	43.8	43.0	44.9	49.9	51.5	52.1
50	60	0.62	14.3	39.4	37.5	45.5	54.9	59.9	56.3	49.9
50	90	0.42	19.9	40.7	38.4	41.2	43.6	51.4	58.6	53.8
50	120	0.97	22.4	37.0	42.7	40.1	46.0	49.6	59.2	53.5
70	90	2.0	24.7	31.5	35.5	43.8	50.5	50.4	60.2	55.5
70	120	2.5	26.0	34.7	38.2	42.0	52.6	48.7	61.4	55.1

SWR less than 2:1 for all dimensions listed (based on tower 10 feet higher than top of TW)

class of antennas called standing-wave antennas, the current is maximum in the middle and decreases to zero at the ends. Let's call the antennas I am about to describe TW (terminated wire), and Sloping TW antennas.¹

All multiband wire antennas suffer from low efficiency at low frequencies and undesired directivity (multiple lobes) at higher frequencies. Their advantages are low SWR over the entire frequency range, easy broadband matching to 50 Ω and simplicity. These two antennas also have both horizontal and vertical polarization components, which may reduce fading of both transmitted and received signals on long paths.

The Terminated Wire (TW) Antenna

Figure 1 shows an end-fed, end-terminated TW antenna. The natural feed impedance is about 450 Ω, so a 9:1 (450-Ω/50-Ω) impedance transformer is used at each end of the antenna to match a 50-Ω power load at one end and a 50-Ω feed at the other end.

Table 1 lists the calculated impedance and typical SWR for this antenna. Table 2 lists the calculated efficiency for the TW antenna on all nine bands for heights from 30 to 70 feet, and for lengths from 30 to 120 feet.

Although the efficiency is less than 5% at 1.8 MHz for smaller versions of this antenna, it's many times more efficient than a mobile antenna and is still useful for general communication. With increasing size and frequency, the efficiency rises to a respectable 50% (-3 dB), which is typical of terminated wire antennas (V beams, rhombics and so on). As is evident from Table 2, the termination power rating should be equal to the transmitter power (nearly all power loss is in the termination at low frequencies). The totals include wire and ground losses, but those losses account

¹You can learn more about traveling wave antennas in Chapter 13 of *The ARRL Antenna Book*, 17th edition, from ARRL.—Ed.

for only a small percentage of the total loss.

The largest problem for the general-coverage spectrum is not efficiency but unwanted directivity. On the upper bands, this antenna shows directivity toward the termination end: Two 24-V coax relays permit us to reverse the feed and termination ends, to improve coverage. The relays are operated by applying +24 V to the coax, as shown in Figure 2.

Results

The first TW antenna I erected was 70 feet high and 120 feet long, running from east to west. There was a 4-foot ground rod below each wire drop with 12 inches extending out of the ground. The transformers, mounted in die-cast boxes, are clamped to the top of the ground rods with stainless-steel hose clamps. A binding post on the top of each box connected to the wire ends.

This antenna was tested at 1 kW on all bands except 10 MHz. The SWR was less than 1.5:1 everywhere. The power measured at the termination end was generally in agreement with the calculated value, $P_{in} \times (1 - \text{efficiency})$. I worked many stations at various distances, from 100 miles to long-path contacts of 15,000 miles on 7-MHz sideband. No front-to-back ratio (F/B) was evident on 160 or 80 meters, but on 7 MHz, the F/B was 10 dB or more. On 14 MHz, F/B ran greater than 15 dB at times. On 18 MHz and above, the F/B was typically 20 dB, which prevented some contacts until I reversed the antenna pattern. These comments really mean that the antenna was too large for good general coverage and a length of 70 feet would probably be better. A review of Table 2 shows that a length of 70 feet has virtually the same efficiency as 120 feet, so the shorter length would be better. Broader lobes on the upper bands would improve the coverage.

My impression, after many SSB contacts, is as follows:

- 160 meters: Moderately effective for stateside QSOs, but not a DX antenna.
- 80 meters: Competitive with dipole stations running similar power. Easily worked VK, LU and DL stations.
- 40 meters: Good performer on both stateside and DX contacts; similar to high dipoles on DX.
- 30 meters: Not tested.
- 20 meters: Excellent performer worldwide, but definitely not a beam.
- 17 to 10 meters: Competitive with small beams. Many excellent reports from DX stations in all directions.

All in all, the results are better than I hoped for, and I believe this antenna has a lot to offer the average HF operator, who many not have the space for many antennas.

Sloping Terminated Wire (STW) Antenna

Although it's less efficient than the horizontal TW, the sloping TW is interest-

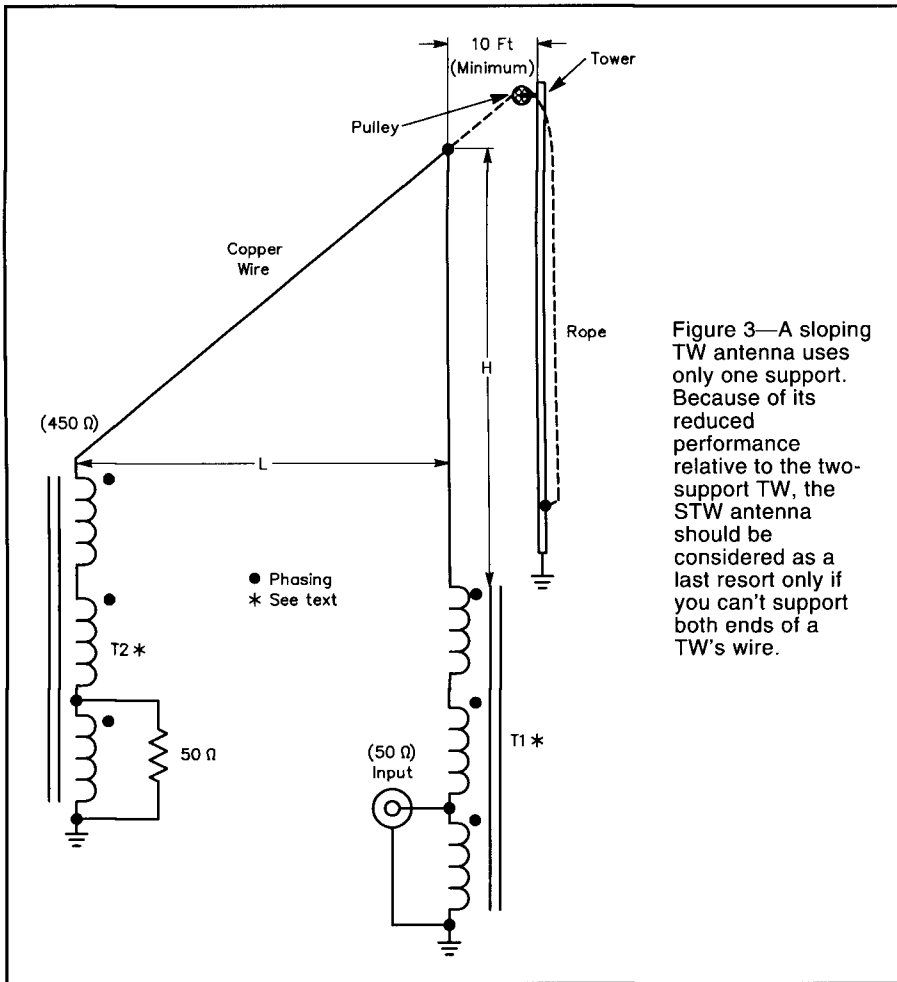


Figure 3—A sloping TW antenna uses only one support. Because of its reduced performance relative to the two-support TW, the STW antenna should be considered as a last resort only if you can't support both ends of a TW's wire.

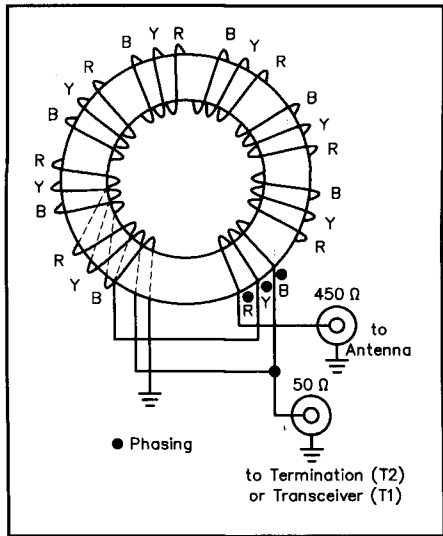


Figure 4—Winding details for the 50:450 Ω impedance transformer.

ing because it requires only one support. If that support is a tree, wooden pole or a non-metallic building, results should be fairly good in all directions. If a metal tower supports the antenna, poor SWR will likely result because of resonances of the tower system.

Figure 3 shows the best way to implement a sloping TW antenna hung from a tower. Use a rope run through a pulley at the top of the tower to hoist the wire. Make sure the end of the TW is at least 10 feet away from the tower. Again, the ability to reverse the antenna feed will improve coverage in distance and direction.

Table 3 gives the calculated TW performance for heights of 30 to 70 feet and horizontal spans out to 120 feet.

Transformer Design

The transformer uses a single ferrite core (Amidon FT-240-61) with a trifilar (three wires) winding of 9 turns of #18 Teflon-insulated stranded wire. It is helpful to use three wire colors; so for the sake of discussion, let's assume the wires are red, yellow and black. After the winding is placed on the core, hookup is as follows: Ground the starting end of the black wire, and connect the other end of this wire to the starting end of the yellow wire. This connection is the 50-Ω point; connect it to the

coax-connector center pin. Connect the opposite end of the yellow wire to the starting end of the red wire. Connect the far end of the red winding to the binding post (450-Ω connection). Figure 4 shows a sketch of the wire hookup.

The first transformers I built were housed in die-cast boxes, but I mounted later units in plastic pipe caps obtained at the local plumbing store. In each case, a binding post is mounted on the top of the housing for the 450-Ω connection to the antenna wire.

My tests have shown that this transformer can be conservatively rated 1500 W PEP, 500 W average, over the 1.8 to 30-MHz range. I will make transformers available, for a nominal charge, to anyone who doesn't want to build their own.

Recommendations

I recommend that the dimensions used not fall outside the limits shown in Tables 2 and 3. If you plan to use this antenna for DX work, mount it as high as possible (up to 70 feet) to achieve lower takeoff angles. On the lower bands, the vertical polarization pattern will dominate; On the upper bands, the horizontal pattern will have more gain at low angles.

For stateside ragchewing, the antenna need not be so high. The horizontal, high-

angle pattern will be most useful on the low bands. On the upper bands, the vertical components of the pattern will also be high-angle.

Picking from the dimensions in Table 2, I recommend the 50-foot-high by 50-foot-long version to favor 80 through 10 meters. If only 30 feet of height is available, you may want to lengthen the top wire; this somewhat reduces the takeoff angle. Certainly, antennas patterned after any of the dimensions shown will work. Consider the STW antenna a last resort for hams who simply can't support both ends of a wire.

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