The Real World Meets Your Real Antenna

You built your antenna "by the book" and it doesn't do what you expect — what's the story?

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Many hams new to HF operation start with a half wave dipole antenna or one of its variants — we even recommended it.[1] What could be simpler? Cut a piece of wire so that the dipole will be a length (in feet) of 468/f, as it says in *The ARRL Antenna Book* and *Handbook for Radio Communications*, feed it in the center and hoist it up — you're on the air.[2,3] Or are you?

A Starting Point — Not the Answer

While the value of 468/f seems like it should result in a right sized antenna for the frequency f, it really is more accurately described as a *typical* length. There are a number of factors that play a major part in the determination of both the resonant frequency (the frequency at which the impedance is totally resistive) and the value of that impedance. We'll discuss the biggest factors below. The SWR of a 40 meter dipole resonant at 7.15 MHz is shown in Figure 1. The example we will use is made of bare #14 AWG wire, tuned to be resonant at 7.15 MHz in free space. This will be our point of comparison.

[1]Notes appear on page 48

Height Above Ground and Ground Characteristics

The height of a horizontal dipole antenna above ground has a major impact on a number of antenna operational characteristics. The vertical and even horizontal, to less extent, radiation patterns are a function of height. Usually more noticeable, however, is the resonant frequency and impedance at resonance as shown in Table 1. This table shows the *EZNEC* antenna modeling software prediction of the resonant impedance of a dipole at different heights above both perfect and typical ground.[4] Your ground is probably closer to "typical" (see the note in Table 1). Note that the value of $L \times F_R$, corresponding to the oft published 468, isn't close for most heights.

Conductor Diameter

The diameter of the conductor has an effect on both the resonant frequency and the bandwidth of a dipole. The results for our usual 40 meter dipole are shown in Table 2.

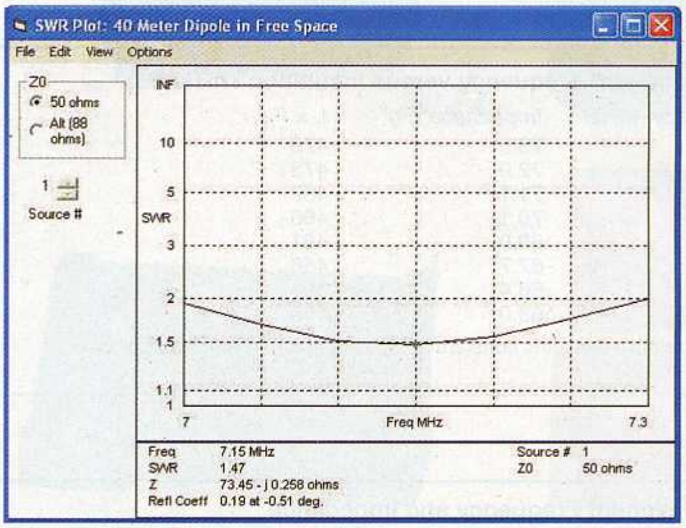

Figure 1 — SWR response of a 40 meter dipole cut for 7.15 MHz.

Table 1
Variation in Dipole Resonant Frequency and Impedance with Height Above Ground*

	Typical Ground			Perfect Ground		
Height (λ)	*Frequency (MHz)*	*Impedance (Ω)*	*$L \times F_R$*	*Frequency (MHz)*	*Impedance (Ω)*	*$L \times F_R$*
Free Space	7.15	73.5	478.3			
1	7.175	72	480	7.19	72	481
0.75	7.1	75	475	7.18	60	481
0.5	7.2	68	482	7.23	70	484
0.4	7.2	84	482	7.21	92	484
0.3	7.13	89	477	7.09	95	475
0.2	7.06	73	472	7.00	63	468
0.1	7.08	53	474	7.07	22	473

*Ground parameters; relative dielectric constant 13, conductivity 0.005 S/m. Bare #14 AWG copper wire.

The change in bandwidth with diameter is particularly striking at the larger diameters. While we are unlikely to make a 40 meter dipole out of 20 inch tubing, we could simulate the effect by using multiple wires in a *cage* configuration. Such an antenna is used at W1AW to cover all of 75 and 80 meters. The same proportions are easily obtained at VHF.

Wire Insulation

While it is commonly known that insulated wire works about as well as bare wire for antenna elements, and may have mechanical advantages, it may be less well-known that the insulation changes the speed of the antenna current on the wire. This results in a shorter antenna being needed for the same resonant frequency. The effect is a function of both the thickness and the dielectric constant of the insulation. Table 3 shows the predicted results with PVC insulation, as on the usual house wire, of different thicknesses.

Table 2

Variation in Dipole Resonant Frequency, Impedance and 2:1 SWR Bandwidth with Conductor Diameter*

Diameter	*Frequency (MHz)*	*Impedance (Ω)*	*Bandwidth (kHz/%)*	*L × F_R*
0.040" (#18)	7.16	74	290 / 4.1	479
0.064" (#14)	7.15	73.5	310 / 4.3	478
0.1"	7.14	73	325 / 4.6	478
0.2"	7.12	72.5	355 / 5.0	476
0.3"	7.11	72.3	375 / 5.3	476
0.4"	7.10	72.3	390 / 5.5	474
0.5"	7.09	72.1	400 / 5.6	474
0.75"	7.075	72.2	425 / 6.0	473
1"	7.055	72.0	445 / 6.3	472
2"	7.01	72.0	500 / 7.1	469
3"	6.98	72.0	535 / 7.7	467
5"	6.93	72.0	590 / 8.5	464
10"	6.86	72.4	685 / 10	459
20"	6.79	74.8	795 / 11.7	454

*Bare copper conductor in free space.

Table 3

Variation in Dipole Resonant Frequency versus Insulation Thickness*

Thickness	*Frequency (MHz)*	*Impedance (Ω)*	*L × F_R*
Bare	7.15	73.5	478
0.01"	7.07	72.0	473
0.02"	7.01	71.1	469
0.03"	6.96	70.1	466
0.05"	6.89	69.0	461
0.07"	6.82	67.7	456
0.1"	6.74	66.4	451
0.2"	6.57	63.0	440

*Polyvinylchloride (PVC) (relative dielectric constant 2.88) insulated #14 AWG copper wire in free space.

Table 4

Variation in Dipole Resonant Frequency and Impedance versus Angle Between Wires

Angle (degrees)	*Frequency (MHz)*	*Impedance (Ω)*	*L × F_R*
180 (Horizontal)	7.15	73.5	478
160	7.16	72.0	479
140	7.17	67.0	480
120	7.2	59.5	482
100	7.26	49.4	486
90	7.29	43.6	488

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Angle Between Wires

Many find the use of a dipole in an inverted V configuration handy, since it requires only a single support, and also provides better support for the transmission line. While it works about as well as a horizontal dipole at an intermediate height, the angle between the wires changes both the resonant frequency and the resonant impedance, as shown in Table 4.

What Does it All Mean?

It is certainly helpful for the antenna builder to be aware of the nature and extent of these relationships and hopefully it will explain a lot of surprises. Note also that the effects are relatively independent — that is an inverted V made from insulated wire will have the effects of each — and they will act in opposite directions.

Perhaps my best advice is to make your best estimate of required antenna length, leave a few feet of excess folded back at the end insulators, hoist it up and see what you have. Lower and adjust as needed until you have what you want. Only then cut off the excess and secure the ends properly.

Notes

[1]J. Hallas, W1ZR, "Getting on the Air — Your First HF or 6 Meter Antenna," *QST*, Jan 2008, pp 65-66.

[2]R. D. Straw, Editor, *The ARRL Antenna Book*, 21st Edition. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 9876. Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop; pubsales@arrl.org**.

[3]*The ARRL Handbook for Radio Communications*, 2010 Edition. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 1448 (Hardcover 1462). Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop; pubsales@arrl.org**.

[4]Several versions of *EZNEC* antenna modeling software are available from developer Roy Lewallen, W7EL, at **www.eznec.com**. QST

Strays

I would like to get in touch with...

◊ anyone who has information about the maritime selective-call system modifications for the Drake TR-7. I'm trying to resurrect a Drake TR-7 that was modified for a maritime selective-call system. The TR-7 was working well with the selcal unit attached but I have misplaced the selcal unit and the TR-7 no longer works. If anyone knows how the selective-call system operates with the TR-7 I would appreciate your help. I have a schematic and maintenance manual. — *Terry Simonds, WB4FXD*, **wb4fxd@arrl.net**