THE FFD ANTENNA: A Field-Friendly Doublet, with Notes on Related Designs
By Charlie Lofgren, W6JJZ. T*he ARS Sojourner* Operation in the field is year-around fun, and with summer here, it's truly time to get outdoors. But what about the antenna? If the rest of the gear is lightweight, why not the antenna system? There's the rub.

The antenna itself may be nothing more than a flyweight wire, but the feedline most likely won't be. A halfwave wire fed against ground is one option, but not optimal.

The Field-Friendly Doublet or "FFD" is the solution. It is a lightweight, quickly-assembled version of a multiband center-fed wire antenna with "tunedfeeders," but it requires no prefabricated feedline. To present the FFD and review related applications, this article includes:

-- A primer on multiband doublet design

-- The FFD and its construction

-- Tuner options

-- Field-friendly approaches to the W3EDP antenna and fullwave loops

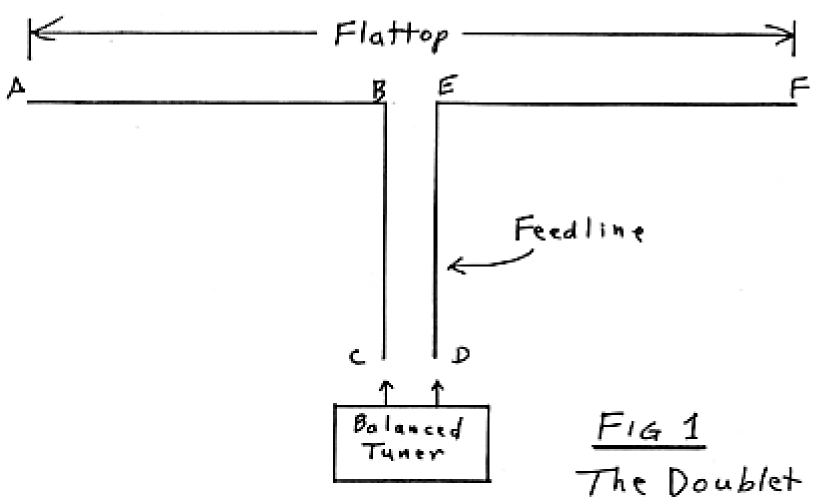
-- An appendix on halfwave wires fed against ground

-- References for additional information

The eager builder may be tempted to skip the first section, "A Doublet Primer," and go directly to "How Simple Can It Get? The FFD," but it's useful first to know the basics.

A DOUBLET PRIMER

The generic "doublet" is simply a center-fed horizontal wire antenna. When the doublet is fed with low-loss balanced feedline fed through an antenna "tuner" (more accurately, an "antenna system tuning unit" or ASTU), it becomes a highly versatile and efficient multiband antenna system that is resonated with the tuner. (See Fig 1.)The G5RV and the so-called "center-fed zepp" are common examples.



Contrary to some impressions, the length of the center-fed wire (or "flattop") is not critical. In this regard, there is nothing magic about the 102 foot flattop of the G5RV. (Another myth is that the G5RV version of the doublet doesn't need an antenna tuner). True, a doublet's radiation pattern will vary depending on the length of the flattop, but efficiency is acceptable with any convenient length over a quarter or preferably a third of a wavelength on the lowest band of interest. The best definition of "convenient" in this regard is "the distance between the available supports." (As usual, of course, the higher up, the better.)

Now for the feedline. In home-station installations, probably the most common feedline nowadays for a multiband doublet is 450 ohm "window" line, although 300 ohm twinlead is used, too. In reality, however, the impedance of the line makes little difference with a multiband doublet, at least within the impedance range of typically constructed balanced feedlines (roughly 300-800 ohms). The feedline's impedance and length affect the impedance seen by the antenna tuner looking into the input end of the line, but they do not affect the radiation from the antenna. (G4FGQ's program DOUBLET.EXE, referenced below in the final section, allows easy examination of the effect of changing the various parameters--flattop and feeder lengths, height, spacing, etc.)

More important than the feedline's impedance is its loss figure, because the standing-wave ratio may be high. With low-loss line, even a high SWR results in insignificant losses. (The last statement is not true when commercially-available twinlead or window line is operated with a really high standing-wave ratio, on the order of 1000:1 or higher, but this condition does not occur with the FFD, nor, for that matter, does the FFD use commercial feedline.)

The ideal feedline for a multiband doublet is true open-wire line, which is lower loss than either window line or twinlead. Sometimes called "ladder line," it consists of two separate parallel wires spaced anywhere from 1 or 2 inches up to 6 or 8 inches, with line spacers as necessary. (The spacers give a ladder-like appearance, hence the name.) In order to minimize radiation from the feedline, the spacing should be no more than 0.01 wavelength at the highest frequency of operation, or about 4 inches on 10 meters. But, to quote my 1939 Radio Amateur's Handbook, "Even at 28 Mc. a separation of 6 inches is fairly satisfactory."

How long should the feedline be? Long enough to reach from the center of the flattop to the operating position.

There's the basic design. For additional background information and theory, see the references at the end of the article.

HOW SIMPLE CAN IT GET? THE FFD Now let's put all of this together to produce the FFD. There are two requirements for a doublet. One is a flattop, preferably over a third of a wavelength long. The second is a feedline that will reach from the center of the flattop to the rig.

But wait! Flattop and feedline together can be made from just two wires or "legs." One leg comprises one side of the flattop plus the related side of the feedline, or A-B plus B-C in Fig 1. The other leg comprises the other half of the system, or D-E plus E-F. The total length of each leg accordingly equals one-half of the flattop's length plus the feedline's length.

Configuring the FFD requires only the positioning of the two legs. The feeder portions of each of the two legs run from the antenna tuner to a center insulator, with the wires roughly parallel to each other and about six inches apart. On the lower HF bands, even wider spacing between the feeder portions of each wire won't degrade performance. From the center insulator, the remainder of each leg runs outward in opposite directions, producing the flattop portion.

Presto! You have a multiband doublet without a bulky feedline. The wire provides a feedline.

Assume for example that 40 meters is the lowest band of interest. If the space between the available supports is about 60 feet, the flattop might be 50 feet long, or 25

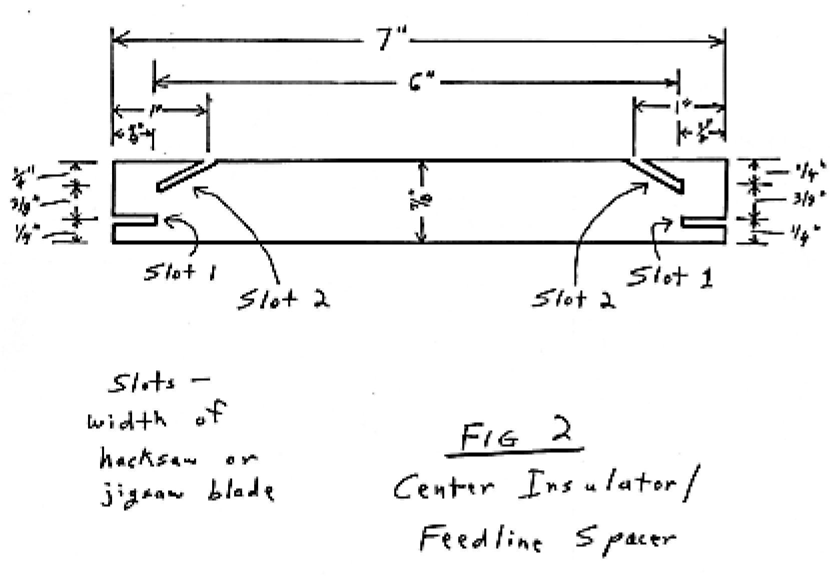
feet on each side of center. (This would allow for 5 feet of support cord at each end, to keep the flattop clear of the trees or whatever.) Suppose the center is about 30 feet up. That means (let's estimate) 30 feet of feedline to reach the well-positioned operating position. For the complete doublet "system" we'll need two 55 foot lengths of wire (25 + 30 = 55).

If space permits, the FFD may be configured to give significant gain in desired directions. Among the options are two halfwaves in phase (a halfwave of wire on each side of the flattop) and an Extended Double Zepp (5/8 wave on each side). For these configurations, the lengths need not be cut to the precise inch or even foot. To realize their full benefit, however, the flattop portion should be at least a half of a wavelength above ground, which is easily obtainable on the upper HF bands with field installations using light wire. On the lower bands, the breaking point of light wire creates difficulties with such large arrays, unless additional skyhooks are used. But nothing prevents trying. And keep in mind (as an example) that a halfwave flattop on 40 meters becomes two halfwaves in phase on 20 meters.

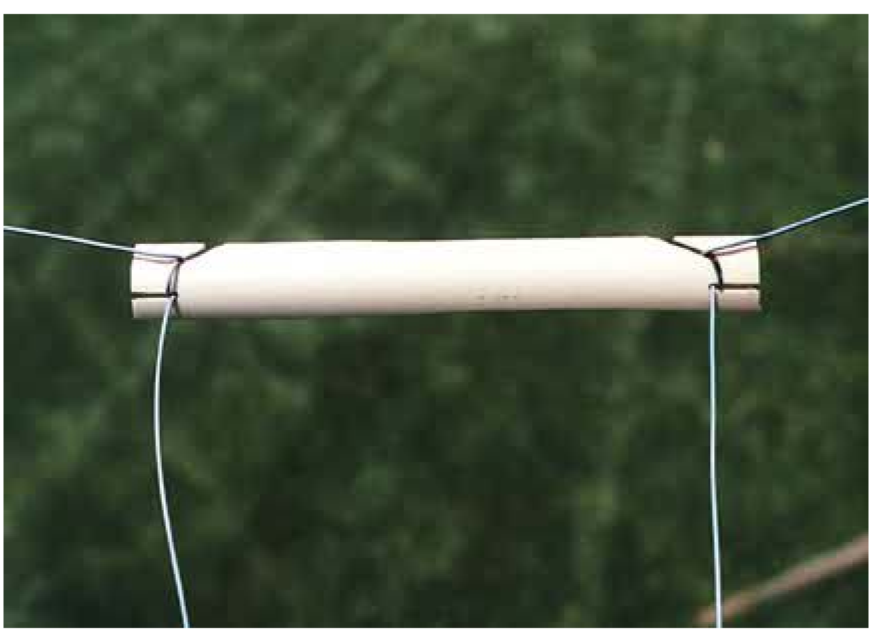
THE CONSTRUCTION DETAILS: HOME AND FIELD PHASES

For the two legs, insulated stranded wire in the vicinity of #22 to #26 gauge is satisfactory and rolls up easily. The insulation does not affect the operation.

While the necessary insulators and spacers can be fabricated in the field with a little ingenuity, the better approach is to make them ahead of time and carry them. They take up hardly any space and weigh almost nothing.



For the center insulator and feedline spacers, strips of plastic may be slotted to allow quick attachment in the field. The design described below and in Fig 2 works for both the center insulator and the spacers. One spacer each six or eight feet along the feedline is adequate. End "insulators" for the flattop need consist of nothing more than string, light cord, or twine tied to knots in the ends of the wires. Or for a classy installation use short plastic strips for the end insulators. The insulator/spacer material should be lightweight and tough.



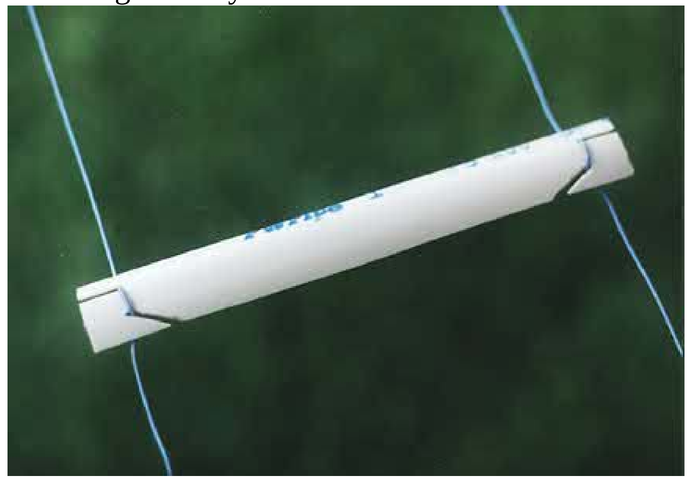
I've found that strips cut from low pressure "1 inch" PVC water pipe work well. (This pipe is about 1 and 5/16 inches in actual outside diameter, with 1/16 inch walls.) Here are detailed instructions:

(1) Begin by cutting four lengthwise strips from a 14 inch length of the PVC pipe, using a jigsaw or long hacksaw (and being careful of the fingers!). To do this, cut the section in half lengthwise, and then cut each resulting strip in half, again lengthwise. This gives four strips each 14 inches long and about 7/8 inch wide.

(2) Next cut the four strips in half, into 7 inch lengths. Then cut ONE of these in half, giving two shorter pieces. The result:

seven strips measuring 7 by 7/8 inches each, and two measuring 3 1/2 by 7/8 inches each.

(3) Saw slots in the 7 inch pieces as indicated in the picture and Fig 2. (With the typical jigsaw or hacksaw blade, the slots will be about 1/16 inch wide.) This gives you a center insulator plus six spacers (the center insulator and spacers being interchangeable), enough for about 50 feet of feedline.



(4) Drill holes in the two 3 and 1/2 inch pieces as indicated in the picture and Fig 3. These are the end insulators, should you choose to use them.

When you head to the field, take the insulators/spacers and as much wire as you think you'll need and then some. If setting up the station will be a leisurely affair, a single roll of wire is best. You can cut the two equal legs after you examine your site. (Remember? Each leg equals the length of the feedline plus half the length of flattop.)

Or you can cut the wire ahead of time. In this instance, marking equal segments along the two wires lets you know quickly -- when you're in the field -- where to put the center insulator to insure that it's at the center. Bands made with a felt-tip permanent marker do nicely.

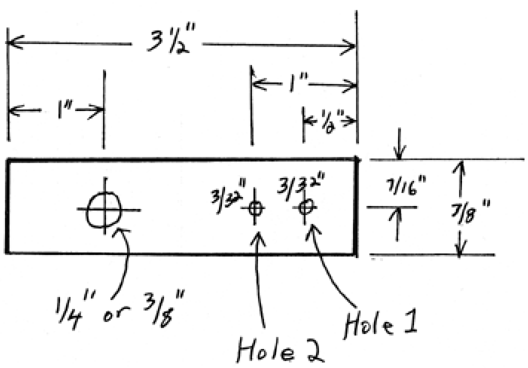
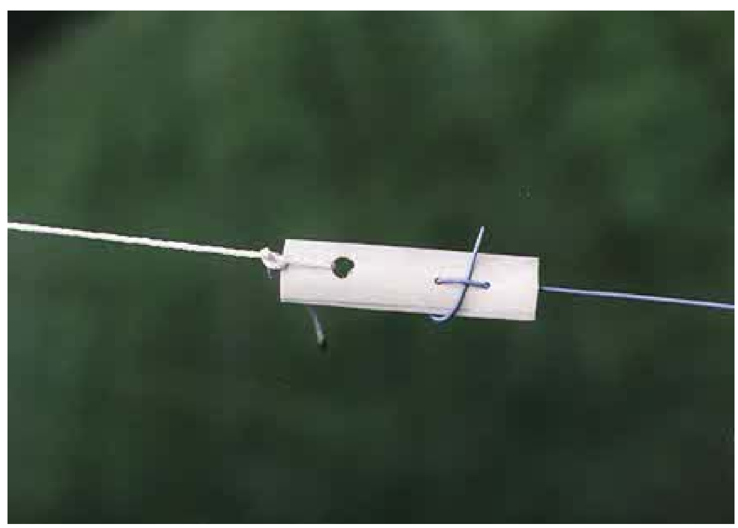


Fig 3

End Insulator



Attaching each leg of wire to the center insulator and spacers is simple and quick. It is easier to do than describe. (Take a look at the pictures.) Begin by attaching one of the wires at its feedline-flattop junction to one end of the center insulator. To do so, start with the feedline side of the junction and slip it into the slot cut inward from the insulator end (slot 1 in Fig 2). Next, loop the flattop side of the junction through the slot that's angled into the insulator (slot 2), then through the end-cut slot, and finally back again through the angled-in slot and outward as the flattop wire. You now have a one-and-a-half turn loop, about 3/8 inch in diameter, around the section of PVC between the two slots. The wire coming out of the end-cut slot (slot 1) runs to the tuner, and the wire coming out of the angled-in slot (slot 2) runs outward as half of the flattop. (If you reverse this, and try to run the wire coming from the end-cut slot as the flattop wire, it will just slip out.)

Next (need it be said?) attach the other leg in the same way to the opposite end of the insulator.

Then attach the spacers to the feedline wires. As indicated earlier, one spacer every six-to-eight feet along the wires is adequate. At each end of each spacer, simply run a feedline wire into one slot and out the other slot. No looping of the wires is necessary in order to keep the spacers in place.

To attach the end insulators, refer to Fig 3 and the picture. Starting from the concave (inner) side, thread the wire into hole #1 and out hole #2 (which puts it back out the concave side), leaving approximately a 2 inch pigtail coming out of hole #2. Then wrap the pigtail around to the other side of the insulator (the convex or outer side) and slip it under the short (1/2 inch) section of wire now running between the two holes. Once the wire is pulled tight, the insulator will hold in place. (Or just thread the wire into hole #1, out hole #2, and knot the end.) The large hole in the insulator is for the support cord.

Assembling and hoisting the FFD takes only a few minutes after you've put the support cords into available trees with slingshot, rock, or other favorite launch vehicle. (This crucial step may take longer, but that's part of the game.) Make the connections to the center insulator before raising the flattop. You may find it easiest to attach the line spacers as the antenna is hoisted, particularly if a second op or helper is around. For the FFD to operate properly, it is not necessary to keep the feedline wires exactly parallel. It is important, however, for the spacing (whatever it is) not to shift significantly if the antenna blows in the wind during operation, because this may affect tuner adjustment.

TUNER OPTIONS

The FFD requires a balanced-output tuner. When the multiband z-match that I've designed (see the reference section) is built with subminiature "plastic" variable capacitors, it fits into a small box, and even with miniature air variables it's not much larger. The design includes both high- and low-impedance output links. Given the range of impedances encountered at the input to the FFD's "feedline," this feature sometimes proves helpful.

The visual LED SWR indicator developed by Dan Tayloe, N7VE, makes a handy accessory to build into the tuner package. Because it incorporates a resistive (or "absorptive") bridge circuit, it is especially good for rigs that will not tolerate a high SWR. During tune-up, just be sure to switch the indicator in before applying power. (And remember to switch it out once the tuner is adjusted! The resistive bridge cuts power output to the tuner/antenna by 6 dB.)

Another suitable z-match is the Emtech ZM-2, which Roy Gregson, W6EMT, markets as a kit. It includes N7VE's indicator.

For single-band operation, or operation on two or three closely adjacent bands, I've developed a variation on the z-match. (It will handle 40 and 30 meters, for example, or 20, 17 and 15 meters.) Pete Hoover, W6ZH, has packaged this design into a minuscule unit, complete with the N7VE SWR indicator, covering 40 and 30 meters.

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TWO MORE FOR THE FIELD: THE W3EDP AND THE FIELD-FRIENDLY LOOP

Two other worthwhile designs for the field are the W3EDP antenna and the fullwave loop. Information on these antennas appears in standard sources. What follows are simply brief descriptions along with suggestions for applying the "field friendly" technique to the two antennas.

AN OLD FAVORITE: THE W3EDP

In 1936, Yardley Beers, W3AWH, described an empirically-derived antenna "designed by the writer's friend, Mr. H. J. Siegel, W3EDP." It consisted of an 84 foot radiator and a 17 foot "counterpoise." The design has lasted through the years. I've explained elsewhere how it is related to an end-fed Zepp (a true Zepp, as once trailed from Zeppelin airships). With the indicated dimensions, the antenna works well on 40, 20, 15, and 10 meters. Like the FFD, the 'EDP requires a tuner.

If you're at a site calling for an end-fed antenna, the W3EDP may be the one for you. Rather than run the short wire off in an odd direction, slightly better performance results from configuring the two wires to produce an end-fed Zepp. Use three of the quick-connect spacers described above. Terminate the short wire with a top spacer at the 17 foot point along the long wire (with a couple of other spacers along the way), and run a support cord outward from the same (short-wire) end of the top spacer. This gives a 17 foot feedline with 6 inch spacing. From the other end of the top spacer, run the remaining 67 feet of the long wire outward as the flattop portion of the Zepp.

If you don't configure the W3EDP as a Zepp, it is still best not to lay the short wire on the ground in the usual counterpoise fashion. This wire is part of the radiating system.

If you're not sure whether you'll need an end-fed or a center-fed design, carry two 84 foot lengths of wire and one 17 foot length. Use the 17 foot length and one 84 foot length to whip up a W3EDP/End-Fed Zepp, or use the two 84 foot lengths for an FFD.

FIELD-FRIENDLY LOOPS

Don't forget full wave loops. A horizontal loop provides good close-in communication on the lower HF bands, and does a decent job, too, on the higher ones. Conventional wisdom has it that such a loop works on its fundamental frequency (where it's a full wavelength in circumference) and on harmonic frequencies. In reality, when a horizontal loop is fed with tuned feeders rather than coax, its exact length is not critical, and it works also on non-harmonically-related bands (although radiation patterns may vary). For example, a 40 meter loop (about 140 feet in circumference) performs on 30 meters and the HF bands further up in frequency, and a 30 meter loop (about 100 feet) will perform on 40 meters and the higher bands. Irregular shapes compared to a neat square or circle are acceptable. One approach is to snake the wire though tree branches at a manageable height (which need not be uniform around the circumference).

Or, should you need predictable gain and directivity, consider a verticalplane fullwave loop with tuned feeders. Examples include the bottom- or side-fed delta loop and the quad loop. Here it may pay to be more careful with the dimensions if you want to insure the directional characteristics.

Whatever loop you choose, the field-friendly construction requirements are simply a single length of wire, a center insulator, and feedline spacers. In this instance, the length of wire should equal the length of the loop itself plus twice the length of the feedline. Attach a center insulator where the two endpoints of the loop meet at the loop-feedline junction, leaving equal lengths of wire on each side to serve as the feedline. (Attach the center insulator using the quick-connect method described above for the FFD.) Run the feedline segments to the operating position, keeping the wires roughly parallel with several quick-connect spacers. Again, a tuner is necessary.

APPENDIX: HALFWAVE WIRES FED AGAINST GROUND

Still another antenna for the field is a halfwave wire worked "against ground." One end of the wire radiator is fed from the antenna tuner, with the remainder of the radiator running to available supports. The ground side of the tuner is attached to a ground stake or short counterpoise (which provides adequate capacitive coupling to ground). This arrangement has the virtue of simplicity.

But an often-unrecognized problem may exist with this antenna, resulting from its ground system.

The antenna supposedly has low ground losses. This conclusion rests on the (correct) observation that the impedance at the antenna's feedpoint at the near end of the halfwave wire is very high, on the order of several thousand ohms. Current flow into the antenna wire at its feedpoint is thus very low and so is current flow into the ground system. The supposed result is low I^2R losses in the ground connection.

By conventional antenna theory dating to the 1930s (supported by some experimental data), this is questionable. With a halfwave radiator fed against ground, current is low in the immediate vicinity of the ground connection, but farther out within the ground the sum of the ground currents rises and higher I^2R losses occur. (A close analogy is the rise in current along the antenna wire itself, from very little at the halfwave feedpoint to a peak a quarterwave away, at the wire's center.) Depending on soil characteristics, the ground portion of the circuit comprising the entire antenna system may be quite lossy in the absence of an extensive radial system.

NEC-4 modeling complicates the picture, however. It does not indicate the losses expected on the basis of conventional theory when a halfwave radiator is fed against ground without an extensive radial system. So from the standpoint of efficiency, this antenna may be an acceptable choice. The jury is still out.

Whichever conclusion is correct regarding its efficiency, a halfwave fed against ground lacks the versatility of the FFD. As we've seen, the FFD requires no particular dimensions. And if supports are available, it may raised higher along its entire length than an end-fed halfwave, part of which is necessarily low. The FFD may also be configured to give significant directivity and gain.

None of this is to argue that the end-fed halfwave does not "work," because people do use it successfully, and it requires one of the simplest of tuners (such as the "Rainbow Tuner"). The real point instead is that in QRP operation, antenna performance needs constant attention.

SOURCES AND ADDITIONAL REFERENCES FOR THE CURIOUS READER

Basics and general:

For multiband, center-fed antennas with tuned feeders, see The ARRL Antenna Handbook (ARRL, 18th ed, 1997), pp 7-2 to 7-3 (in other editions, look up the section "Center-Fed Antennas" in the chapter on "Multiband Antennas"); Lew McCoy, W1ICP, Lew McCoy on Antennas (CQ Communications, 1994), pp 57-60 (Lew calls his version of the multiband doublet "the McCoy dipole," a.k.a. "the real McCoy"); and John D. Heys, G3DBQ, Practical Wire Antennas (RSGB, 1989; available through the ARRL), pp 15-24 (ch 2, on "Centre-fed antennas using tuned feedlines"). For detailed exploration of various doublet configurations (flattop length and height, feeder spacing, etc.), try the program DOUBLET.EXE by Reg Edwards, G4FGQ, downloadable from Reg's Webpage: http://www.btinternet.com/~g4fgq.regp

L.B. Cebik, W4RNL, has written numerous pieces on various aspects of centerfed antennas along with other designs and related topics, which may be found on his Webpage: http://web.utk.edu/~cebik/radio.html

The z-match:

My improved z-match design may be found in Lofgren, "The Z-Match Coupler: An Update," QRP Quarterly, July 1995, pp 10-11; in Lofgren, "An Improved SingleCoil Z-Match," The ARRL Antenna Compendium, vol 5 (ARRL, 1996), pp 194-196; and on K0JD's Webpage: http://www.pconline.com/~rohrwerk/k0jd

The Antenna Compendium article also includes my design for a "single-band" zmatch that actually covers two or three closely adjacent bands. (The core and winding data in the article give 40-30 meter coverage; adaptation to other ranges and yet smaller cores is easy.) Pete Hoover, W6ZH, has done a tiny version of this design, covering 40 and 30 meters, which will appear in a forthcoming issue of QRP Quarterly.

The LED SWR indicator designed by Dan Tayloe, N7VE, with modifications by Jim Hossack, W7LS, and me, may be found on KI7MN's Webpage: http://www.dancris.com/~ki7mn/n7veswr.htm

Dan's original design (without the mods) appeared as the "ScQRPion Visual SWR Indicator (SVSI)," QRPp, Spring 1997, pp 22-24.

Roy Gregson, W6EMT, offers his ZM-2 in kit form. Inquire by e-mail to roygregson@aol.com, or see the EMTECH Webpage: http://pages.prodigy.net/roygregson

Miscellaneous:

For the original W3EDP antenna, see Yardley Beers, W3AWH, "An Unorthodox Antenna," QST, March 1936, pp 32-33. A modern description is in Heys, Practical Wire Antennas (cited above), pp 33-34. A posting containing my detailed analysis of the 'EDP (where I show its relationship to the end-fed Zepp) may be found in the archives of QRP-L for March 7, 1998. I have the same analysis available via e-mail.

Horizontal and vertical fullwave loops are covered in The ARRL Antenna Book (pp 5-16 in the 18th edition). See also W4RNL's Webpage, cited above, and the chapter on "Large Loops" in John Devoldere, ON4UN, Antennas and Techniques for Low-Band DXing (ARRL, 2nd ed, 1994). Although many of the loop designs show coax feed, in most instances tuned feeders also work.

For fuller treatments of the ground losses associated with a halfwave radiator fed against ground without an extensive radial system, see Devoldere, Low-Band DXing (cited above), p 9-30; Paul H. Lee, N6PL, Radio Amateur Vertical Antenna Handbook (CQ Publishing, Inc., 2nd ed, 1984), pp 81-84; the classic studies by George H. Brown done in the 1930s that Lee cites; and also H. E. Gihring and G. H. Brown, "General Considerations of Tower Antennas for Broadcast Use," Proceedings of the Institute of Radio Engineers, vol 23 (April 1935), especially pp 329-338. Lee states that without a good ground system, feeding a halfwave against ground may result in power losses of 40 to 80 percent, or about 2 to 7 dB. NEC-4 modeling does not show these losses, perhaps indicating that a radial system makes little difference with an endfed halfwave radiator. For the "Rainbow Tuner" for end-fed halfwaves on 40 and 30 meters, which includes a built-in SWR indicator and is kitted by the New Jersey QRP Club, see the club's Webpage: http://www.njqrp.org

Acknowledgements:

I'm indebted to Richard Fisher, nu4SN, for his photography; to John Dundas, W6SU, Cam Hartford, N6GA, Pete Hoover, W6ZH, and Steve Miller, W6FEB, for important suggestions; and to L. B. Cebik, W4RNL, for full and timely answers to several questions and especially for his NEC-4 modeling and for sharpening my understanding of voltage-fed antennas.