Notes on Ribbons, Cages, Parasites, and Lines
Broadband Coverage of the 80-75-Meter Band with AWG #12 Copper Wire

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The chapter in *The ARRL Antenna Book* (9 in the 20th edition) is an excellent introduction to techniques for obtain full coverage of the 3.5-4.0-MHz amateur band, a 13% bandwidth as such things are reckoned. It is also a tribute to long years of work, analysis, and measurement by Frank Witt, AI1H the chapter's author. Nevertheless, the subject is not completely closed.

The premise for these notes is that we have an endless supply of AWG #12 copper wire. As well, we can support an 80-75-meter dipole at 90' above average ground. Besides a little preliminary modeling in free space, we shall use these values as constants. Our goal is to create a dipole antenna that covers the entire band with an SWR of less than 2:1, using a reference impedance value that is appropriate for each situation that we examine. We shall look at ribbons, cages, parasitic drivers, and transmission lines. We shall omit the various broadband antennas that involve using coaxial sections as part of the construction simply because we cannot effectively model coaxially arranged wires. As we proceed, we shall recall a pair of matching techniques that employ combinations of transmission lines, including the system that Witt calls the transmission-line resonator or TLR. Toward the end, we shall do something that seems to have eluded authors to this point: we shall combine techniques for improved radiation and SWR performance. But first, we shall wrap ourselves in wire.

Some Ribbon and Cage Basics

We may create virtual fat wires by combining thinner wires in certain arrangements. The most popular forms are the ribbon and the cage. **Fig. 1** outlines some of the basic shapes and some of the critical dimensions. We shall consider ribbons with 2 and 4 wires. As well, we shall look at cages consisting of 4 and 6 wires. Our first task will be to see what dimensions for each shape coincide with which single-wire diameters. We may do this within the boundaries of NEC modeling if we observe a few precautions.

The ends of ribbons and cages often come to a point at both the center feedpoint gap and at the outer ends to which we normally attach support ropes. Both angular geometries tend to yield AGT values that are not ideal (1.000 in free space), and these variations can distort comparisons. We can avoid the variable AGT values by two simple modeling techniques. At the outer ends of cages and ribbons, we can use a simple set of perimeter wires to join longitudinal ends. At the feedpoint, we may run the wires in straight parallel lines. To create a common feedpoint, we next select one wire as the source wire. We then connect from this wire to each other wire in the group a near-zero length of lossless transmission line. The characteristic impedance is not critical, since the length is almost zero (1e10-5 or shorter) and virtually no impedance transformation can occur. These models tend to yield more accurate results relative to physical ribbon and cage antennas than do models that try to replicate the details of the many angular junctions. For example, the current values along wire that are directly fed and fed via the lengthless lines are identical. As well, the scheme yields rather precise feedpoint impedance values that coincide with physical antennas.

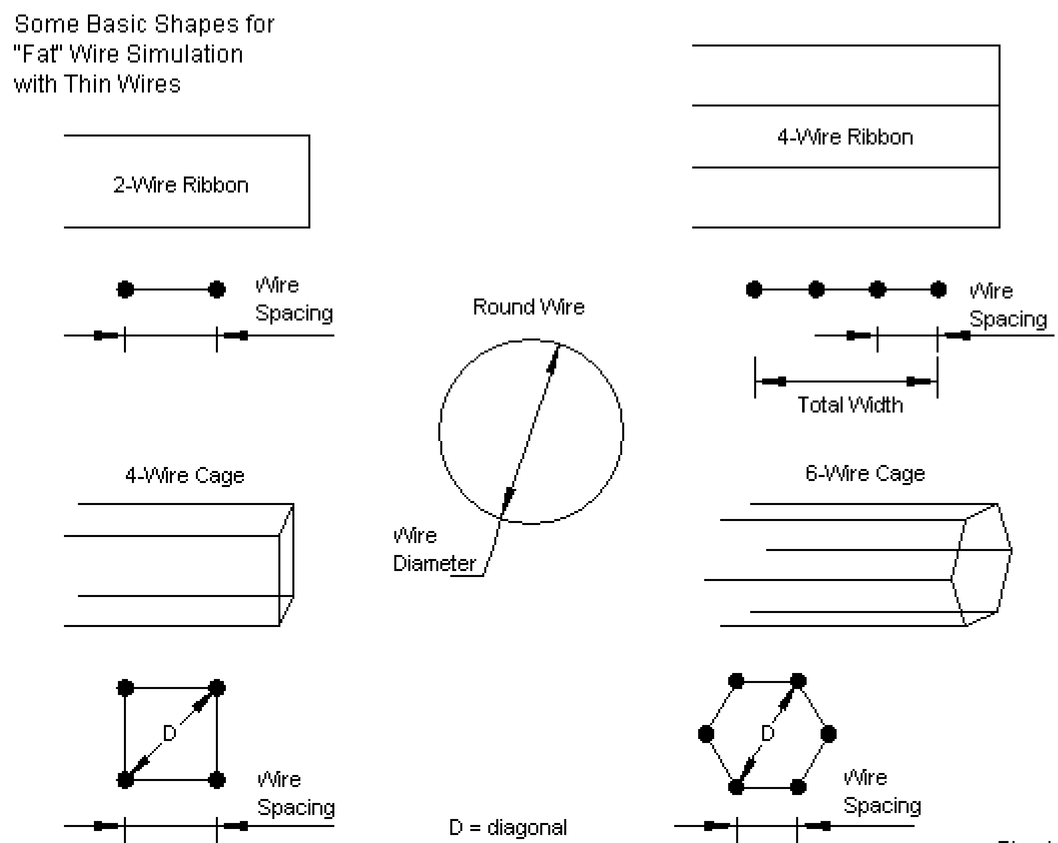


Fig. 1

Preliminary modeling consisted of checking the correlation between multi-wire dipole ribbons and cages with roughly equivalent round-wire dipoles. The test begins with a simple 1-wire dipole. Then it proceeds to various multi-wire dipoles. In each case, the maximum dimension is 1' (12"). So for ribbon elements, the outer wires are 1' apart. There is a 2-wire ribbon and also a 4-wire ribbon with the wires 0.3333' (4") apart. The 4-wire cage is 0.707' per side for a diagonal dimension of 1'. The 6-wire cage has wires 0.5' apart for a diagonal of 1'.

In each case, I adjusted the length of the dipole to resonance +/-j1-Ω reactance at 3.6 MHz in free space. The resistive component in each case is 72 Ohms +/-1 Ω. For each resonant length, I then created a single-wire dipole of the same length and adjusted the wire diameter for resonance. A comparison of the "fat" single wire dipole gain values with the gain for ribbon or cage dipole elements gives a comparative measure to the relative losses of equally resonant structures. All models showed an AGT score of 1.000, eliminating the need for any gain value adjustments. No intermediate current-equalizing shorting wires are used, although they are common in actual practice.

Table 1 provides the results of the initial runs for a resonant frequency of 3.6 MHz. From the data, we may draw a few initial conclusions.

1. The minor drop in gain for each multi-wire element relative to its associated fat-single-wire element shows the small but numerically noticeable difference in losses. In each case, the fat-wire element also has a slightly wider 2:1 72-Ω SWR span than the associated multi-wire element.

Table 1. Multi-wire dipoles and the equivalent single fat-wire dipoles

Antenna	Length	Gain dBi	72-Ohm SWR Span
Single wire	133.07	2.04	3.50 to 3.71 MHz
2-wire ribbon	130.90	2.09	3.45 to 3.76
Fat 2.5" wire	130.90	2.13	3.40 to 3.78
4-wire ribbon	130.30	2.11	3.43 to 3.79
Fat 4" wire	130.30	2.13	3.43 to 3.80
4-wire cage	129.40	2.11	3.43 to 3.80
Fat 7" wire	129.40	2.13	3.41 to 3.80
6-wire cage	129.10	2.12	3.42 to 3.80
Fat 8" wire	129.10	2.13	3.41 to 3.83

2. The added two wires in the 4-wire ribbon element are inside the outer wires that are 1' apart. The current levels on the inner wires are about 0.75 the values on the outer wires: lower but still very significant, as indicated by the shorter resonant length of the 4-wire ribbon relative to the 2-wire ribbon.

3. The differences across the range of multi-wire models are too small to be operationally noticeable. Even the SWR variation is only 0.07 MHz.

The slight differences in losses between each multi-wire dipole and its single fat-wire equivalent is not as important a result as the progression of increases in equivalent single-wire diameters as we increase the complexity of the multi-wire dipole. If we wish to obtain less than 2:1 SWR ac5ross the entire 3.5-4.0-MHz span, we can expect to use much wider wire spacing. However, as we move from simple wire ribbons to cages, we can also expect a decrease in spacing between wires. At this stage in our efforts, we may expect some spacing values that would place the dipole structure outside the range of practicality. Nevertheless, we shall explore almost all of the initial options. The one exception is the 2-wire ribbon. This structure did not achieve the desired goal even with a spacing of 9', so I eliminated it from the list of samples.

Table 2 lists the remaining candidates for full-band 80-75-meter coverage, beginning with a 16"-diameter single-wire dipole. All antennas are 90' above average ground, and the multi-wire structures are composed of AWG #12 copper wire. The antenna specifications list the wire spacing and the total or the diagonal spacing, as appropriate. See **Fig. 1** to identify the indicated dimensions relative to the structure. The new table also replaces the data on the SWR span (which is at least 3.5 to 4.0 MHz) with the resonant frequency and the impedance at resonance. Because these values are all about 72 Ω, the SWR values are referenced to that value.

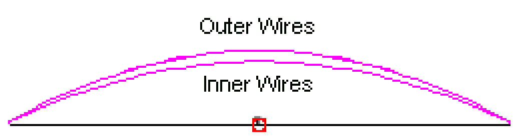
The table has a few minor surprises. Although the spacing between wires shows the progression established in the preliminary tests, the antenna lengths do not all grow shorter as we increase the complexity of the structure. The 6-wire cage is somewhat longer than the 4-wire cage. The table also omits gain values for the 90'-high dipoles, since we shall address the question of gain across the band once we add a few other broadband AWG #12 wire antennas to our collection.

Table 2. Multi-wire dipoles for full coverage of 3.5-4.0 MHz

Antenna	Length	Res. Fq.	Impedance
Single wire 16" diameter	123.6'	3.72 MHz	71.6 – j0.4 Ω (free space) 89.1 – j4.8 Ω (90')
4-wire ribbon Wire spacing 2' Total width 6'	123.4'	3.72 MHz	72.4 + j0.4 Ω (free space) 89.3 – j4.1 Ω (90')
4-wire cage Wire spacing 3' Diagonal 4.24'	121.8'	3.71 MHz	72.1 – j0.5 Ω (free space) 88.3 – j6.0 Ω (90')
6-wire cage Wire spacing 1.5' Diagonal 3'	122.2'	3.73 MHz	72.1 – j0.7 Ω (free space) 88.6 – j5.9 Ω (90')

4-wire ribbon structures are subject to some overgeneralization to the effect that most of the current lies in the outer wires (with the presumption that little current is along the two inner wires. As shown in **Fig. 2**¸ the differential is only about 15%. (Since the antenna view is in the plane of the wires, only two current curves appear, with overlapping outer-wire and overlapping inner-wire values.) The ratio of maximum current on the inner wires to the maximum current on the outer wires increases as the spacing between wires increases. The ratio for the 4-wire ribbon with a wire-to-wire spacing pf 0.333' is about 75% in contrast to the 85% value for the widely space wires of the full-band 80-75-meter 4-wire ribbon element.

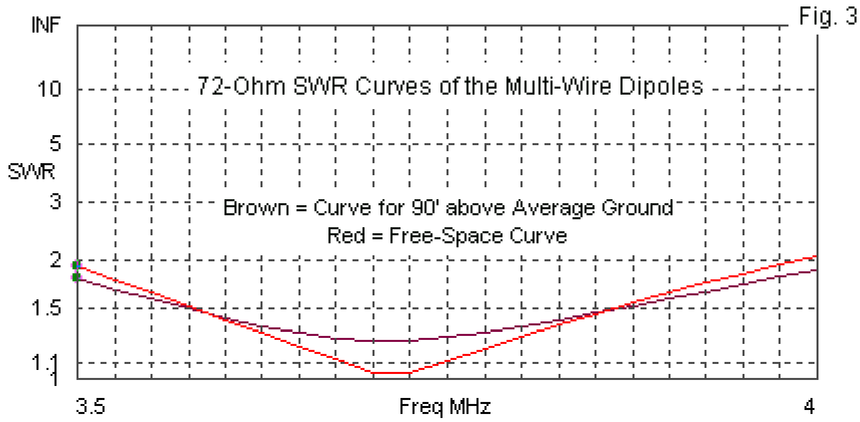
Fig. 2



Relative Current Magnitudes on the Wires of a 4-Wire Ribbon Dipole

The models used in developing the data in **Table 2** initially used a free-space environment. The goal in each case was to achieve a 72-Ω SWR curve. When placed at 90' above average ground, the values change, as shown in the table for the free-space resonant frequencies. However, 72-Ω SWR curve actually becomes shallower, as shown by **Fig. 3**. One desirable consequence is the fact that there is enough "play" to allow for variations in ground quality and potential interactions with other objects in the near field of the antenna with minimal need for field adjustment of the antenna. In addition, the use of a coaxial cable feedline of any length will further increase the SWR bandwidth, but with the usual losses associated with coaxial cables.

The SWR curves in **Fig. 2** are based upon the impedance values at the actual antenna feedpoint. Before we close these notes, we shall have occasion to add a feedline to the system. However, it will not be the sort of single-cable installation that we usually think of in connection with dipole antennas.



Except for the 16”-diameter single-wire dipole, all of the antennas modeled are feasible constructs for a serious 80-75-meter installation. The 4- and 6-wire cages may be the most compact in terms of the cross section, but require special attention to the set of wire spacers along the length of the antenna. The 6’ total width of the 4-wire boon version requires, in contrast, only linear spacing bars at periodic positions along the element. In all cases, the construction of both the element and the necessary supports represents a serious antenna installation project.

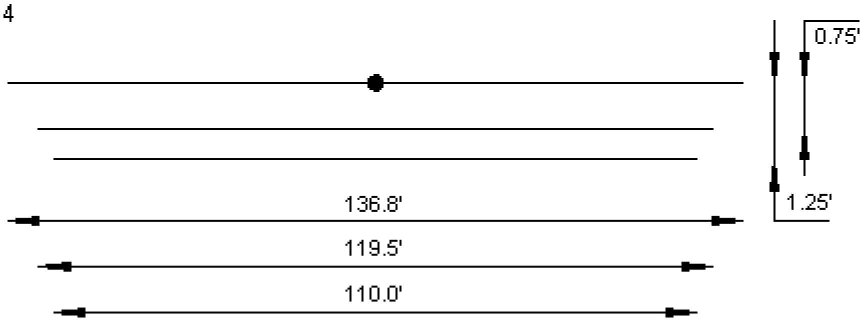
Parasitic Driver Basics

The cage and ribbon elements share some common features. All have very significant cross section dimensions. As well, all show a typical single-element dipole SWR curve with a single minimum at a frequency just below the arithmetic mid-band point. If we can give up the shape of the SWR curve, we may achieve full-band 80-75-meter coverage with other antenna designs, some of which are more compact with respect to the cross section dimensions.

The use of open-sleeve or coupled resonator dipoles (and monopoles) has been around for a considerable length of time. Chapter 7 of *The ARRL Antenna Book* contains a good introduction to the practice, although mostly in a multi-band context. The principle is simple to state, but more difficult to implement, either in models or in physical antennas. Essentially, we directly feed an element for the lowest desired frequency in a set of frequencies. By selecting proper spacing and length values, we may add a series of parasitically coupled elements and achieve resonance on one or more higher frequencies as determined by the measured impedance at the feedpoint of the fed element. The goal is not simply to achieve any resonant condition whatever, but to show an impedance similar to that of the fed element along. This condition allows us to use a single transmission-line characteristic impedance to provide a matched impedance system for all frequencies covered by the multi-element antenna.

The most common applications of the use of coupled resonators include collections of monopoles with a common radial system and Yagi-type directional antennas. In most cases, the goal is to cover 2 or more amateur bands with a single directly fed element. However, we may also apply the same technique to expand the SWR coverage of a single antenna with multiple horizontal wires to cover a very wide band, such as 3.5-4.0 MHz. Slaved or secondary driver elements tend to have a narrower SWR bandwidth than the directly fed driver. Hence, a single parasitic element will not normally suffice to spread the coverage of an AWG #12 copper wire to handle the entire band. We may need more than one slaved element.

Fig. 4



3-Element (1 Fed, 2 Parasitic) Dipole Array
for 80-75-Meter Coverage

Fig. 4 shows one version of a 3-wire broadband dipole array for 80 and 75 meters. The elements are AWG #12 copper wire, and the dimensions apply to that diameter element. Only the longest element has a direct connection to the feedline, although all three elements contribute to the ability of the antenna to provide satisfactory SWR coverage from 3.5 to 4.0 MHz. The elements shown are arrayed below the fed element running from the longest to the shortest. Equally possible is a version of the antenna with one parasitic element on each side of the directly fed element, although such an arrangement might well require adjustments to the length and spacing values used. In the version shown, note that the spacing between the two slaved elements is less than the spacing between the fed element and the first parasitic element.

The 3-wire system shown requires a cross-section width of only 1.25’, considerably less than required by any of the multi-wire dipoles shown in the previous section of these notes. Moreover, the SWR pattern shown at the driven element feedpoint does not have a single minimum value with slowly rising values above and below the resonant frequency. Instead, as shown in **Fig. 5**, the SWR show multiple minimums. The values are well below 2:1 across the band, but often higher than 1.5:1, a value at which some high-power amplifiers for amateur service set their fold-back circuit cut-off points. However, like the ribbon and the cage dipoles, the SWR curve for the 3-wire parasitic system does not include the losses of reasonable lengths of coaxial cables in the 70-75-Ω range.

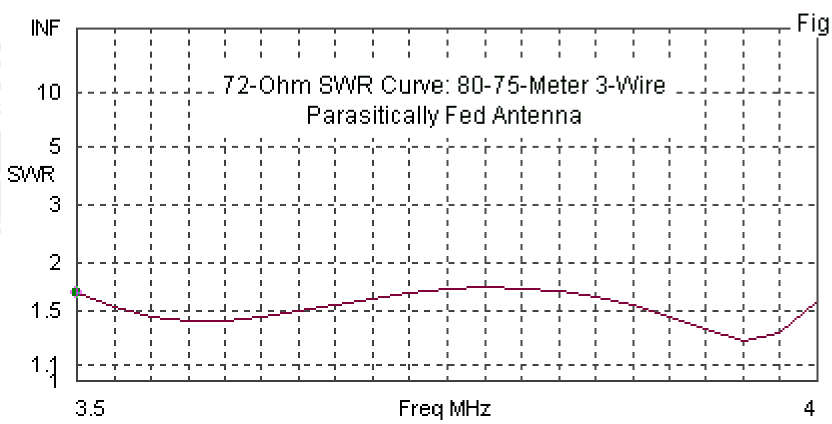
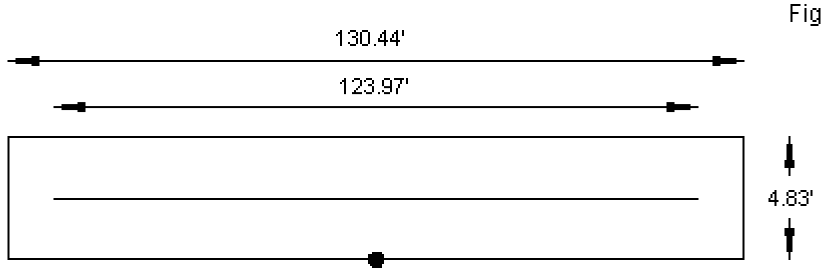


Fig. 5

The design shown, although generated just for these notes, is not unlike coupled resonator antennas that have appeared in amateur journals, such as *QST*. Construction may be simpler than for any of the other antennas examined so far, and it does not require any further matching relative to current equipment input/output impedance standards.

An alternative method of achieving a similar goal is to use a folded dipole structure in which we place a linear parasitic element in the center. Lou Rummel, KE4UYP, developed such a design for AWG #12 copper wire, and the outline and dimensions appear in **Fig. 6**. The wire arrangement is one possibility within a continuum of dimensions that yield a multi-minimum SWR pattern.

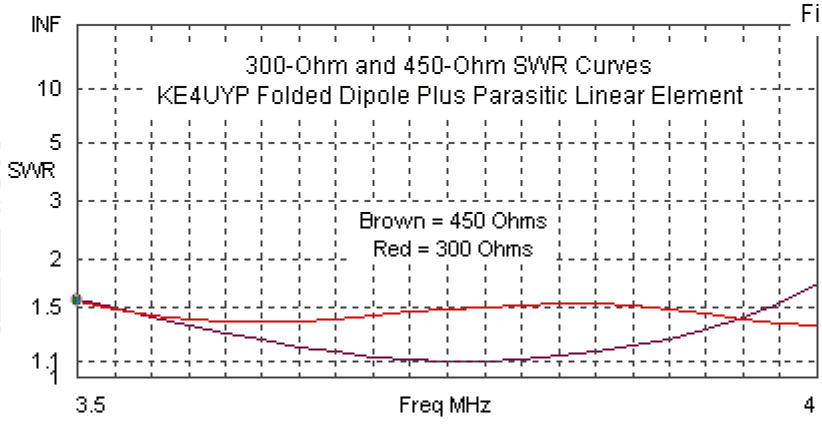
Fig. 6



The KE4UYP Folded Dipole Plus a Linear Parasitic Element for 80-75-Meter Coverage

The width of the folded structure is less than 5'. This width is in a frontier zone between the folded structure acting like a folded dipole and the structure acting like simply a highly elongated loop. The loop alone is resonant at about 3.52 MHz, with the linear element having a self-resonant point at about 4.05 MHz if it were not subject to very high interaction with the loop. In turn, the parasitic linear element raises the self-resonant point of the loop to produce the 300-Ω SWR curve in **Fig. 7**. The curve for 450 Ω shows that the antenna would be equally at home with a higher-impedance parallel line, such as common window line. The latter has about half the loss per unit length as even transmitting versions of 300-Ω ribbon or tubular line.

Fig. 7



The folded-dipole-linear-parasitic element version of the coupled-resonator 80-75-meter antenna is the logical counterpart of the 3-wire version for those who prefer to feed antennas with parallel transmission line. Since advantages or disadvantages would lie mainly in the preferred feeding system, we may bypass them for this discussion.

Transmission-Line Broad-Banding

Back in 1997, Dave Leeson, W6NL, brought to my attention an interesting technique for achieving wide-band operation on the lower HF bands, especially the 80/75-meter band. The technique derived from mentions in texts and from references in ARRL publications by Frank Witt, AI1H, a noted experimenter and evaluator of low-HF broad-banding methods.

The broad-banding method begins by selecting the geometric mean between the two desired frequencies (that is, the square root of the product of the two frequencies). Suppose that we cut a dipole to be resonant at this frequency. Next, for the dipoles design frequency, we should cut a length of 50-Ω coax that is a multiple of a half wavelength so that its length is perhaps from 0.5-λ to 2.0 λ. Of course, the physical length will be the line's velocity factor times the electrical wavelength at the design frequency. To the shack or source end of this line, we connect a 1/4-λ 75-Ω transformer line section, again multiplying the electrical length by the line's velocity factor to arrive at a physical length. The result is a well-established broadening of the operating SWR-bandwidth.

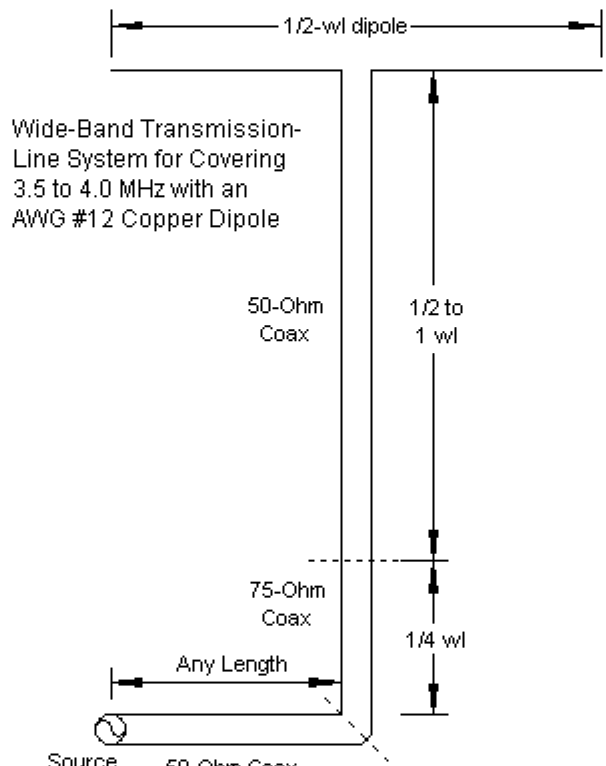


Fig. 9

Fig. 8 shows the general outline of one recommended system consisting of a 0.5-λ length of 50-Ω cable, followed by a 0.25-λ section of 75-Ω cable. Essentially, the 50-Ohm cable replicates the antenna feedpoint impedance at resonance, but off resonance, the line is no longer ½-λ and the impedance is either capacitively or inductively reactive, according to whether we move below or above the resonant frequency. Once we further transform these initially transformed impedance values with the 75-Ω matching section, we obtain a usable 50-Ω impedance across the band.

The results of the technique can be modeled in a misleading way if we only use the lossless transmission lines available within NEC. However, recent implementations of the NEC have introduced methods of including line losses and arriving at a more accurate picture of the results. To provide a clearer view of how well the system works, I used the following lines to model the matching system with the dipole at 90' above average ground: 50 Ω: RG-213, VF 0.66, loss 0.6 dB/100' @ 10 MHz; 75 Ω: RG-216, VF 0.66, loss 0.7 dB/100' @ 10 MHz. These cables easily handle the upper limits of amateur power levels. The sum of the two lines, accounting for the velocity factors involved, is 129.83' of cable that is both part of the matching system and part of the main feed system, since the elements are in series. (This line length will become significant shortly.) The total line length is not unreasonable as nearly a minimum value for a dipole that is 90' above ground and somewhat offset from the station equipment.

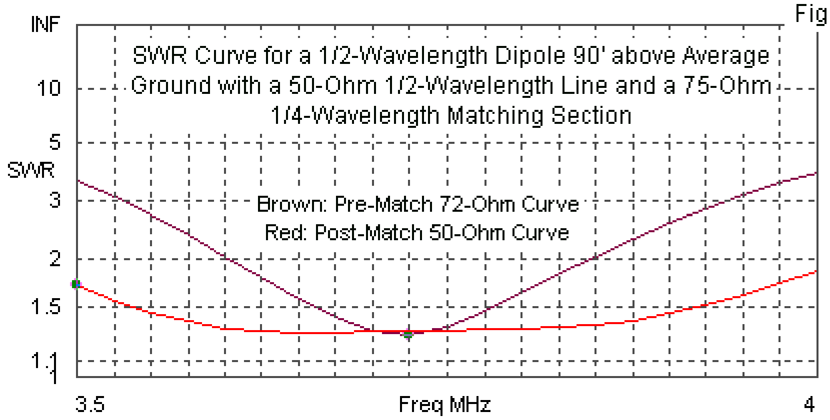


Fig. 9

Fig. 9 shows the 72-Ω SWR curve for the dipole without the matching system in place and the 50-Ω curve at the junction of the matching section and the main feedline. The system easily covers the entire band, although the SWR values exceed 1.5:1 near the ends of the band. Theoretically, we can use any multiple of ½-λ for the 50-Ω section of the line. Longer lines will show the double-dip SWR curve that is not fully visible with a single half-wavelength section. However, for real lines with losses, the band-edge SWR performance will deteriorate.

In 1995, Frank Witt, AI1H, presented an alternative to the 50-75-Ω transmission-line broadband matching system. He called the system the Transmission-Line Resonator (TLR). It consisted of three lengths of 50-Ω cable. We shall continue to use RG-213 with a velocity factor of 0.66 and a loss factor of 0.6 dB/100' as our implementation, which coincides with Witt's own version. A length of cable connects the antenna terminals to the source, which can be the station equipment or a further length of 50-Ω cable that reaches the equipment. At the antenna terminals, he connects an open stub across the terminals, effectively adding a shunt capacitance (more correctly, a capacitive reactance) to the antenna terminal impedance. At the source end of what Witt calls the "link" line, he adds a shorted stub across the line, effectively adding a shunt inductance (or inductive reactance). With the proper proportions, shown for the 80/75-meter band in **Fig. 10**, the combination yields a broadband 50-Ω match for the dipole. The dimensions used in the model vary slightly from Witt's original, but fit the dipole length and cables used in the model. Any implementation of the matching system would require a bit of field adjustment to arrive at the final lengths of the two stubs and the linking line. (For detailed information on and calculations for the TLR matching system see chapter 9 of the current (20th) edition of *The ARRL Antenna Book* and Witt's original article.

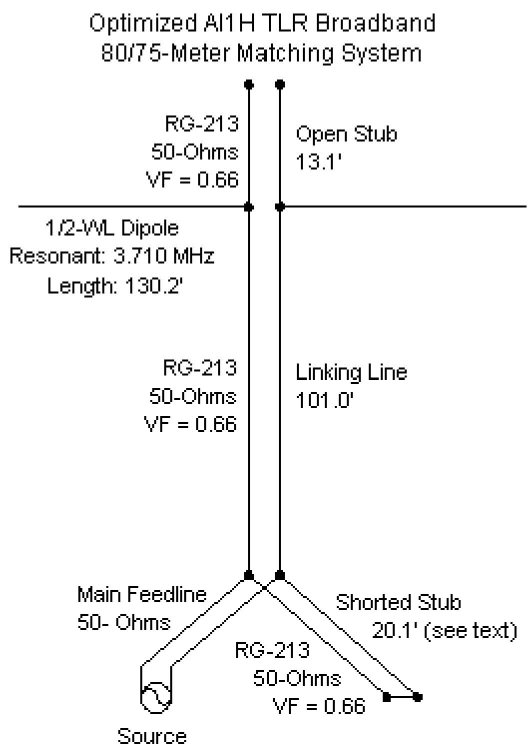
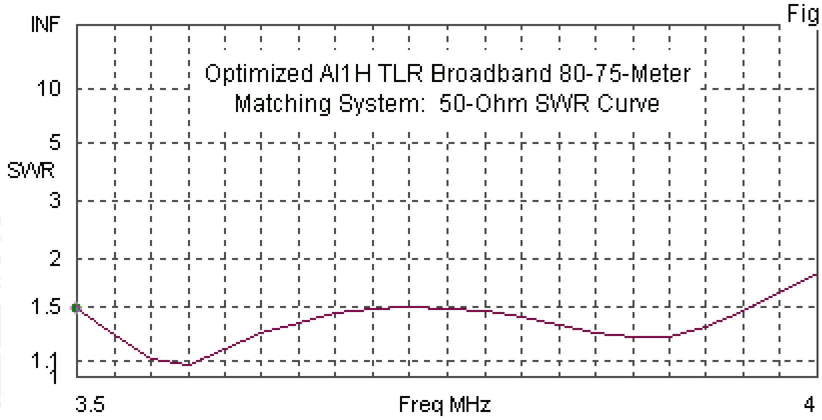


Fig. 10

We can view the Witt system as a version of the "match line and stub" matching system, after suitable adjustment of the feedpoint impedance values with the top open stub. The calculated values required for each of the three lines provides for broad-band service by opposing the natural trends in impedance transformation at key points in the system. The result is the double-dip 50-Ω SWR curve shown in **Fig. 11**.

Fig. 11



Of the systems that we have examined, only the two transmission-line matching systems and the 3-wire coupled resonator array arrived at 50-Ω impedances. The ribbon and cage systems use 72-Ω reference impedances to achieve full band coverage, while the folded-dipole and linear parasitic element array uses a high impedance value suited to parallel transmission lines. 50-Ω coaxial cable remains the preferred feedline based on the nearly universal standard of a 50-Ω input and output impedance value of current amateur equipment.

Efficiency

When we combine any antenna with a transmission line in broadband service, we incur losses at one or both ends of the band relative to potential performance of the dipole alone. None of our systems is immune to this condition. Even a system that is well matched at the resonant frequency is subject to increased feedline losses as we move away from the resonant frequency and add the SWR multiplier to basic matched line losses.

Arriving at a reasonably fair comparison of system losses is difficult at best when we consider that two of the systems require certain lengths of coaxial cable as part of the matching system. The maximum line length involved in matching for our 80-75-meter samples is 129.83'. Therefore, to equalize the playing field, I added to each sample antenna a cable of this length, using RG-213 for the 50-Ω runs and RG-216 for the 75-Ω lines. The ribbon and cage antennas required a single cable, while the TLR system requires the addition of a short section of 50-Ω cable to arrive at the total cable length. Rather than calculating losses in dB, I simply obtained gain values for each entire system, including antenna wire and cable losses. The resulting pattern of gain values will reveal—by comparison with an uncabled AWG #12 copper dipole—not only the level of loss, but as well the pattern of where in the band those losses are likely to occur. **Table 3** summarizes the loss picture with sample gain values at 3.5, 3.75, and 4.0 MHz.

Table 3. Comparative gain values of broadband 80-75-meter antennas and matching systems at 90' above average ground with 129.83' of feedline

Antenna	Gain in dBi at 3.5 MHz	3.75 MHz	4.0 MHz
Bare antenna with no feedline	6.10	6.24	6.44
"W6NL" ½ -λ + ¼-λ matching system	5.07	5.68	5.36
AI1H TLR matching system	5.07	5.68	5.36
16" diameter reference dipole/75-Ω line	5.52	5.75	5.86
4-wire cage dipole/75-Ω line	5.51	5.76	5.88
3-wire coupled-resonator/75-Ω line	5.58	5.74	5.69

Except at mid-band, the two matching systems show about 0.5-dB lower gain than the wire antenna samples. Besides showing a higher band-edge gain, the addition of 129.83' of 75-Ω transmission line provides improved SWR bandwidth at the source end of the line by forming a 3/4 –λ transformer. **Fig. 12** exemplifies the altered SWR curve by showing 50-Ω and 75-Ω curves for the 4-wire cage. All of the ribbon and cage dipoles would show similar curves.

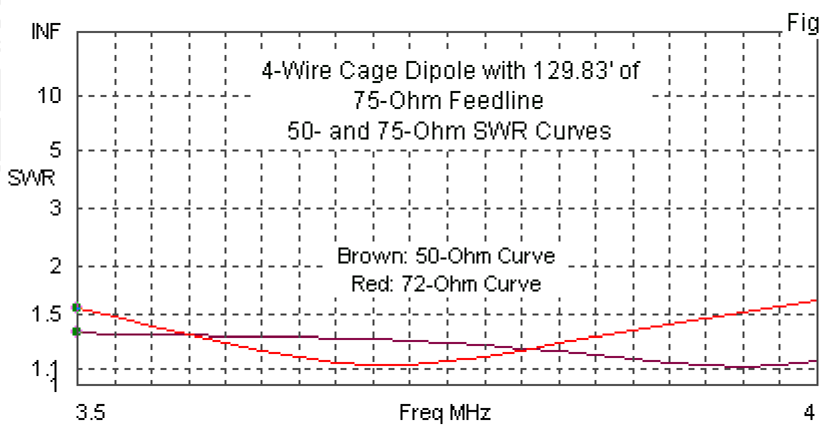
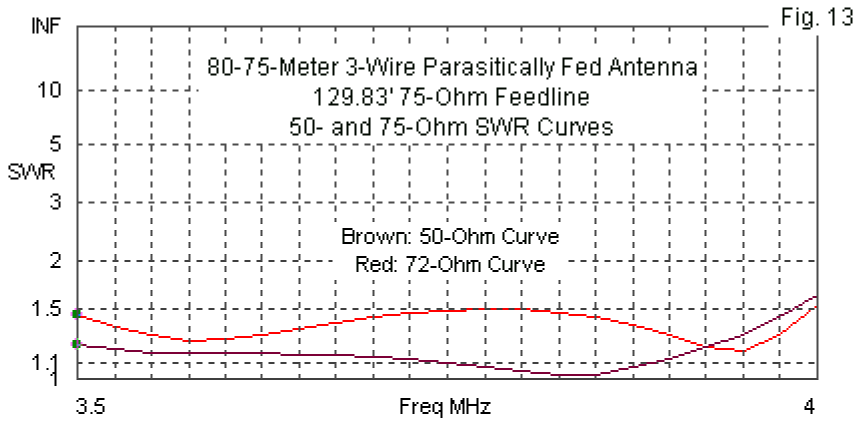


Fig. 12

The SWR curves are satisfactory for virtually al applications. Perhaps only users of high power amplifiers with very sensitive fold-back circuits might find a shortcoming: the 72-Ω SWR exceeds 1.5:1 at the band edges, although the 50-Ω curves is quite well tamed. A similar concern might strike the user of a 3-wire coupled resonator system with an equal length of 75-Ω cable, as shown in **Fig. 13**.



The final question is whether we can further tame the SWR curves without adversely harming dipole efficiency.

Combining Techniques

A simple AWG #12 copper wire dipole responds to either the W6NL or the AI1H transmission-line based matching systems with an SWR curve that yields a 50-Ω SWR less than 2:1 across the 80-75-meter band. Equipping the ribbon and the cage dipoles with a 75-Ω cable of the specified length (129.83') produces even lower SWR values using a 50-Ω reference. The final question, applicable only to those who use equipment sensitive to 50-Ω SWR values above 1.5:1, is whether we can lower the SWR curve even further. To a limited extent, we can.

Although I am aware of no actual attempt to do so, there is no rule against combining a wide-band dipole with the W6NL matching system. Like the thin-wire dipole, all of the cages and ribbons have resonant impedances close to 72 Ω. Therefore the mid-band SWR values for the original design and when applied to a ribbon or cage will be quite similar. The differences will appear as we move away from the resonant frequency. The thin-wire dipole shows a rising SWR based on a slow change in the resistive component and a faster change in the reactance.

The 3-wire coupled resonator system shows a relatively flat SWR relative to 72 Ω across the band. At the band edges, we find no significant increase in the reactance, but instead a small fluctuation. As a consequence, the band-edge values should not depart radically from the mid-band SWR value.

In fact, as revealed by the SWR curves in **Fig. 14**, we do obtain a small amount of improvement, but it applies in the main to the 72-Ω SWR curve. The 50-Ω curve average value is not quite as good as when we use a simple run of 75-Ω cable, but the value at 4.0 MHz is marginally better. (In either case, we might shorten the second parasitic driver slightly and stretch the SWR curve to give us a vale of less than 1.5:1.) Modeling simplifies the calculation of both the antenna impedance and the line losses at each frequency in the 3.5-4.0-MHz span so that we can obtain a relatively reliable assessment of our design options.

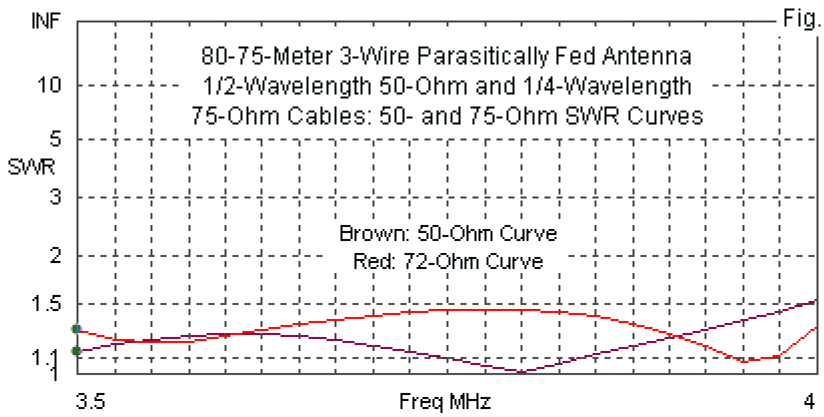


Fig. 14

We can apply the same technique to any one of the wide-band ribbon or cage dipoles and assess its performance against the use of a 75-Ω cable alone. **Fig. 15** provides the 50-Ω and 72-Ω SWR curves for the 4-wire cage version. Once more, the improvement accrues to the 72-Ω curve rather than to the 50-Ω curve.

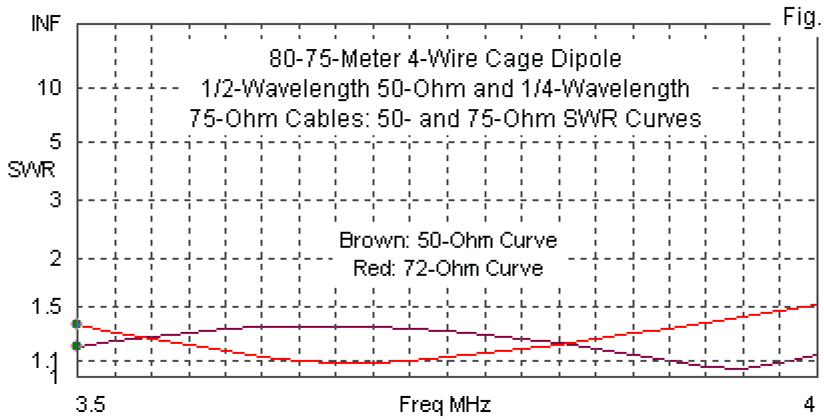
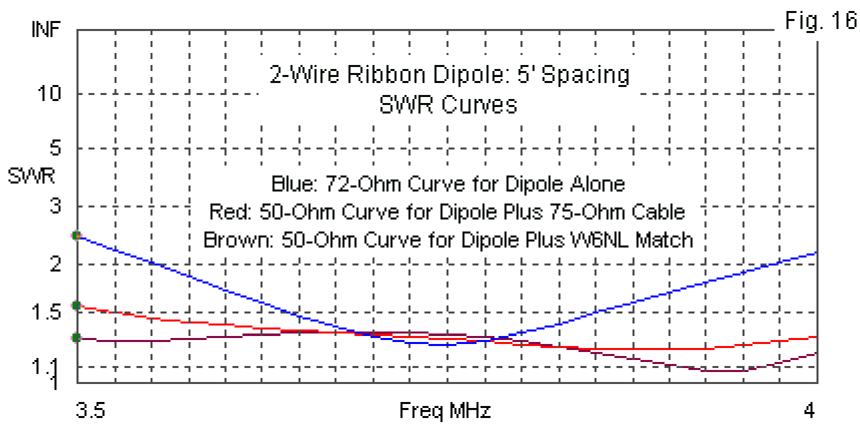


Fig. 15

Perhaps the best application of combined broad-banding methods involves dipole designs that do not quite reach the desired goal of an SWR curve with maximum values of less than 2:1, but that are improvements upon the simple thin wire (AWG #12) dipole. Early on, we rejected the use of a 2-wire ribbon dipole for this very reason. Suppose that we construct such a dipole with a 5' wire spacing. The 72-Ω SWR curve in **Fig. 16** shows why we omitted the design. The SWR rises above 2:1 well before we arrive at either band edge, although the curve is certainly an improvement upon the thin-wire dipole shown as one of the curves in **Fig. 9**.

If we add our standard 129.83' length of 75-Ω cable, we obtain a 50-Ω curve with a maximum SWR value of about 1.6:1. However, if we instead employ a ½-λ 50-Ω cable plus a ¼-λ 75-Ω matching section, we obtain a curve with a maximum 50-Ω SWR of about 1.3:1. This final curve would satisfy the requirements of even the most sensitive fold-back circuit. Similar results would emerge with undersized versions of most of the ribbon and cage dipoles.



Whether we lose anything by using the matching system rather than the simple cable run appears in **Table 4**. The data compares antenna-only gain values with values that emerge from the use of a simple 75-Ω cable and from the more complex matching system.

Table 3. Comparative gain values of a 2-wire ribbon dipole for 80-75-meter at 90' above average ground alone, with 129.83' of feedline, and with a 129.83' matching system

Antenna Gain in dBi at	3.5 MHz	3.75 MHz	4.0 MHz
2-wire ribbon antenna with no feedline	6.13	6.26	6.45
2-wire ribbon/75-Ω line	5.33	5.70	5.77
2-wire ribbon/ "W6NL" match	5.36	5.70	5.73

As we might expect, the 2-wire ribbon dipole with either feedline shows better gain values than a thin-wire dipole equipped with either the AI1H TLR match or what we have labeled for convenience as the W6NL match. The similarity of gain values between the single-cable feedline and the matching system shows that there is essentially no difference in feedline efficiencies, since the SWR values at the antenna feedpoint do not rise to very high values but instead only to inconveniently high values. One way to minimize losses from a matching system and to arrive at a more nearly perfect SWR curve is to begin with a reasonably wide-band dipole design (even if not perfect) and to apply the matching system to it rather than to a thin-wire dipole.

Conclusion

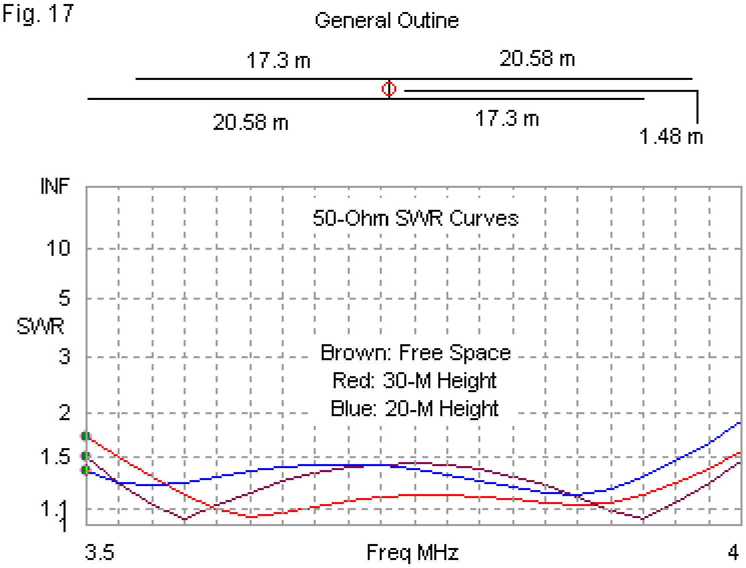
We have examined numerous, but by no means all, of the broad-banding techniques. We progressed from complex wire dipoles to multi-wire coupled resonator arrays and finally to transmission-line-based matching systems. We required no lumped components or coaxial antenna sections to achieve exceptionally broadband results. Our only presumption was that we would need a feedline about 1.4 times the height of the antenna above ground for the 90' height used in the samples.

The best results occurred with broadband dipoles and either 75-Ω cable or one of the transmission-line-based matching systems. Although the samples used the W6NL system, the AI1H system would have returned equivalent results. Each case showed that if we opt for a coaxial cable feedline, a certain reduction in gain is a cost of the option, however we arrange the cable. However, the broader the bandwidths of the initial dipoles, the lower were the losses at the band edges. Moreover, by combining physical methods of creating broadband dipoles with appropriate matching methods, we could reduce the required structural size of the dipole and still obtain a 50-Ω SWR curve that never reach a value of 1.5:1. Hence, the initial broadband ribbon and cage dipoles can have smaller cross sections and still arrive at a very desirable SWR curve without further sacrificing gain at either band edge.

Appendix: The UR0GT Broadband 80-75-Meter Dipole

Recently, I uncovered an interesting dual-wire broadband antenna for 80 and 75 meters from Russia, a design by UR0GT. In metric terms, it consists of two 2-mm diameter copper wires, each 37.88 m long. However, as shown in **Fig. 17**, the wires are offset relative to the center point. The shorter wire is (in my NEC-4 model) 17.3 m long, while the longer wire is 20.58 m. The spacing is 1.48 m, although this dimension is not critical within several centimeters, but it does set the mid-band relative phase angles of the element currents. At the center point, between the two wires, we run a single wire and feed it in the middle.

Fig. 17

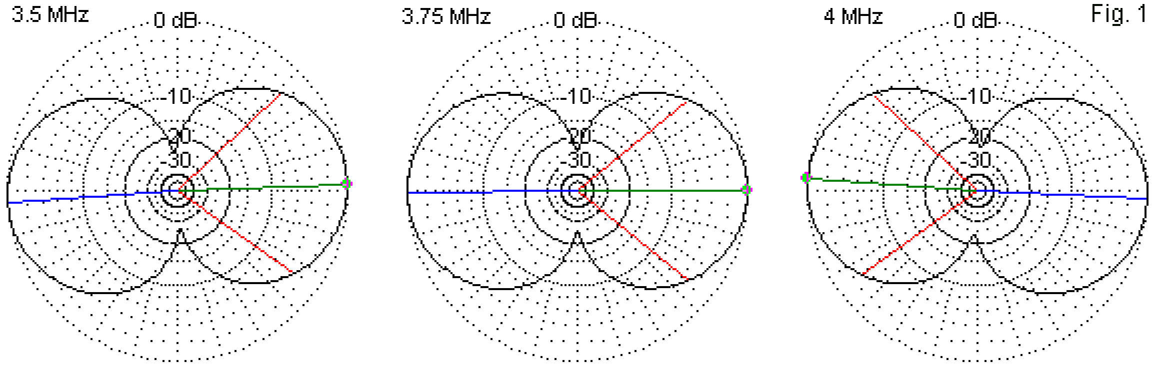


General Outline and 50-Ohm SWR Curves
UR0GT 2-Wire Broadband 80/75-Meter Dipole

The 50-Ω SWR curves show distinct higher and lower frequency resonance points. To move each resonant frequency, one may adjust the length of either the longer wire or the shorter wire. Although the frequencies of the resonant points are relatively independent, their positions determine both the band-edge and the mid-band SWR values. Note from the SWR curves that, like all broadband 80/75-meter antennas, the SWR curves will be somewhat height-sensitive, since on average, antennas for the band are less than ½-λ above ground. Therefore, anyone who wishes to replicate the antenna—and it is worthy of replication—should model the exact dimensions for the planned installation height.

The offset wires of the antenna produce some patterns—at the band edges—that are also offset from a true broadside to the wires. **Fig. 18** provides 3 E-plane free-space patterns to show the effect. In general, the pattern offset is only about 3° relative to a true broadside in the extreme cases. Therefore, with a beamwidth approaching 80°, an operator could not detect the pattern offset during use, even when switching from the low end of the CW band to the top end of the phone allocation.

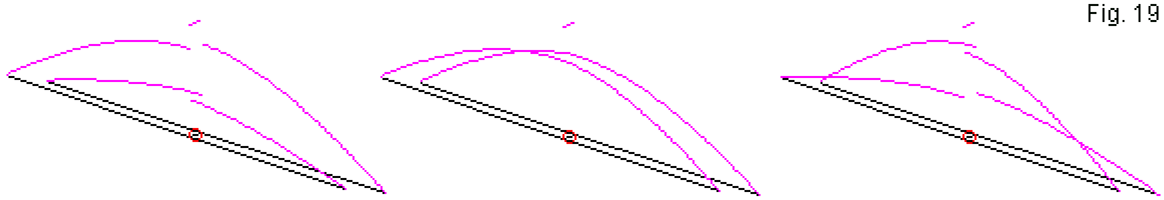
Fig. 18



Free-Space E-Plane Patterns of the UR0GT 2-Wire 80/75-Meter Antenna

One key to the operation of the UR0GT wide-band antenna is the fact that on each side of center, the two wires are 90° apart in current phase angle at 3.75 MHz. The relative current magnitudes on the short and the long sections vary with frequency within the overall passband, yielding a low 50-Ω SWR across the entire band. Note in **Fig. 19** the dominance of either the long wire or the short wire at the lower and upper band edges. (The last line in the data in the figure shows the ratio of higher to lower current and also the phase-angle difference [Δ] between the wires at each sampled frequency.)

Fig. 19



Frequency	3.50 MHz		3.75 MHz		4.00 MHz	
Current	Mag.	Phase	Mag.	Phase	Mag.	Phase
Short Wire	0.335	44.05°	0.703	44.27°	0.783	19.34°
Long Wire	0.792	162.72°	0.700	134.84°	0.369	134.61°
Ratio/Delta	2.36:1	18.67°	1:1	90.57°	2.12:1	115.27°

Current Distribution of the UR0GT 2-Wire 80/75-Meter Antenna

The relative simplicity of the UR0GT antenna recommends it for consideration among the array of broadband options for the 80/75-meter band. With the usually lengths of coaxial cable necessary to connect the antenna to the station, the SWR curves at the equipment end of the line should be even flatter than those shown. However, as with all antenna designs, successful replication lies in the details of the installation. .