# The "Lazy-8JK"
# or
# The Collinear-Broadside-Endfire Array

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For many years, *The ARRL Antenna Book* has shown a combination collinear, broadside, endfire array, for example on pages 8-51 to 8-54 of the 19th Edition. The array looks something like the outline in **Fig. 1**.

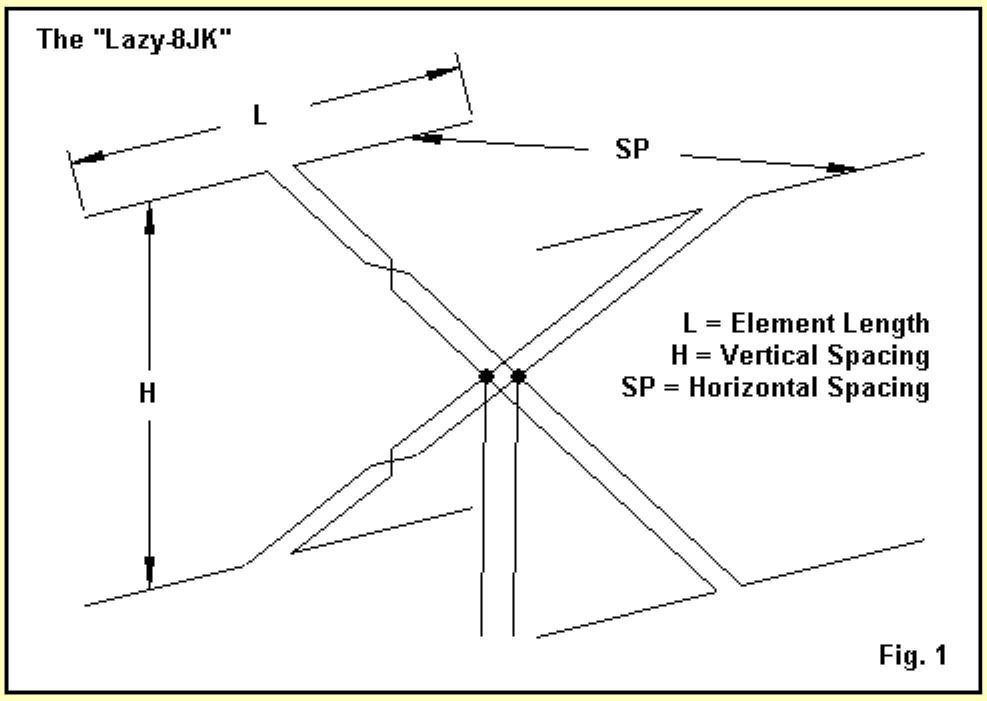



Fig. 1

The dimensions are locked up in 3 key factors.

1. L = Element Length: Length may vary from 1/2 wavelength up to well over 1 wavelength.
2. SP = Horizontal Element Spacing: Horizontal spacing may range from 1/4 wavelength to 3/8 wavelength.
3. H = Vertical Element Spacing: Vertical spacing may range from 3/8 wavelength to 3/4 wavelength.

The write-up shows a typical pattern with good bi-directional gain. However, a myriad of questions remains for anyone contemplating building such an array. However, we can boil the questions down to just two.

**What do we get? What do we pay?**

If we look carefully at the sketch, we can see that the array in **Fig. 1** only becomes a collection of collinear elements when the element lengths approach and pass beyond the 1-wavelength mark, at which time, we can consider them to be collinear half-wavelength elements. The vertical dimensions surround those that we associate with the Lazy-H antenna. If we look carefully at the sketch, we can see that the two left-side elements are in phase with each other, since the lines to each left-side element have half-twists. Likewise, the right-side elements are also in phase with each other. The 2 top elements are out of phase with each other, the sign of a W8JK array. Likewise for the bottom 2 elements. Of course, all of this assumes that all 4 lines from the central junction are equal in both length and characteristic impedance.

Therefore, I have dubbed the array the "Lazy-8JK." This name is very much shorter than calling the assembly a collinear, broadside, endfire array. The latter expression is descriptive, because the top and bottom elements form pairs that are endfire arrangements, while the left and right pairs are broadside arrangements.

Identifying the array as related to both the Lazy-H and the W8JK gives us a means of answering the latter question, at least in part. What we pay is something over twice the complexity of either the 8JK or the Lazy-H. Before we are finished, we shall examine some other costs for the array, but this much is a beginning.

The tougher question is knowing what we get for our effort. However, identifying the array as a combination of Lazy-H and 8JK arrays gives us a foundation from which we can work. Let's transform the question into this one: What are the advantages in performance of the Lazy-8JK over either the Lazy-H alone or the W8JK alone? Now we have something with which to work.

### A Review of the Lazy-H Broadside Array

In its basic form, the Lazy-H is a very old but well-proven antenna design with distinct advantages among wire arrays. Originally, it consisted of two 1-wavelength elements vertically spaced 1/2-wavelength apart. However, users later discovered that the antenna would operate effectively over a wide frequency range using a parallel transmission line and a wide-range antenna tuner.

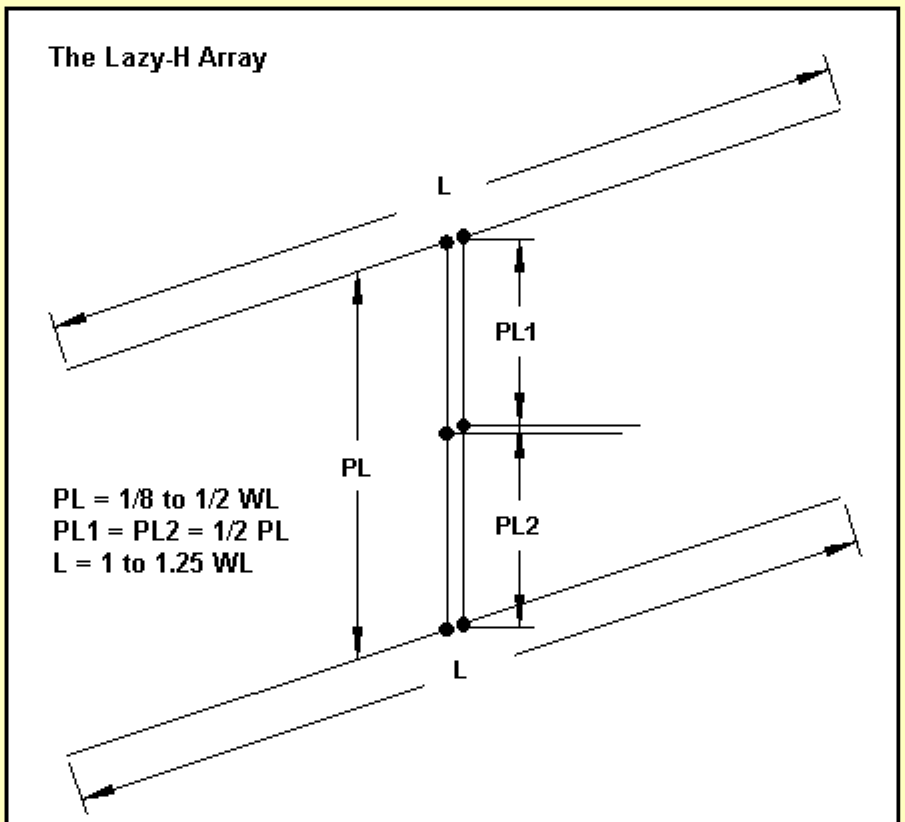
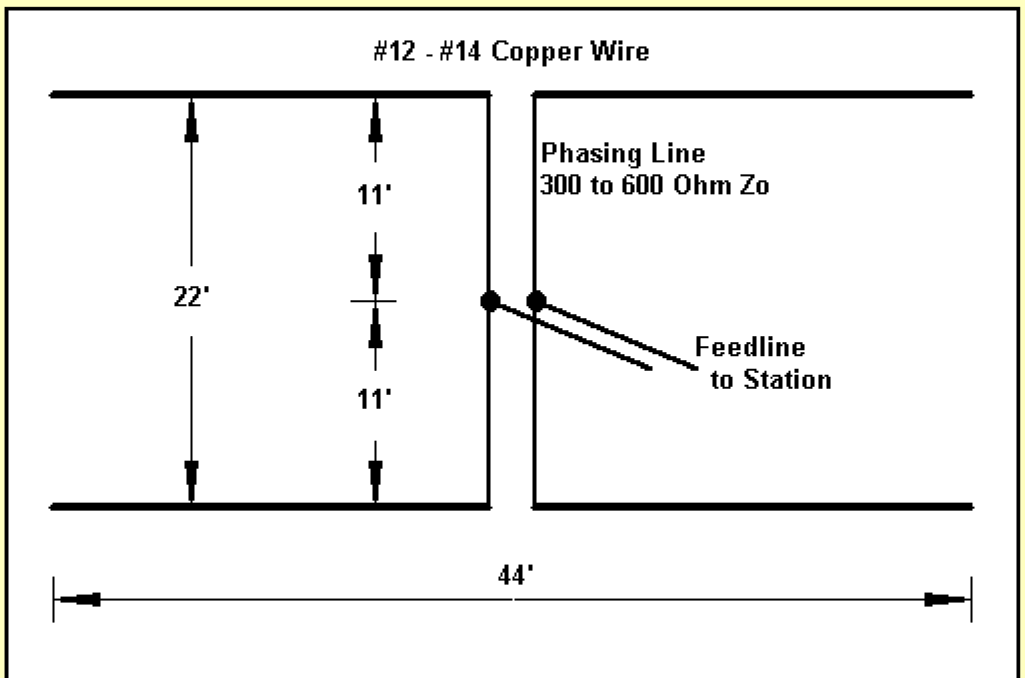



Fig. 2

In **Fig. 2**, we see the essential electrical components of the Lazy-H. The horizontal wires marked L are the elements. PL, the phase-line, is broken into two equal parts, PL1 and PL2. As the diagram indicates, the two elements are fed in-phase with no twists on either phase line section. The main feedline, attached at the junction of PL1 and PL2, provides equal power to each element. Essentially, then, the Lazy-H consists of two doublets, vertically spaced and fed in-phase, in order to obtain considerable gain over a single doublet of the same length mounted at the approximate array center.

The array produces bi-directional patterns on all bands within the operating range. The elements must be no more than about 1.25 wavelengths to achieve a bi-directional pattern. The antenna will operate at higher frequencies, but the pattern breaks down into multiple lobes as the electrical length of the elements increases at higher frequencies. As well, maximum gain occurs when the elements are about 5/8-wavelength apart. At the highest frequency of bi-directional operation, the antenna has been called the extended or expanded Lazy-H.



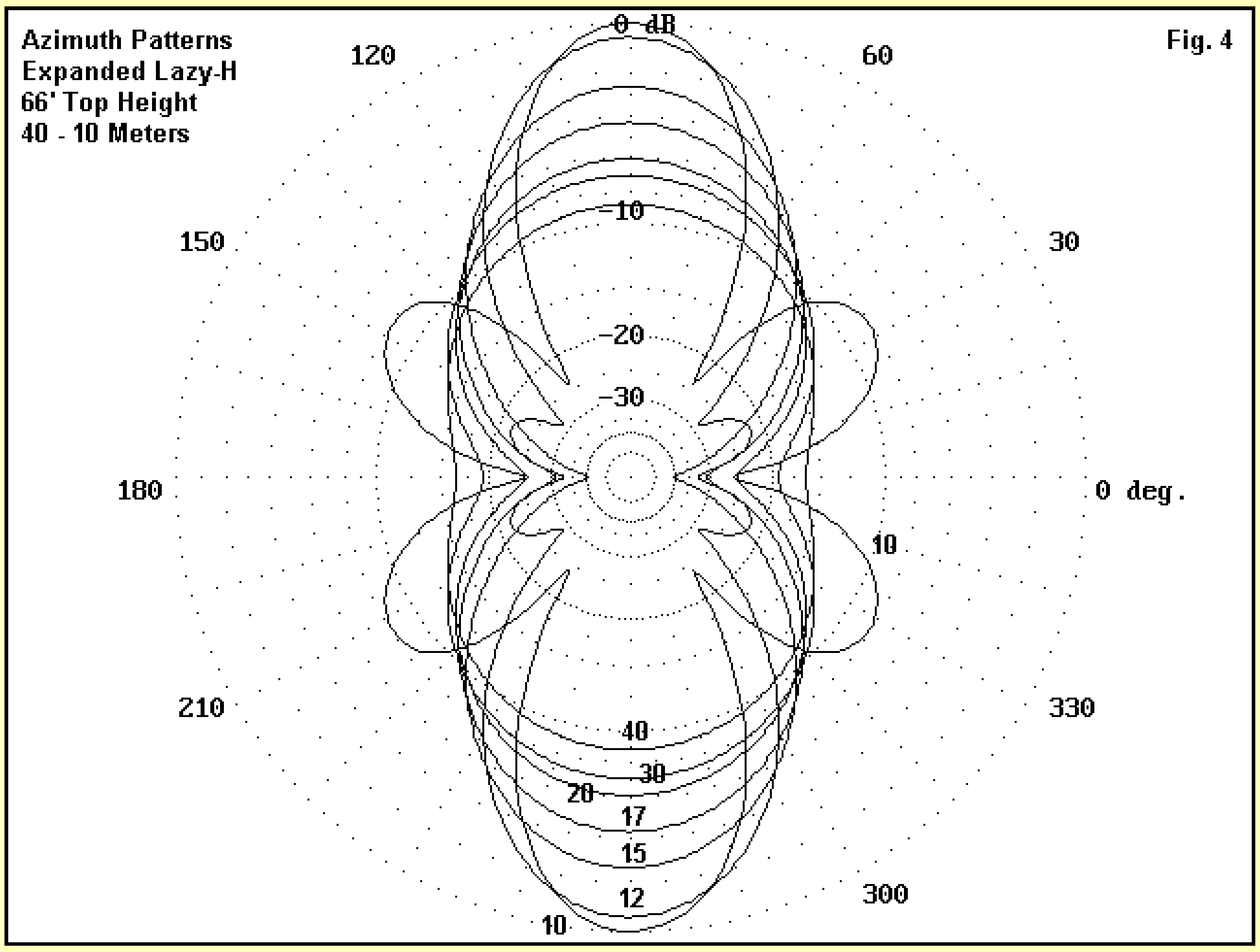

Extended/Expanded Lazy-H: Physical Dimensions Fig. 3

**Fig. 3** shows one common form of the Lazy-H that is useful for operation on amateur bands from 10 meters down to 40 meters. On 10 meters, the 44' wires are about 1.25 wavelengths, dropping to 1 wavelength on 15 meters, and becoming progressively electrically shorter as we reduce frequency. The 22' spacing is 5/8 wavelength on 10, 1/2 wavelength on 15, and electrically closer on lower frequencies. We shall use this model as a foundation for this evaluation of the Lazy-8JK in order to provide a consistent set of dimension throughout. In addition, we shall place the bottom wire of the Lazy-H at 44', with the top wire at 66'. With these dimensions and heights, we obtain the performance in the following table.

**Extended Lazy-H Performance Potential**

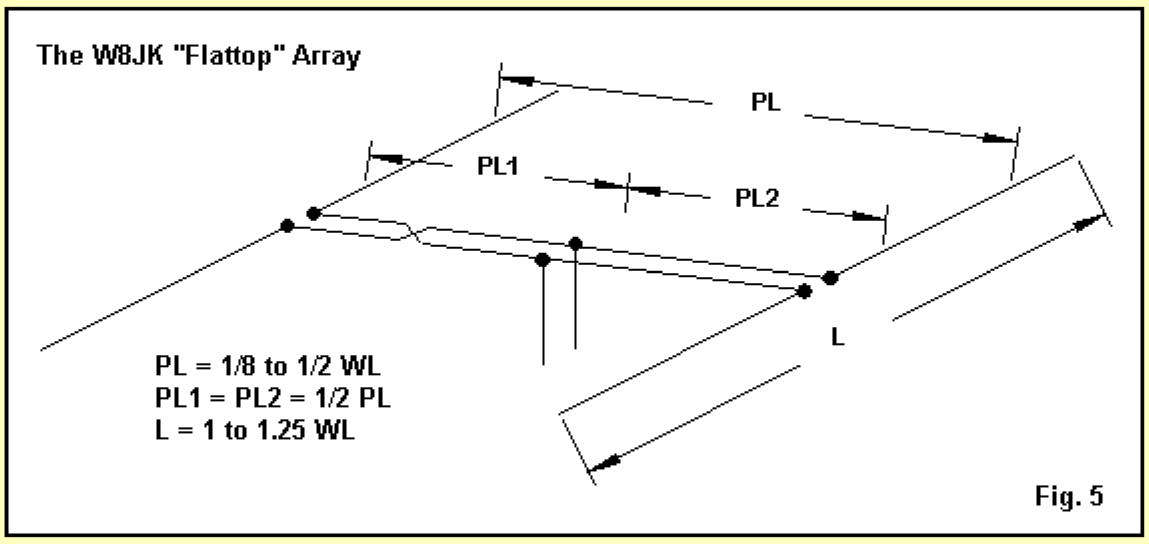
| Freq. MHz | Gain dBi | TO angle degrees | Beamwidth degrees | Feed Z R+/-jX Ohms |
|---|---|---|---|---|
| **28.1** | **15.3** | **9** | **31** | **40 + j 305** |
| **24.95** | **14.6** | **10** | **41** | **20 + j 100** |
| **21.1** | **12.5** | **11** | **52** | **25 - j 35** |
| **18.118** | **10.9** | **13** | **61** | **50 - j 145** |
| **14.1** | **9.0** | **17** | **73** | **495 - j 145** |
| **10.125** | **8.1** | **24** | **85** | **50 + j 105** |
| **7.1** | **6.3** | **33** | **99** | **10 - j 100** |

Because the elements grow shorter and the spacing becomes closer with decreasing frequency, the gain drops with frequency. That fact becomes clear from the overlaid azimuth patterns in **Fig. 4**. The 10-meter azimuth pattern shows its extended-double-Zepp family resemblance, while the 15-meter pattern has the classic shape for 1-wavelength elements. Although the full usable operating band-spread for the antenna appears in the table and pattern graphic, we shall focus only on operation in the 5 highest HF bands from 20 meters onward.




**A Review of the W8JK Endfire Array**

In its basic form, the 8JK is a very old but well-proven antenna design with distinct advantages among wire arrays. The array name derives from its inventor, John D. Kraus, W8JK, who wrote on various forms and facets of the antenna from 1937 to the present. Originally, the 8JK consisted of two 1/2-wavelength elements horizontally spaced from 1/8 to 1/2 wavelength. However, users later discovered that the antenna would operate effectively over a wide frequency range using a parallel transmission line and a wide-range antenna tuner.




In **Fig. 5**, we see the essential electrical components of the 8JK. The horizontal wires marked L are the elements. PL, the phase-line, is broken into two equal parts, PL1 and PL2. As the diagram indicates, the two elements are fed out-of-phase with a half-twist on one of the phase line sections. The main feedline, attached at the junction of PL1 and PL2, provides equal power to each element. Essentially, then, the 8JK consists of two doublets, horizontally spaced and fed out-of-phase, in order to obtain considerable gain over a single doublet of the same length mounted at the approximate array center.

The array produces bi-directional patterns on all bands within the operating range. The elements must be no more than about 1.25 wavelengths to achieve a bi-directional pattern. The antenna will operate at higher frequencies, but the pattern breaks down into multiple lobes as the electrical length of the elements increases at higher frequencies. The element spacing is subject to significant variation among builders. The version that we shall explore uses a spacing of 5/8 wavelength at the highest operating frequency. This spacing becomes electrically smaller as we reduce frequency, but still is not the spacing for the highest possible gain. In fact, the array tends to increase gain with closer spacing, although the impedance at the feedpoint becomes impractically low. The advantage of the 5/8-wavelength spacing used in this model is that it yields almost constant gain over the entire operating range of the antenna.

The version that we shall explore uses the same wire lengths and spacing as the Lazy-H in **Fig. 3**. The only differences are the fact that the antenna is placed in a horizontal position and there is a half-twist in one (and only one) of the phase lines from the common junction to the elements. Since the Lazy-H has elements at both 44' and 66' above ground, we shall sample performance on 20 through 10 meters at each of these heights.

**Extended Lazy-H Performance Potential**

**44' Above Ground**

| Freq. MHz | Gain dBi | TO angle degrees | Beamwidth degrees | Feed Z R+/-jX Ohms |
|---|---|---|---|---|
| 28.1 | 11.8 | 11 | 33 | 160 + j 505 |
| 24.95 | 11.8 | 13 | 41 | 35 + j 170 |
| 21.1 | 11.1 | 15 | 50 | 25 + j 25 |
| 18.118 | 11.0 | 17 | 55 | 25 - j 75 |
| 14.1 | 10.5 | 21 | 61 | 110 - j 420 |

**66' Above Ground**

| Freq. MHz | Gain dBi | TO angle degrees | Beamwidth degrees | Feed Z R+/-jX Ohms |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **28.1** | **11.7** | **8** | **33** | **165 + j 505** |
| **24.95** | **11.9** | **9** | **40** | **35 + j 170** |
| **21.1** | **11.4** | **10** | **40** | **20 + j 25** |
| **18.118** | **11.3** | **11** | **54** | **25 - j 75** |
| **14.1** | **10.8** | **14** | **60** | **110 - j 410** |

In these tables--indeed, in all of the tables--the impedance figures are representative values modeled with 450-Ohm transmission line for the phase lines. The actual feedpoint values will tend to vary with changes in either the characteristic impedance or the velocity factor of the line selected. for that reason, I recommend that any prospective builder of any one of these arrays model the installation including the characteristic impedance and velocity factor of the phase lines to be used. From these values, you may calculate the anticipated impedance at the antenna tuner using any one of a number of available transmission line programs, such as TLW or TLD.

At either height, the gain variation is less than 1 dB from 20 through 10 meters. Although the gain is generally lower, on 20 meters the 8JK outperforms the Lazy-H. **Fig. 6** provides the overlaid azimuth patterns for the W8JK in extended operation to even lower frequencies. Once more, the extended-double-Zepp origins of the 10-meter pattern are apparent.

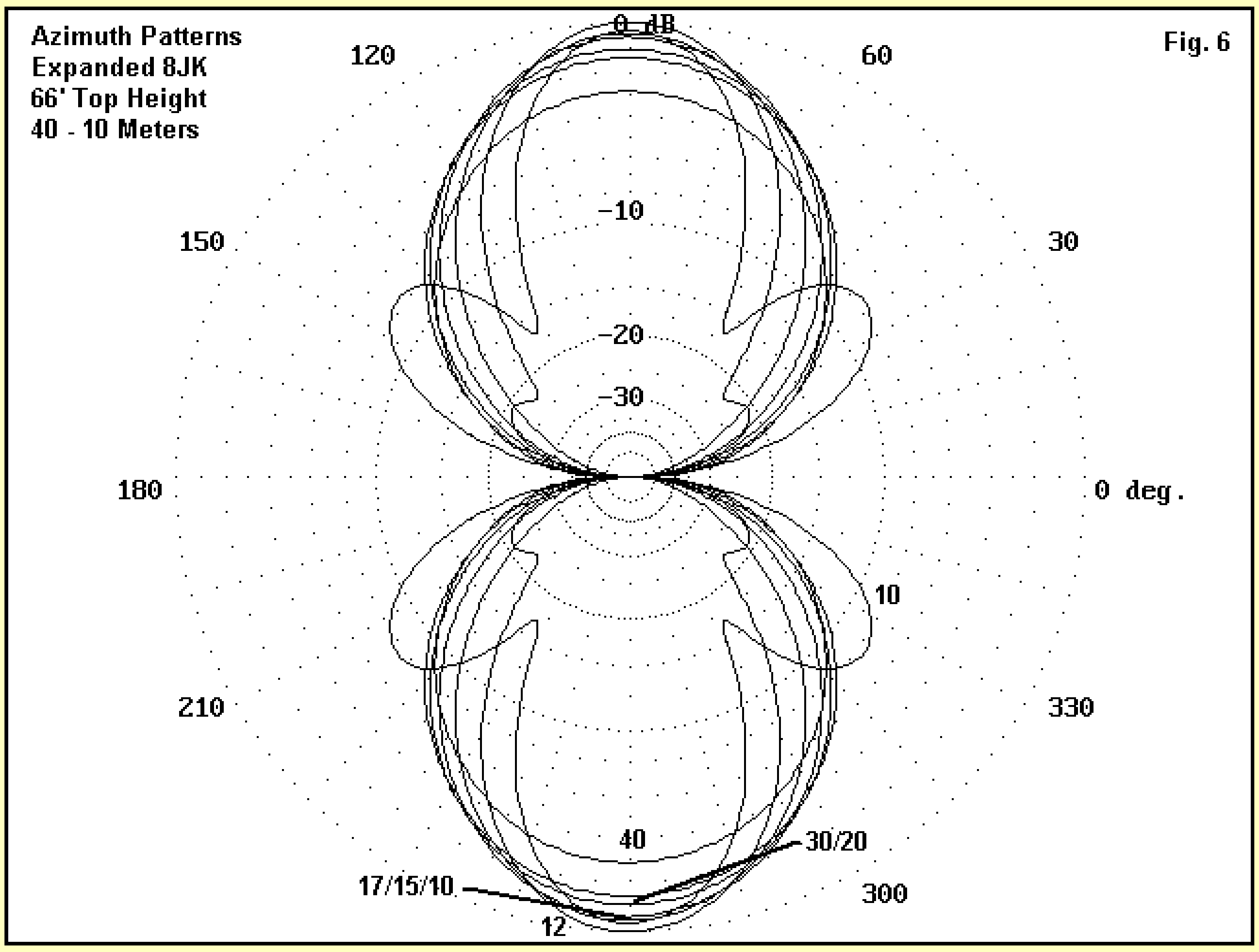
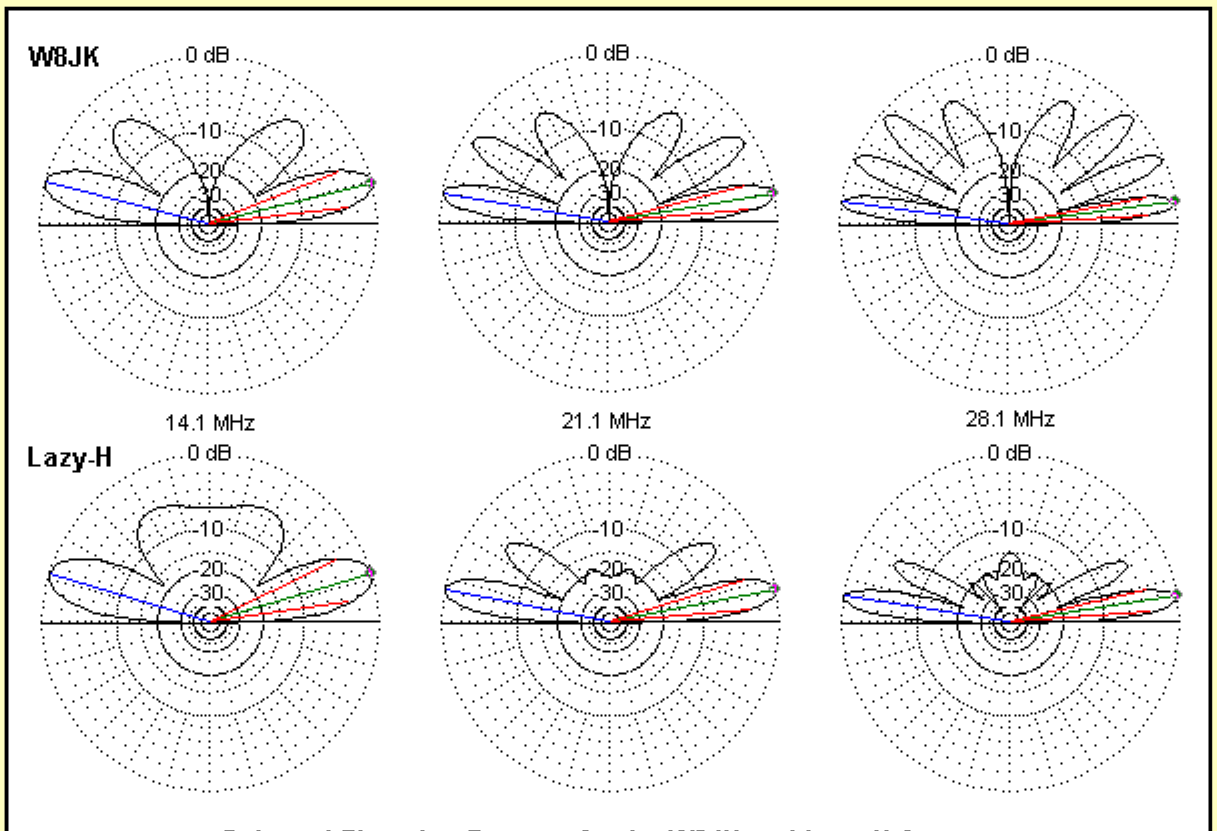


Fig. 6

The gain differences between the 8JK and the Lazy-H are largely due to differences in the amount of energy radiated at high elevation angles. **Fig. 7** shows selected elevation patterns for the two arrays, with the 8JK patterns taken for a 66' height above ground.



Selected Elevation Patterns for the W8JK and Lazy-H Arrays

Fig. 7

At 21 MHz, where the Lazy-H spacing is almost a perfect half-wavelength, the Lazy-H effectively suppresses high-angle radiation, in contrast to the multiple strong upper-angle lobes of the 8JK. On 10 meters, the Lazy-H does not suppress overhead radiation perfectly due to the wider spacing, but overall suppression of high-angle radiation is excellent. Still, the 8JK shows even more high-angle lobes. The 8JK begins to exceed the Lazy-H in gain in the lowest lobe on 20 meters. The Lazy-H spacing is down to about 5/16 wavelength, a value that is too close for effective suppression of high angle radiation.

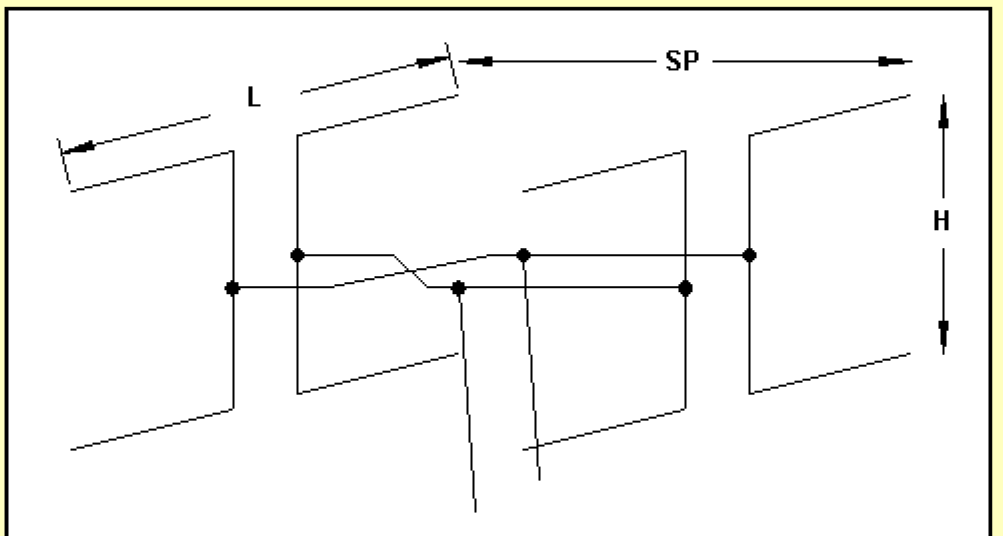
**The "Lazy-8JK" Array**

Against this background, we may now combine a Lazy-H with an 8JK to arrive at the collinear broadside endfire array, that is, at the Lazy-8JK. The elements of **Fig. 1** describe the most common version of the antenna. For our comparisons, we shall use 44' element lengths, which is about

1.25 wavelengths at 10 meters. The vertical spacing will use the Lazy-H value of 22'.

However, we cannot use the 22' element spacing of the 8JK that we have reviewed. At that spacing, the Lazy-8JK actually shows less gain than a single Lazy-H for 15 through 10 meters. We must compress the horizontal spacing to about 8-11 feet to obtain any usable additional gain from the 4-doublet array. The modeled data are based upon the 11' spacing, although the differences between 8' and 11' are not operationally significant.

In addition, there is an alternative feed system to the one shown in **Fig. 1**, where each of 4 equal-length phase lines combine at a central feedpoint. As shown in **Fig. 8**, we may also construct individual Lazy-H arrays with center feedpoints. We then run equal lines to a center position, giving one and only one of those lines the necessary half twist to place the left-side doublets out of phase with the right-side doublets.




An Alternative Way of Making a "Lazy-8JK" Fig. 8

For the 44' elements at 44' and 66' above ground, 11' left-to-right spacing requires two 5.5' phase lines. For the data in the tables, I again used 450-Ohm line for all phase lines.

**Lazy-8JK Performance Potential**

**Standard Feed System (Fig. 1)**

| Freq. MHz | Gain dBi | TO angle degrees | Beamwidth degrees | Feed Z R+/-jX Ohms |
|---|---|---|---|---|
| 28.1 | 16.5 | 9 | 33 | 50 + j 300 |
| 24.95 | 15.4 | 10 | 37 | 9 + j 90 |
| 21.1 | 13.8 | 11 | 45 | 6 + j 10 |
| 18.118 | 12.8 | 13 | 51 | 7 - j 40 |
| 14.1 | 11.6 | 16 | 58 | 42 - j 260 |

**Alternative Feed System (Fig. 8)**

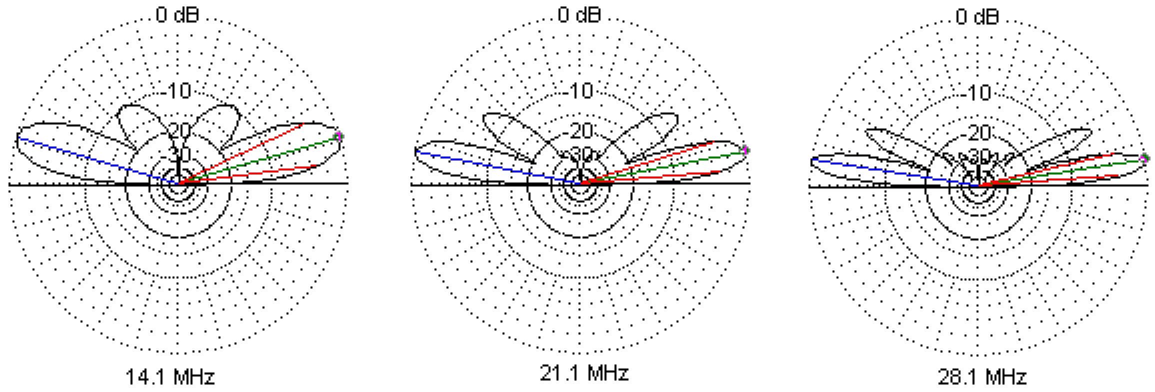
| Freq. MHz | Gain dBi | TO angle degrees | Beamwidth degrees | Feed Z R+/-jX Ohms |
|---|---|---|---|---|
| 28.1 | 16.5 | 9 | 33 | 1590 + j1870 |
| 24.95 | 15.4 | 10 | 37 | 35 + j 465 |
| 21.1 | 13.8 | 11 | 45 | 10 + j 190 |
| 18.118 | 12.8 | 13 | 51 | 9 - j 85 |
| 14.1 | 11.6 | 16 | 58 | 30 - j 135 |

*1. Gain Factors*: There is no difference in the gain performance between the two feed systems for the Lazy-8JK. The Lazy-8JK provides a variable gain value according to frequency according to the Lazy-H part of its origins. However, the W8JK portion of its origins shows up in the increments of gain above each of the corresponding simpler arrays. The following table tracks the gain advantage of the Lazy-8JK over the Lazy-H and the W8JK, where the latter uses values for a 66' height above ground.

**Gain Advantage of the Lazy-8JK**
**All gain values are in dBi at the elevation angle of maximum radiation.**

| Freq. MHz | Lazy-8JK | Lazy-H | Added Gain | W8JK | Added Gain |
|---|---|---|---|---|---|
| 28.1 | 16.5 | 15.3 | 1.2 | 11.7 | 4.8 |
| 24.95 | 15.4 | 14.6 | 0.8 | 11.9 | 3.5 |
| 21.1 | 13.8 | 12.5 | 1.3 | 11.4 | 2.4 |
| 18.12 | 12.8 | 10.9 | 1.9 | 11.3 | 1.5 |
| 14.1 | 11.6 | 9.0 | 2.6 | 10.8 | 0.8 |

The Lazy-8JK adds only about 1 dB gain to a single Lazy-H in the upper-most bands. However, the 8JK portion of its origins increases the gain on 20 meters by about 2.6 dB. In contrast, the Lazy-8JK shows its highest gain additions over a single 8JK on the top bands, with reduced gain additions with descending frequency. Additionally, the beamwidths for the Lazy-8JK are slightly narrower than for the standard 8JK as a function of the additional gain.




Selected Elevation Patterns for the "Lazy-8JK" Array

Fig. 9

**Fig. 9** shows selected elevation patterns corresponding to those shown for the Lazy-H and the W8JK. The added gain is largely due to a continuing progression of upper lobe suppression. A comparison of 20-meter patterns among all three arrays is especially notable.

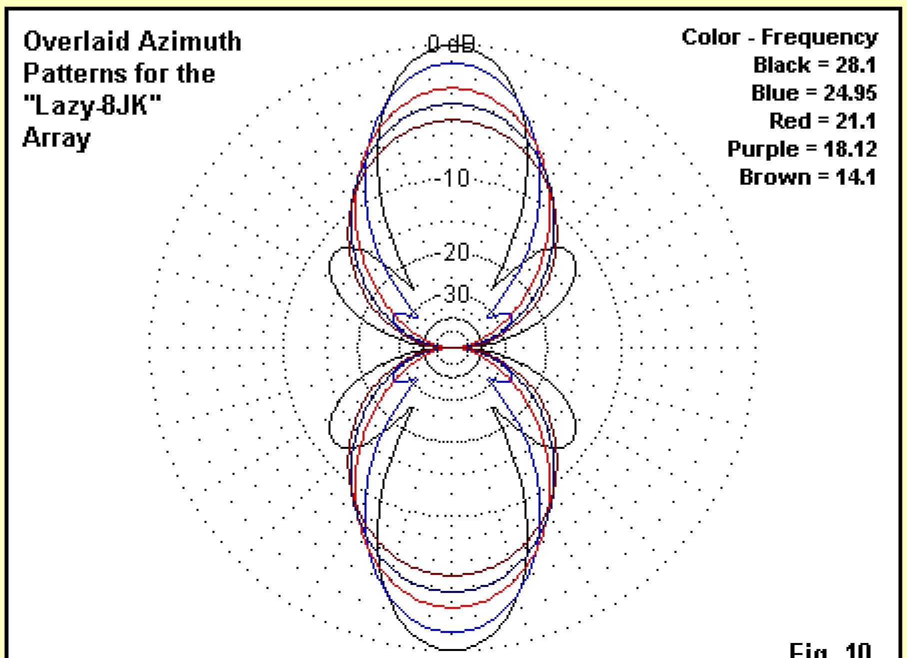



Fig. 10

To complete the comparisons, **Fig. 10** shows overlaid azimuth patterns for each band, with each pattern taken at the elevation angle of maximum radiation.

From the perspective of gain, then, there are two considerations facing the builder who may weigh the increase in construction complexity against the performance advantage. First, the more complex array shows a better balance of gain than a single Lazy-H, with improvements especially in the 20-meter performance. Second, the Lazy-8JK increases gain on the upper bands over the sampled standard 8JK array. Whether the total improvement is sufficient to warrant the increased construction problems is ultimately a user judgment.

*2. Impedance Considerations*: The differences in the two ways of feeding the Lazy-8JK lie wholly in the area of the feedpoint impedances. The standard X-form of the phase lines (**Fig. 1**) yields more bands on which the feedpoint impedance is under 10 Ohms resistive. Under these conditions, every fraction of an Ohm of loss resistance in the connections transforms a proportionately higher percentage of the power into heat. Hence, great care must be used in the assembly of the system, and equal periodic maintenance care is required.

The alternative configuration for feeding the Lazy-8JK has fewer instances of very low resistive components to the feedpoint impedance. However, 10 meters present a high impedance, with both the resistive and reactive components above 1500 Ohms. As a result of the high variability in feedpoint impedances, the builder very likely will have to pay close attention to the line length between the antenna feedpoint and the tuner terminals to present impedances within the tuner's matching capabilities. This aspect of the Lazy-8JK is the second half of the answer to the original question of what do we pay.

**Conclusion**

The Lazy-8JK (or collinear broadside endfire) array offers different advantages over the standard Lazy-H and the standard 8JK. Since these advantages change with each upper HF band, there is no single answer to the question of whether the larger array is worth the effort of construction.

Nevertheless, by setting up reasonable comparators, these notes will hopefully provide a better sense of both the advantages and disadvantages of going to the more complex arrangement. There are additional dimensions of the final decision. For example, the Lazy-8JK does not lend itself to the relatively simple triangular arrangements of Lazy-H arrays that permit switched directional changes. Nor does the Lazy-8JK allow one to construct an easily rotated version of the array, as is possible with a single 8JK. Yet, the lure of added gain is likely to appeal to at least some aficionados of wire antenna construction. With dimensions of 44' by 22' by 11', it is still a fairly compact upper HF bi-directional array with outstanding performance potential.

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