The *GRASSWIRE:* Another Approach to Hidden HF Antennas

The article is an AntenTop Magazine variant of Chapter 7 from K3MT book "HF Antenna Topics."

Deed restrictions got you down? Neighbors intimidating your tower plans? Need a really easy, portable HF antenna? Then the Grasswire may be the answer! Virtually invisible, lightweight, and compact (you can carry one in your hip pocket), this antenna works! I've used one in various installations for more than 10 years.

Read on - and listen to the "experts" telling you that this is hogwash, that an antenna like this can't work. But it does. And true experts, who have taken a decade or more to come to grips with the intricacies of Maxwell's Math, know why.

Grasswires will not out-perform a yagi, or a decent dipole up a half wavelength. Not in gain or signal strength, at least. But they do survive ice and wind storms, and are practically immune to lightning. And they don't need a large tower or tall support. I deploy one from my hip pocket at times - the balun to match it is larger than the antenna!

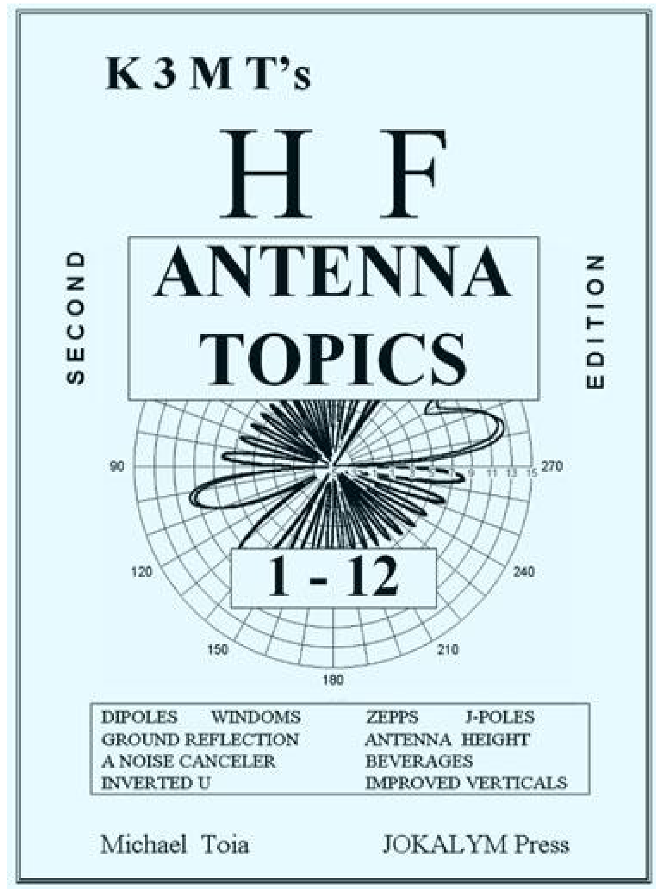
The Grasswire - In Brief

What is it? Put simply, it's an end-fed, longwire antenna that is laid right on the grass. Hence the name. Look familiar? Yup! It's a very low beverage antenna…

My first Grasswire, built in the summer of 1988 was just 204' of #22 AWG magnet wire laid along the property line, anywhere from 1" to 6" above the ground. **Figure 1** shows plan and elevation views of a typical installation.

An 8' ground rod and optional counterpoise wires are shown. The counterpoise is a 40' wire, center tapped. Use it or the ground rod: you don't need both.

These antennas are largely resistive, with values ranging from 150 to 500 ohms or so on average ground. I've used them successfully on the soils northwest of Washington, DC, on the sandy soils of the Cape Canaveral, Florida area, in the rocky, shale soils of the mountains in Somerset county, PA, and on river bottomland of Allegheny County, PA. One was used with great success by K3MT/VP9 in Southampton, Bermuda - the object of nightly pileups on 30 m CW for four nights.



Reflection and the Brewster Angle

The skeptic in you will doubt that such low antennas can work. After all, its image in the ground radiates and cancels out all radiation. True - if the ground is perfect. But nothing is perfect!

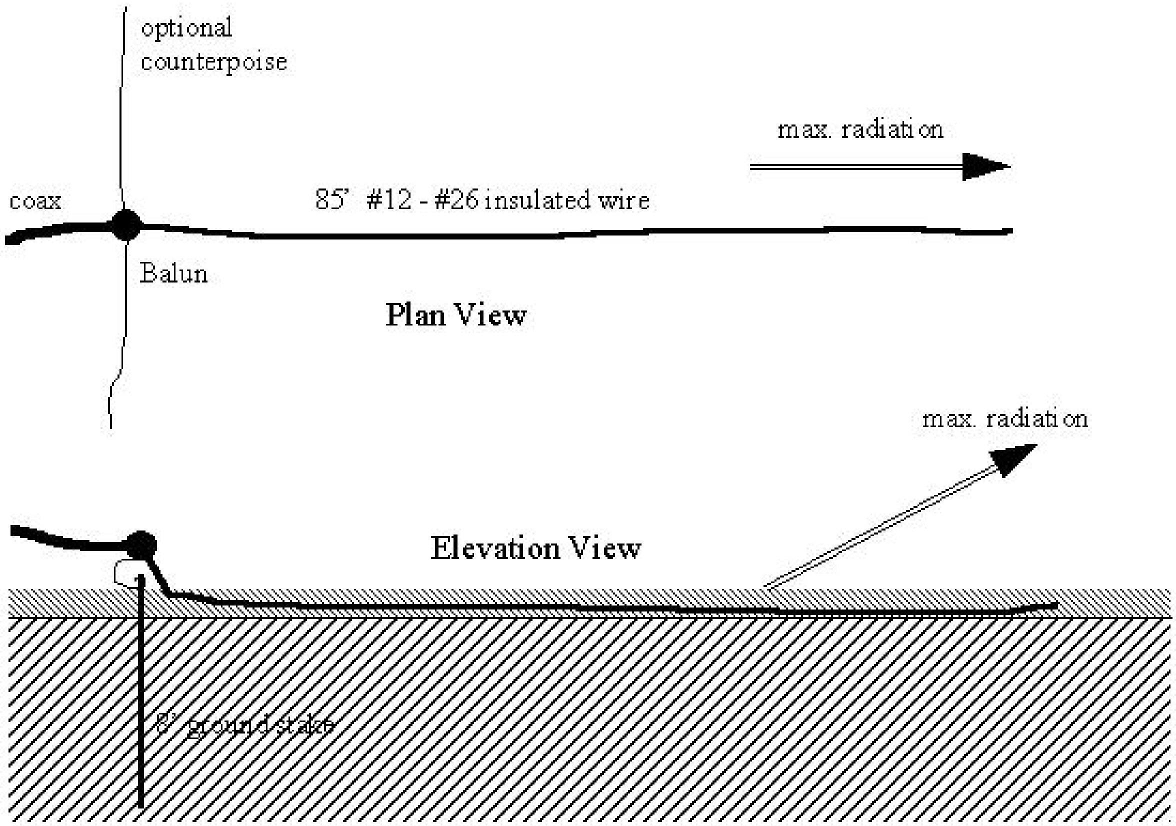


Figure 1

Plan and Elevation views of a Typical Installation of Grasswire Antenna

The grasswire radiates *vertically polarized* off the *end* of the wire. Extensive monitoring tests with wires laid along the great circle route toward WWV, and perpendicular to that line, demonstrate the end-fire nature of the antenna. So why does it work?

When a plane wave reflects from an air-earth boundary, an incoming ray reflects, giving an outgoing ray. These two, and the line normal to the boundary plane, form a *plane of incidence.* Solutions of Maxwell's equations differ for the case of the E-field being perpendicular to this plane (i.e., horizontally polarized), and the case when the E-field vector is *in* the plane of incidence.

You will probably call the latter "vertical" polarization, although this is technically not correct. Electromagneticists (a.k.a those who practice Electromagical effects) refer to these cases as *normal* incidence (horizontal polarization) and *planar* incidence (vertical polarization.)

For the normal incidence case, reflection is nearly total, with a nearly 180 degree phase reversal. Thus very low antennas neither respond to, nor generate, appreciable amounts of horizontally polarized radiation. But for the planar incidence case, the reflection varies in strength considerably. At some *takeoff angle* (angle between outgoing ray and the ground) the reflection becomes quite weak, and has a 90 degree phase shift. Near this angle, the sum of direct and reflected rays will have a magnitude as if the antenna were in free space! Of course, at other angles, ground reflection largely cancels the direct ray, and the antenna does not radiate well at all.

A *reflection coefficient* is calculated as the ratio of the electric field in the incoming ray to the electric field in the reflected ray. It varies from one (total reflection without loss) to zero (no reflection at all.) It depends on the takeoff angle, frequency, and the soil parameters (dielectric constant and conductivity.) **Figure 2** shows plot of planar incident (vertical polarization) reflection for typical "good" soils and **Figure 3** shows plot of planar incident (vertical polarization) reflection for typical "poor" soils.

Figure 2

Plot of Planar Incident (Vertical Polarization) Reflection for Typical “Good” Soils

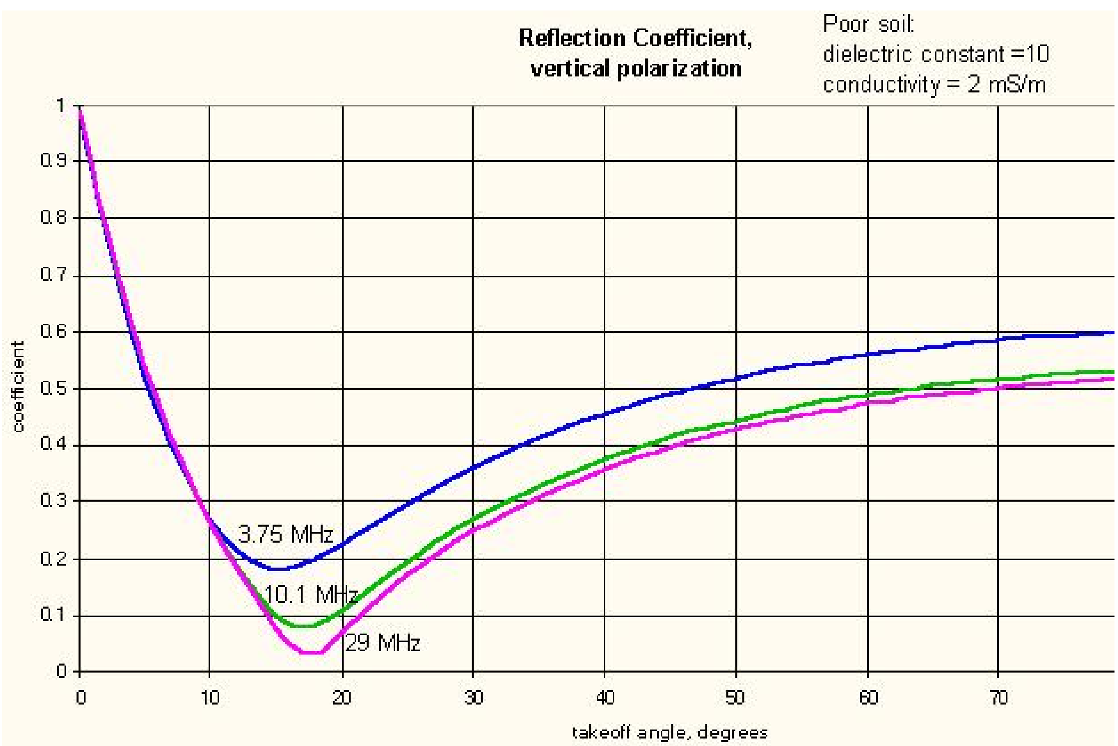


Figure 3

Plot of Planar Incident (Vertical Polarization) Reflection for Typical “Poor” Soils

Notice that, at 10 to 25 degrees, the ground reflection is very weak. It also is shifted 90 degrees in phase from the incident ray. Therefore, radiation from the grasswire, off the ends will be about the same as if the ground were not present.

But launching a ray at, say, 15 to 20 degrees takeoff angle, in a direction toward Europe, can be useful! That's what a grasswire does. It is lossy in all directions, but least lossy when exciting the ionosphere for a long-haul DX contact. To demonstrate the point, here's an extract of K3MT's log, for October of 1988, (ahh, glory! Yes, the SSN was good then!) using a grasswire!

Not bad, for a wire on the ground. Notice that contacts were made on 80, 40, 20, 15, and 10 meters. The signal reports are not fantastic.

But contacts were made, and ham radio was enjoyed! Five countries were worked in 3 days. And the best part of this setup: *the neighbors never knew that a ham station was on the air!*

During our Bermuda excursion, I took a TR-7, small antenna tuner, a power supply, and a Grasswire. We were guests of a small family-run group of rental cottages in Southampton for four days. On the third day, one of the elder family members chatted with me a bit, and asked if I was perhaps a radio amateur.

I said, "yes." In fact, I had been on the air for the previous two days, using a Grasswire. It was only that morning that he, in cleaning up around the area, came across the antenna! *That's* a low-profile antenna.

GMT	CALL	his/my RST	FREQ	Power	
27 OCTOBER					
1554	SM6DYK	579 / 559	28004	80	
1601	SM0LBR	569 / 439	21007	100	RAY - STOCKHOLM
2001	W4JBQ	579 / 569	7029	40	JOE - FT WRIGHT, KY
2141	W8LNJ	579 / 459	28015	80	DAVE - DALLAS, TX
28 OCTOBER					
0227	W8AO	589 / 569	3547	15	BOB - SILVER LAKE, OH
1720	G3RFE	579 / 559	21016	100	TOM - BARROW
1932	G0CBW	569 / 559	14029	50	MEL
1945	VE2FOU	589 / 559	7032	100	ANDRE - IBERVILLE
2026	KB7UX	569 / 539	21040	100	RUSS - CHINO VALLEY, AZ
2100	I2JIN	589 / 559	14022	40	BOB - COMO
2123	G3JVC	569 / 559	14022	40	JOHN - LONDON
29 OCTOBER					
2105	WA200JXT	599 / 599	28015	80	ND

Feeding the Grasswire

Since this antenna is largely resistive, a simple trifilar balun is all that I have ever had to use. **Figure 4** shows how to make a Balun that works.

Typically I pull the insulated jacket off some indoor telephone wiring cable. Four insulated #22 copper wires are inside: discard one of these and use the remaining three.

Wind about 16 turns on a T-200-2 core (available from Amidon and others), without allowing the wire to twist (keep the three conductors parallel at all times.)

Notice that this "balun" really matches an unbalanced antenna to an unbalanced transmission line. It is basically a wide-band, three-winding autotransformer. Impedance ratios are as shown on the drawing. Generally it is necessary to connect the coax to either A2/B1 or B2/C1, and the antenna to B2/C1 or to C2. This may change from one band to another, and usually does.

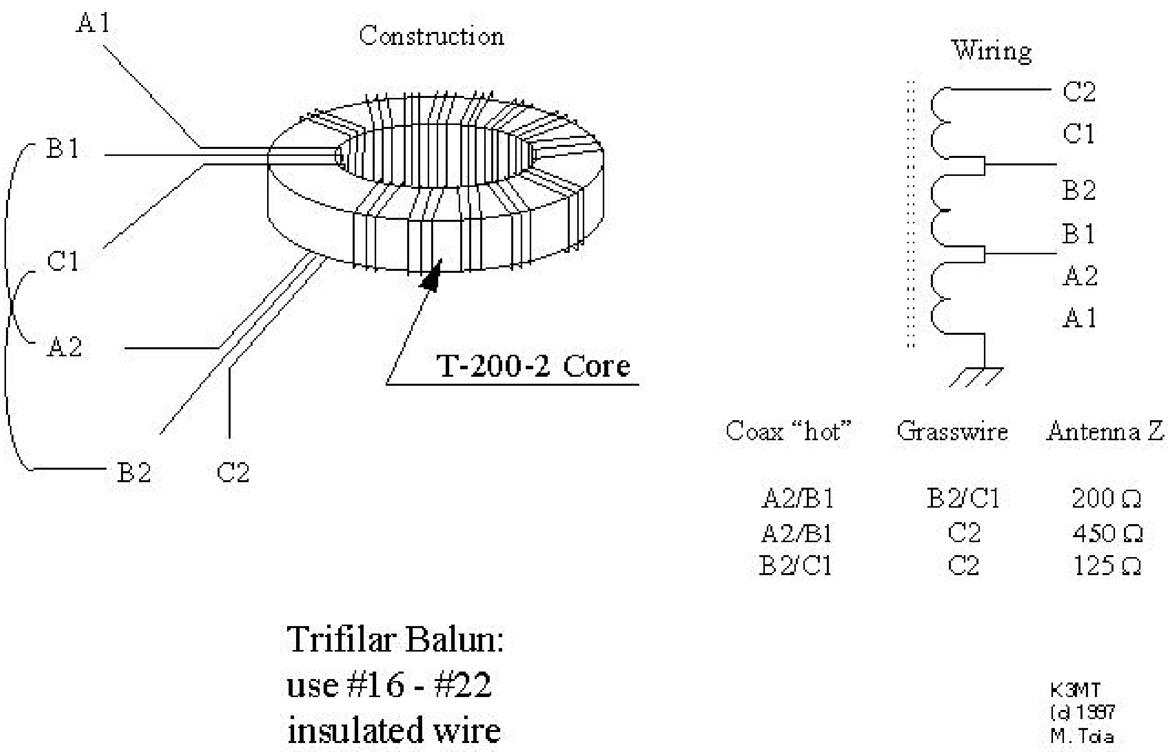


Figure 4

Balun for Grasswire Antenna

How much wire?

A general rule of random wire antennas is to get as much wire in the air as you can - longer is better. Does this still hold for the Grasswire? The answer is no. Measurements show that anything over a wavelength does no appreciable good.

My first measurement program parked a car on a dirt trail, with a spool of 18 gauge insulated wire unwound, one end tied to the bumper and the rest run on down the trail. The dirt was average stuff, mostly clay and loam on top of granite. At the car the wire was untied from the bumper, passed through a small RF toroid, and connected to an antenna tuner, the latter driven by a TR7 transceiver at approximately fifty watts. The car itself served as a counterpoise.

A ten-turn secondary winding on the toroid drove a small diode and capacitor. RF current in the antenna developed a DC voltage across the capacitor that I measured with a handheld DC voltmeter. As the toroid slid along the wire, the voltage dropped and fell below 10 percent of the starting value a wavelength along the wire.

There was a small rise in voltage for a short bit farther along the wire, but at a full wavelength it fell below one percent, and never showed any further improvement. This occurred on 80 40, 20, 15, and 10 meters.

This measurement indicated that the current in the wire dropped almost exponentially along the wire, and beyond a wavelength was more than 20 dB down, so could produce little radiation. The excess wire can simply be removed. Thereafter my Grasswire deployments always used about one wavelength of wire at the lowest operating frequency.

Continuing the measurement at a later date, an assistant and I laid a center-fed wire dipole on a grassy field, 396 feet of insulated, 12 gauge wire - all that we happened to have handy. Again a small toroid RF transformer and diode/capacitor, similar to the earlier one, had one side of the dipole threaded through it. A fiberglass surveyor's tape stretched from the center along the dipole to one of its ends. The DC voltage, measured as a function of distance along the wire is a measure of the RF current. **Figure 5 and Figure 6** show the falloff of current along the wire at 7 and 29 MHz amateur Bands and its attenuation by at least 20 dB at one wavelength (seventy, and sixteen and a half feet, respectively.)

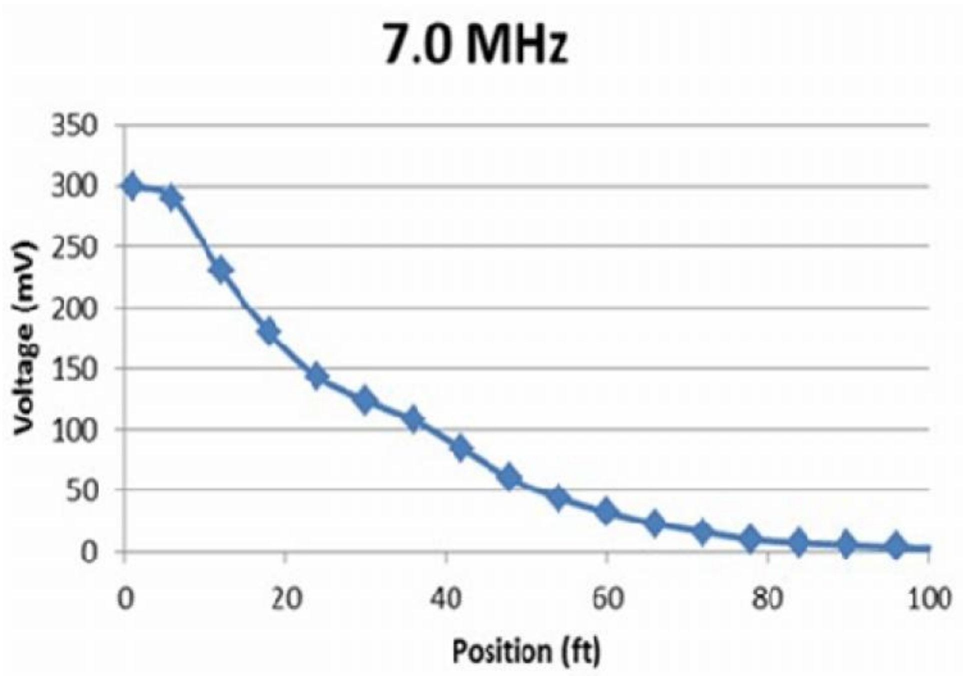


Figure 5

Current Profile at 7- MHz

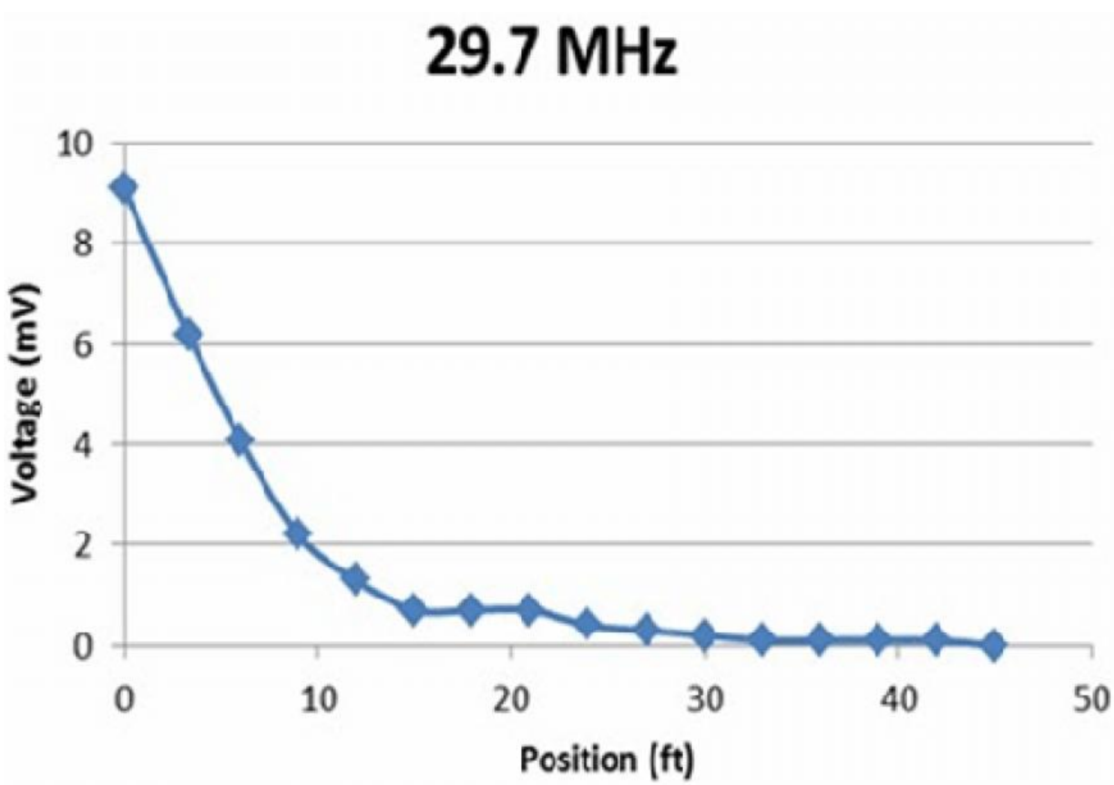


Figure 6

Current Profile at 29- MHz

Windom In The Grass

I have elsewhere described a Windom antenna. While it is usually hung from a pole or in a tree, it works when used in a "grasswire" mode. Just lay it on the ground. Dimensions are repeated in **Figure 7** for ready reference.

When I travel, I sometimes take one of these made of #22 insulated hookup wire. Since I often set up beside motel parking lots, and often after a day's work, sometimes after dark, I've color-coded the wires. The longer is black, and the shorter, red. This helps me determine which way to point the Windom. Remember, though, that it fires off the long end. Of course, it fires the other way, too, but with a bit less gain.

I hope this has given you a good case of curiosity. Go out and try one of those ground - mounted wires. They're easy to build. Even the balun is easy to build.

And they're fun to play with.

A last word to put off discouragement: the Grasswire, and Beverages in general, are lossy compared to a good Dipole at a half-wave height. They are disappointing for QRP operation. Run a bit of power with these antennas. 100-W RF or more should do the trick.

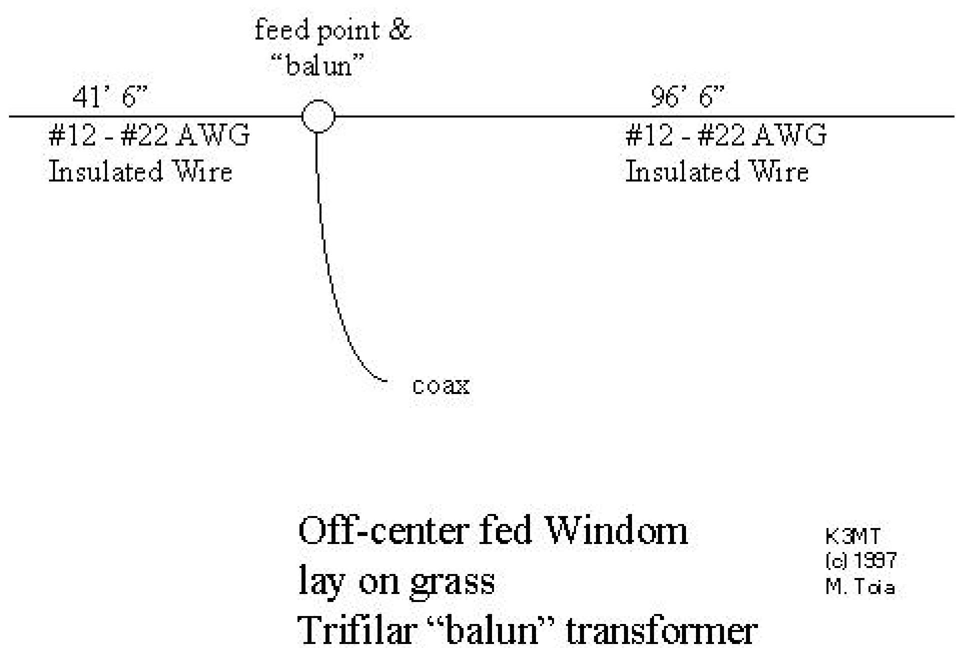


Figure 7
Windom on the Ground

Flourish Magloop Antenna by Klaus Boecker

Credit Line: The Urban Radio Ham group at Facebook