Adjacent-Band Quad Behavior

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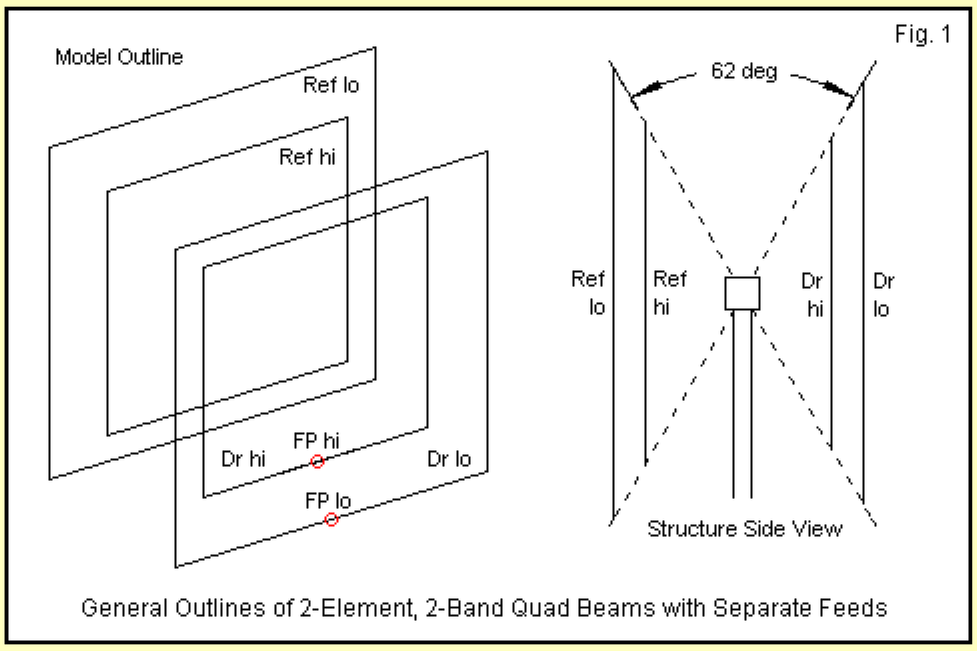
In the study of quads that led up to some notes on dual-band antennas using a common feedpoint, I intentionally by-passed an important question. Dual-band quads required a frequency ratio of at least 1.3:1 for inclusion in the earlier notes. As a result, I omitted combinations such as 20 and 17 meters or 12 and 10 meters. That set of notes reached a number of conclusions about quad behavior based on consistent trends shown by the models that I did use. Foremost among the results was the observation that most of the major performance and dimension changes resulted from the simple proximity of the element loops, even when using separate feedpoints. The major dimensional change that occurs when using a common feedpoint instead of separate feedpoints is the lengthening of the inner or higher-frequency driver loop.

We are now positioned to fill in the gap in our exploration of dual-band quad behavior. The study can restrict itself to quads with separate feedpoints on each band, thus simplifying the required modeling. Most of the dimension and performance behaviors that we shall find interesting occur using separate feedpoints. **Fig. 1** shows the general parameters of the models used in this sequence of examinations. Of course, only one of the two feedpoints shown in the sketch will be active at any one time.

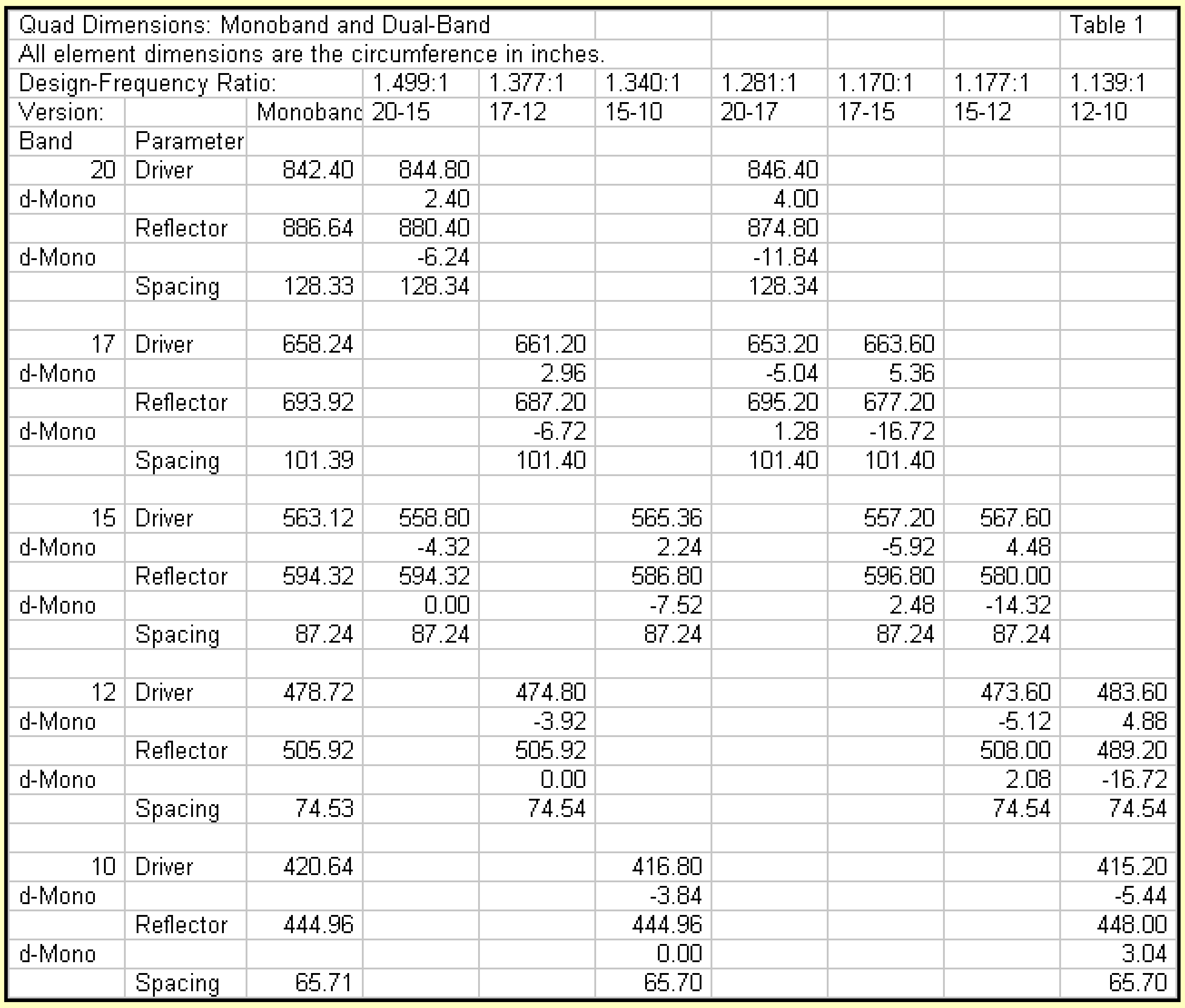


Like the earlier sequence of quad models, the new set will rest on the monoband quad designs derived by equations, as described in Part 1 of that study. Dual band models will presume spider construction, which calls for an angle of about 62 degrees between the driver and the reflector support arms. Indeed, the only restriction that we shall remove is the minimum frequency ratio between bands. Hence, we can now see what trends develop as we change the ratio. By using combinations of 17 and 12 meters, 15 and 10 meters, and 20 and 15 meters, we encountered relatively small interactions that left the performance curves quite similar to those for the monoband beams, with variations only in the limiting values for each band. We also noted small variations that depended upon whether a loop was part of an inner or higher frequency beam or was part of an outer or lower frequency beam.

To the collection of dual-band quads previously used, we may now add 4 other combinations: 20-17, 17-15, 15-12, and 12-10, where each designation is for an amateur band pair. We shall divide the trends into 2 parts. The first set of trends will involve the physical dimensions. The second (and longer) exploration will deal with performance.

General Notes on Dual-Band Quad Dimensions

Table 1 provides a summary of the dimensions, starting with those of the monoband beams. Along side each monoband beam are the dimensions of the loops and the spacing for all of the dual-band quads that we shall examine. As in past notes, all dimensions are in inches. Multiply the values by 0.0254 to obtain dimensions in meters. The loop dimensions appear as circumferences in this table, and a loop side is the value shown divided by 4. Spacing values are the distance between the front and rear loops for each band. As I did for the monoband beams, I used 14.14, 21.19, and 28.4 MHz as offset design frequencies so as to level the band-edge front-to-back ratio values to the degree possible. 17 and 12 meters are narrow enough to allow the band center frequency to serve also as the design frequency. All drivers are resonant at the design frequency within about +/-j1 Ohm of remnant reactance. In anticipation of potential trends, I extended the degree of element size precision to 0.05". All values of element spacing remain constant between the monoband and dual-band quads.



Quad Dimensions: Monoband and Dual-Band									Table 1
All element dimensions are the circumference in inches.									
Design-Frequency Ratio:			1.499:1	1.377:1	1.340:1	1.281:1	1.170:1	1.177:1	1.139:1
Version:		Monobanc	20-15	17-12	15-10	20-17	17-15	15-12	12-10
Band	Parameter								
20	Driver	842.40	844.80			846.40			
d-Mono			2.40			4.00			
	Reflector	886.64	880.40			874.80			
d-Mono			-6.24			-11.84			
	Spacing	128.33	128.34			128.34			
17	Driver	658.24		661.20		653.20	663.60		
d-Mono				2.96		-5.04	5.36		
	Reflector	693.92		687.20		695.20	677.20		
d-Mono				-6.72		1.28	-16.72		
	Spacing	101.39		101.40		101.40	101.40		
15	Driver	563.12	558.80		565.36		557.20	567.60	
d-Mono			-4.32		2.24		-5.92	4.48	
	Reflector	594.32	594.32		586.80		596.80	580.00	
d-Mono			0.00		-7.52		2.48	-14.32	
	Spacing	87.24	87.24		87.24		87.24	87.24	
12	Driver	478.72		474.80				473.60	483.60
d-Mono				-3.92				-5.12	4.88
	Reflector	505.92		505.92				508.00	489.20
d-Mono				0.00				2.08	-16.72
	Spacing	74.53		74.54				74.54	74.54
10	Driver	420.64			416.80				415.20
d-Mono					-3.84				-5.44
	Reflector	444.96			444.96				448.00
d-Mono					0.00				3.04
	Spacing	65.71			65.70				65.70

The dual-band quads are listed according to the bands covered, that is, as 20-17, 20-15, etc. Each combination shows the loop circumferences that result in a peak front-to-back ratio and near resonance at the design frequencies. The entries marked "d-Mono" show the difference between the required circumference of the element in its place within the dual-band quad and the corresponding monoband element. A positive value means that the dual-quad element is larger; a negative value means that it is smaller.

The dual quads fall into 2 groups. The 20-15, 17-12, and 15-10 models are wide, that is, have a greater spacing between the two element sets due to the larger frequency ratio. The ratios range from 1.34:1 up to 1.5:1. These patterns replicate what we uncovered in the previous study. If a driver is an outer (or lower frequency) elements, then it will increase in length relative to the monoband value. For the upper HF bands used here, the amount and the range is small: 2.2 to 3 inches. If the driver is an inner (or higher frequency) elements, then its length will decrease relative to a monoband quad. Again the amount and range are small: 3.8 to 4.3 inches.

If a reflector is an outer loop, then it will be shorter than the corresponding monoband reflector. The amount is greater than for the other affected elements: 6.2 to 7.5 inches. In contrast, for the wide dual quads with higher frequency ratios, if a reflector is an inner loop, it requires no change from the monoband length.

The other group of dual quads includes 20-17, 17-15, 15-12, and 12-10 meters. The frequency ratios for this set run from a low value of 1.14:1 to a high value of 1.28:1. The average ratio is 1.21:1, in contrast to the average ratio for the wide group: 1.42:1. The result, of course, is a 2:1 ratio of ratios.

For the narrow group, if a driver is an outer loop, then it increases in size relative to the monoband quad element and roughly in proportion to the ratio of ratios. That is, the driver range of increase is 4.0 to 5.3 inches. If the reflector is an outer loop, then it decreases in size, not only with reference to the monoband antenna, but as well by a factor greater than the ratio of ratios. Outer reflectors for the narrow group decrease their circumferences by 12 to 17 inches relative to the monoband models. In general, the closer the spacing between the elements of a dual-band quad, the more rapidly that a reflector becomes shorter to maintain the same performance points.

If reflector is an inner loop, the wide dual-band quads required no change in circumference. However, with closer spacing, the narrow group of dual-band quads show a small amount and range of increase relative to the monoband quads: 1.3 to 3 inches. Like the wide-group drivers, the narrow group drivers--when forming inside loops--require shortening relative to monoband values. However, the amount is less than proportional to the ratio of ratios. The range of 5.1 to 5.5 inches is only about 30% greater than the amounts required by the wide group.

Physically, then, the elements of dual-band quads show a varied pattern of changes as we shrink the spacing between loops by creating beams for adjacent bands. Some changes are roughly proportional to the ratio of ratios, while others are not. However, trends that first appeared for the wide group continue in the same direction as we decrease the loop spacing by using adjacent bands. (Of course, the one exception is the inner reflector, which showed no trend for the wide-group dual quads.)

Within reason, one might use the patterns shown in **Table 1** as a design aid if developing a dual-band quad. The exact amounts of change will themselves change if we alter the element diameter, that is, the wire size. A further variable prevents me from trying to codify the patterns into a set of design equations. The performance points listed as criteria for success at the design frequencies--peak front-to-back ratio and driver resonance--are not perfect. The attainment of the peak front-to-back ratio at the design frequency is a judgment call within the limits of the increments of side-length change in the test models. As the frequency goes up, an increment of 0.05" per half-side length may not be sufficient to place the peak with precision. Operationally, such small departures from perfection are superfluous worries. However, they are enough to preclude final codification. Even regression analysis is not feasible, since it would apply to only one fixed wire size. A true set of design equations would require a survey that included a wide range of wire sizes. Such a survey is theoretically possible, and the results would amount to an extension of the existing monoband design equations, showing the modification of a monoband design for a dual-band quad for frequency ratios of perhaps 1.1:1 up to 1.5:1. However, the work involved so far does not seem to to yield a sufficiently useful result.

Band-by-Band Performance Trends

The performance side of our adjacent-band behavior question requires a gallery of graphs. For each loop tuned to the design frequency on each of the upper-HF amateur bands, I plotted the following results across the band: gain, 180-degree front-to-back ratio, feedpoint resistance, and feedpoint reactance. Hence, there are 5 graphs for each parameter, one for each band. Each graph also contains the curve for the monoband quad as a reference. In all cases we shall be more interested in the slope or general shape of a curve than in in precise values.

Each graph covers a different territory because not all wide and narrow group potentials appear in every graph. For example, the 20-meter graphs will show only 3 curves, and the two dual-band curves will apply only to loops that are outer elements, that is lower in frequency than the accompanying band. 10-meter graphs show just the opposite in their 3 lines. Besides the monoband curve, we shall find only instances where the 10-meter elements are inner or higher frequency elements. Only 15 meters shows the full spectrum of potentials, with 2 outer loop and 2 inner loop cases to accompany the monoband curve.

The dimensional table used a single designation for each combination, for instance, 17-12. The graph legends use a modification of that system. The band of interest to the graph always appears first in the dual-band quad designation. Therefore, in the 17-meter graphs, we shall find the label 17-12, but in the 12-meter graph, we shall designate the same dual-band quad as 12-17.

Gain

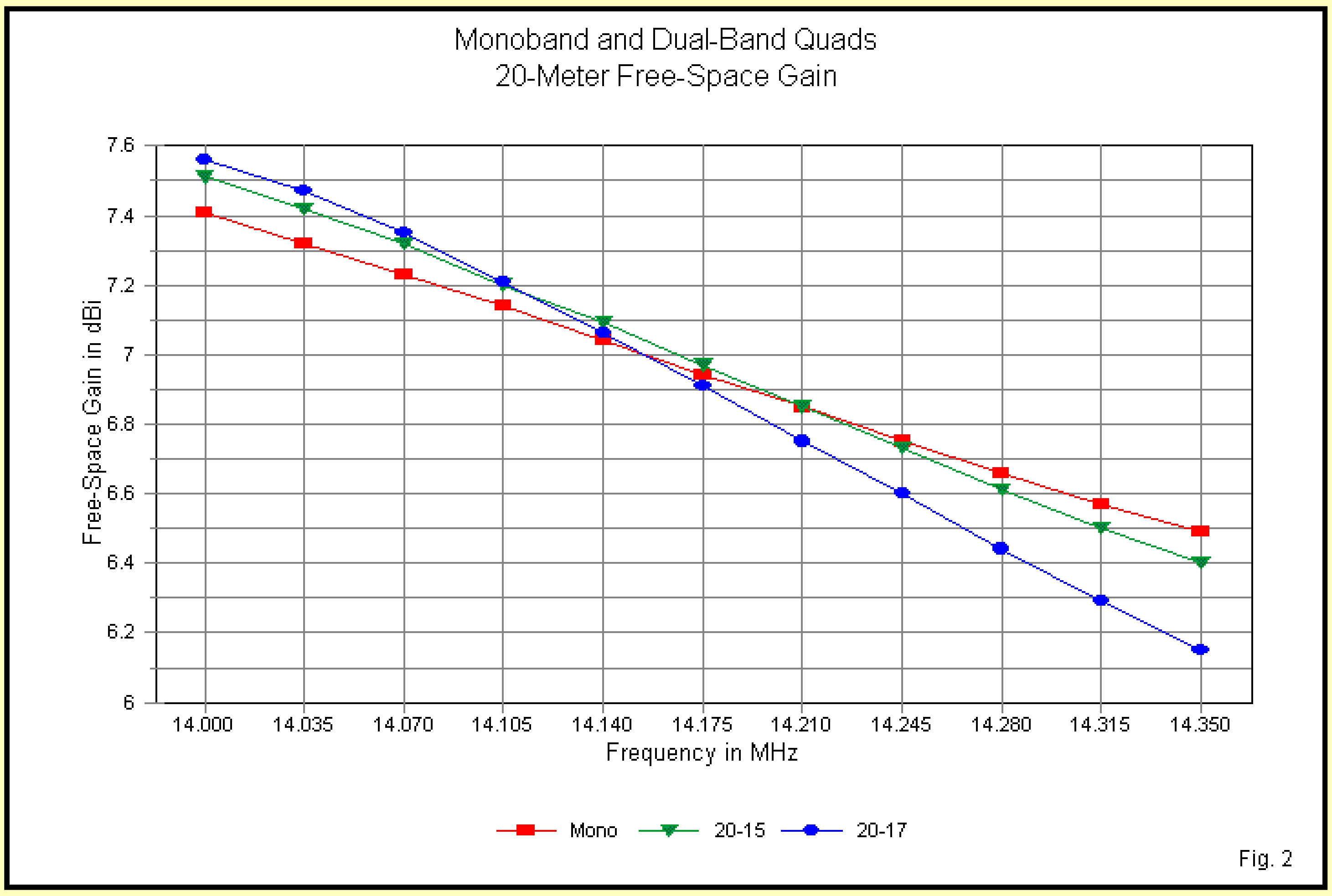


Fig. 2

Both dual-band 20-meter curves in **Fig. 2** refer to outer elements in their pairs. The monoband curve shows the lowest rate of gain decrease across the band. Note that as we add a higher band--even widely separated--the rate of gain decrease becomes steeper. In addition, as we reduce the space between the 20-meter elements and the second set in the pair, the rate of gain decrease becomes even greater.

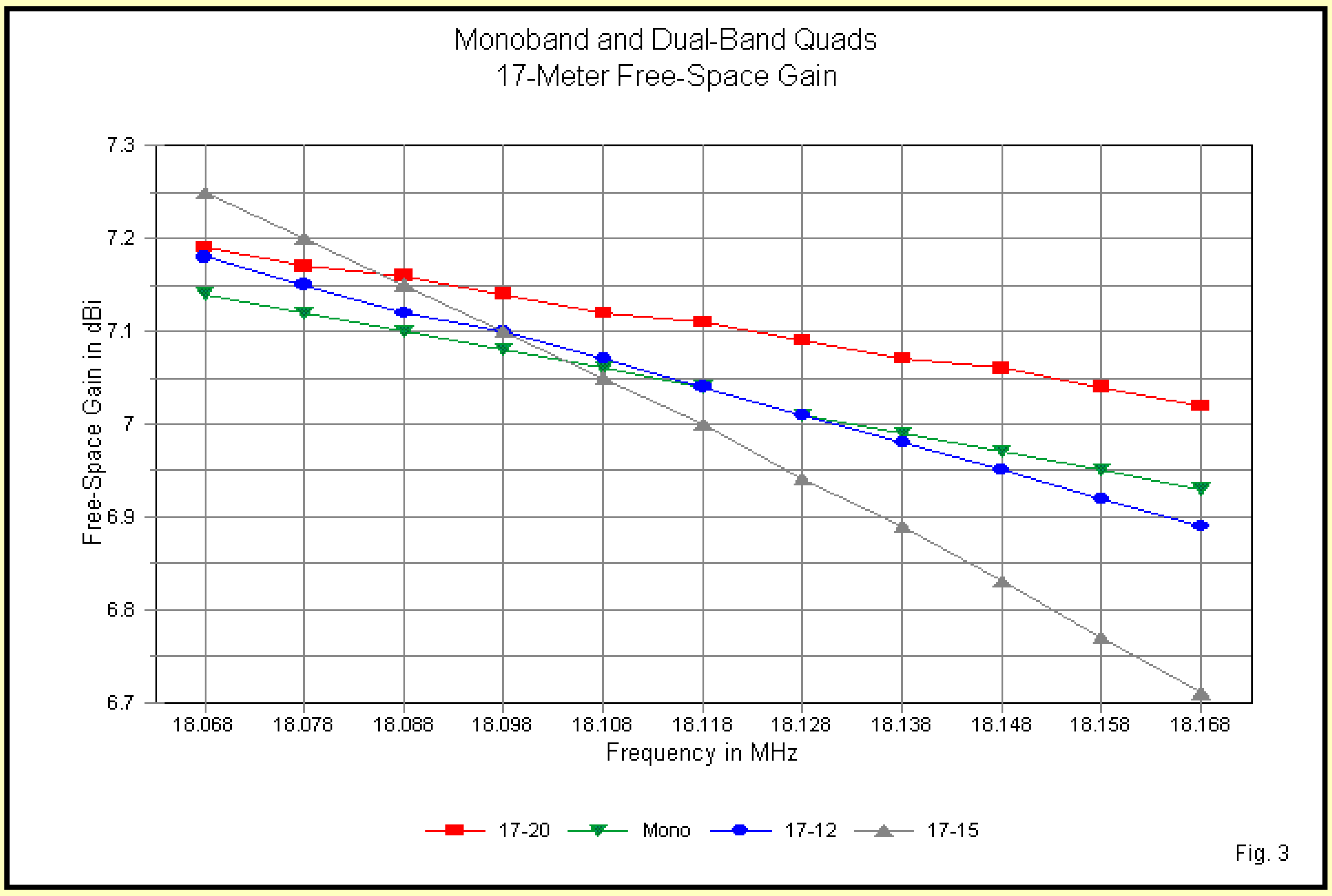
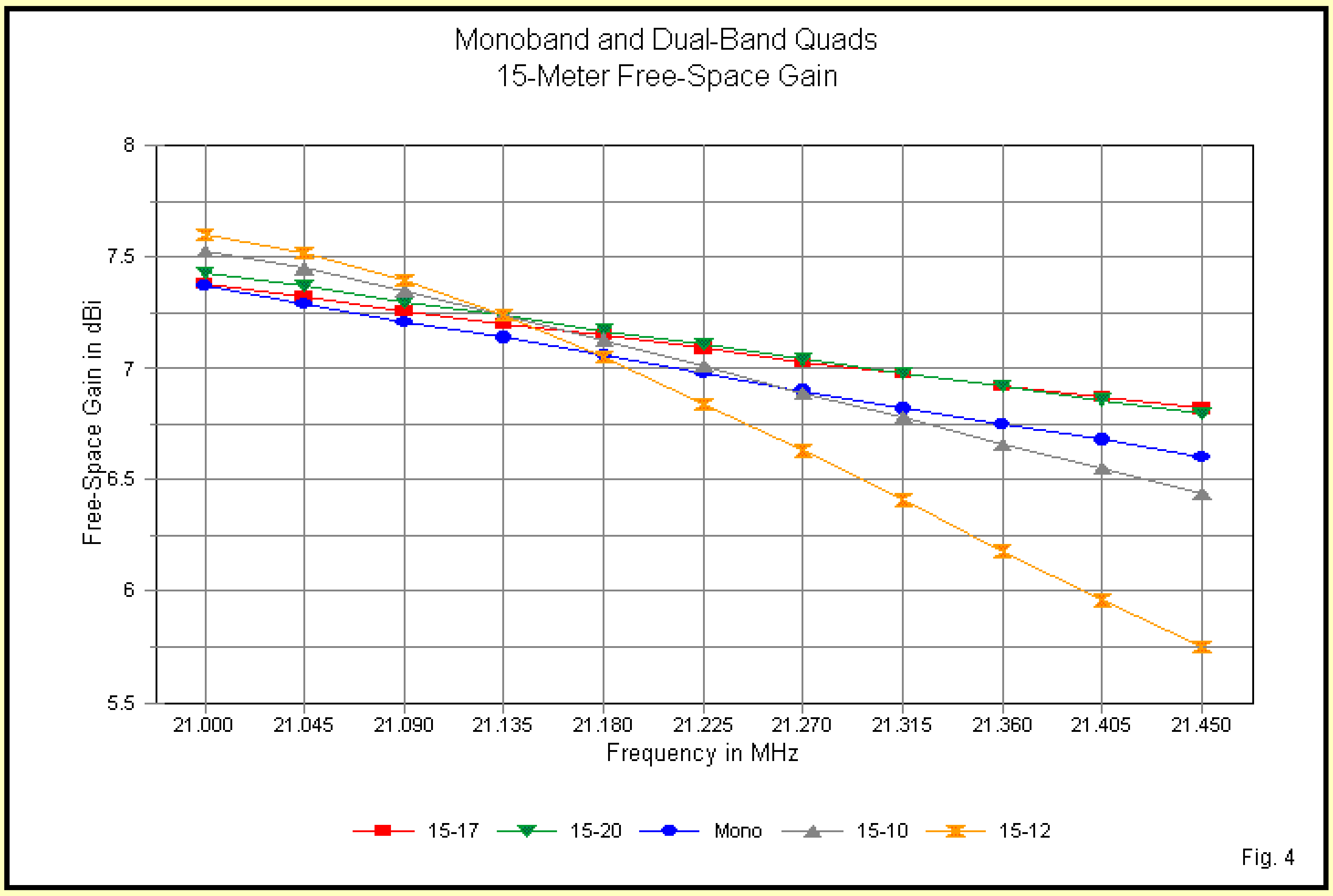
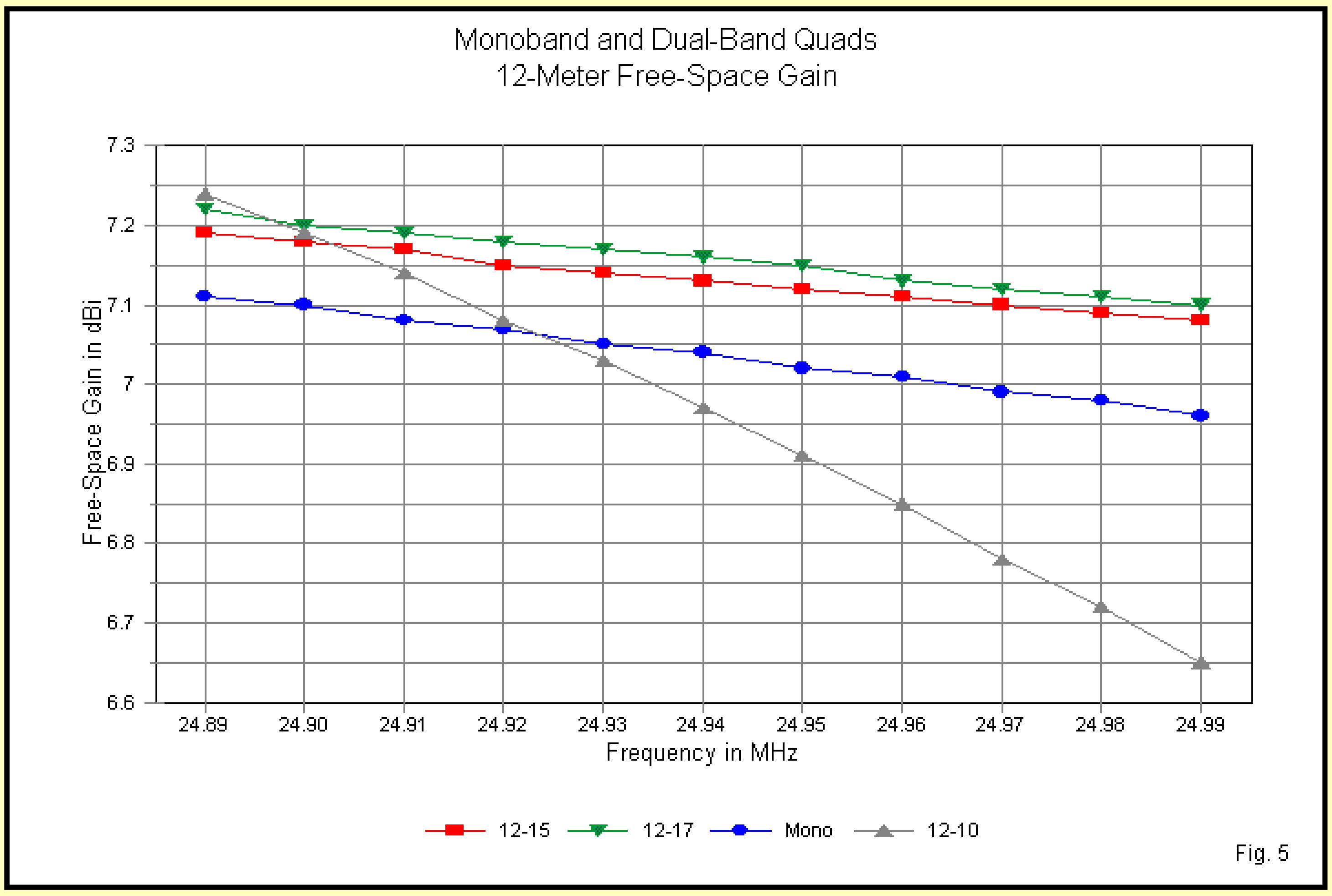


Fig. 3

The 17-meter gain chart (**Fig. 3**) includes one instance where 17-meters is an inner element. In this case, the rate of gain decrease is slightly less than the rate for the monoband quad. For the two cases in which the 17-meter elements are outer loops, the rate of gain decrease is higher than the monoband rate. Once more, the more closely spaced elements result in a more rapid decline in gain than for the more widely space elements. Indeed, the slope angles for the two outer-loop cases is dramatic. In passing, we may also note that the monoband and the two outer loop curves do not vary in gain by much at the design frequency. However, the inner-loop case shows a numerically noticeable higher gain value (more than 0.1 dB).



One reason for including graphs of the small 17- and 12-meter bands is that they show some fine detail better than graphs for the wider amateur bands. **Fig. 4** covers the gain situation on 15 meters, but some of the detail may be obscured by the wide range of values. When we pair 15 and 12 meters, the outer 15-meter loops show a very steep gain curve with a total gain decrease of nearly 2 dB across the band. When we pair 15 meters with 10 meters, the gain decrease range drops to just over 1 dB. The two cases where 15 meters forms the inner loop set (15-17 and 15-20) show gain decrease curves that are shallower than the monoband curve. With the scales used, it is difficult to see, but the 15-17 curve is slightly shallower than the 15-20 curve. Both inner loop curves show a slightly higher gain at the design frequency than the monoband quad. In short, the 15-meter gain curves reflect all of the trends shown for the other bands surveyed so far.



The 12-meter gain curves in **Fig. 5** provide us with only 1 case where the 12-meter loops serve as outer elements. The narrow spaced 12-10 combination produces a very steep gain decrease curve, even over the 100 kHz of the band. When the 12-meter elements are inner loops, they show slightly higher gain than the monoband quad. However, the curves for the 2 dual-band quads are too close together for any definitive conclusions regarding relative curve flatness.

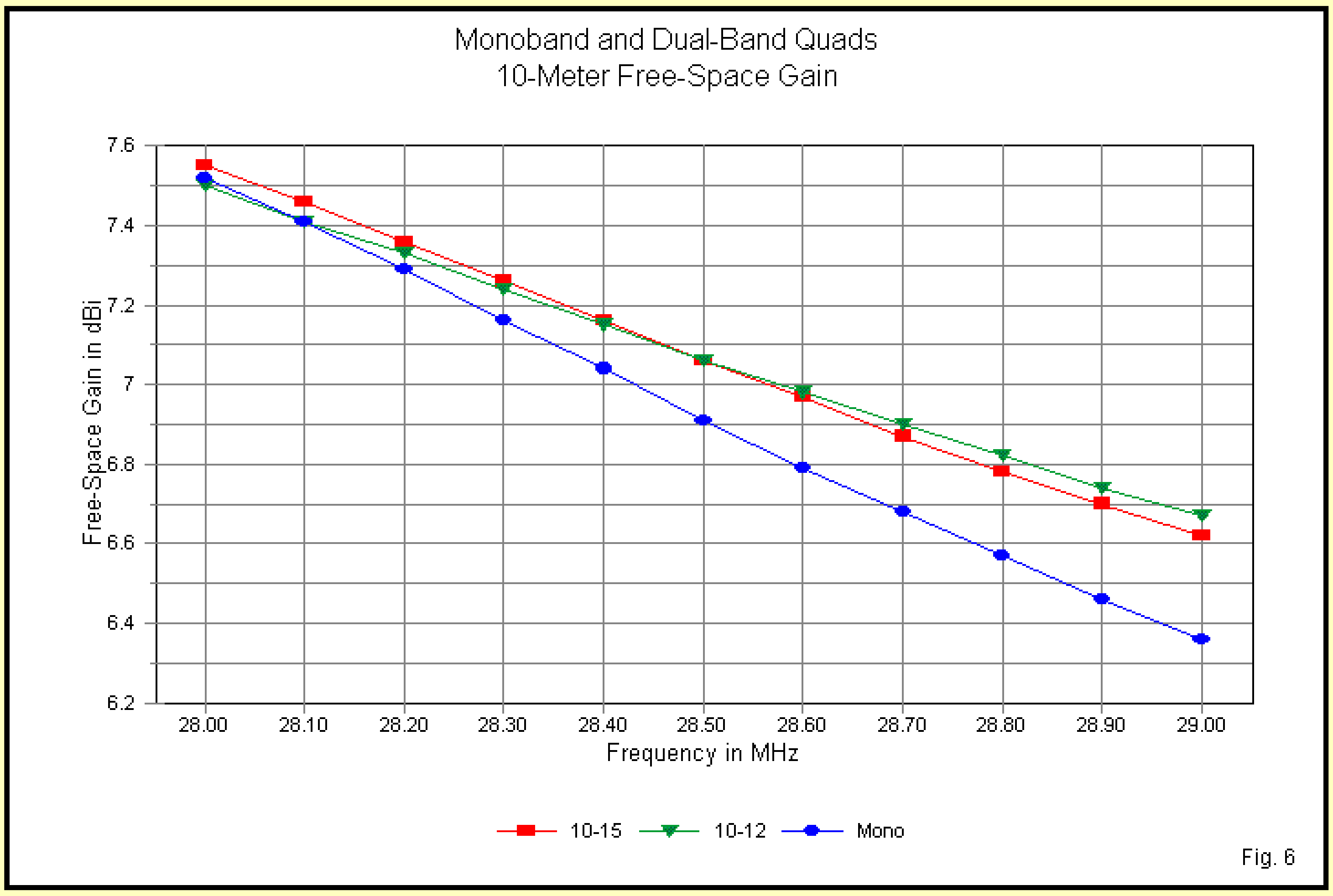


Fig. 6

Besides the monoband reference gain curve, the 10-meter dual-quad gain curves in **Fig. 6** are limited to cases where the 10-meter elements are inner loops. At 28.4 MHz, both dual-quad curves show a higher gain than the monoband quad. As well, the more widely space 10-15 combination shows a steeper curve than the narrow 10-12-meter pair.

In general, then, the gain of inner loops at the design frequency is higher than the monoband value, but the rate of decrease is greater. Using adjacent amateur bands in a dual-quad results in a high rate of inner-element gain decrease compared to using bands that more widely spaced. The situation for the outer loops in a dual quad is the reverse. Although the gain value at the design frequency does not vary significantly from the monoband value, the outer-loop gain curves are shallower. The closer the element spacing from one band to the other, the shallower the curve. However, outer-loop advantages over the monoband quad are generally too small to be operationally significant.

180-Degree Front-to-Back Ratio

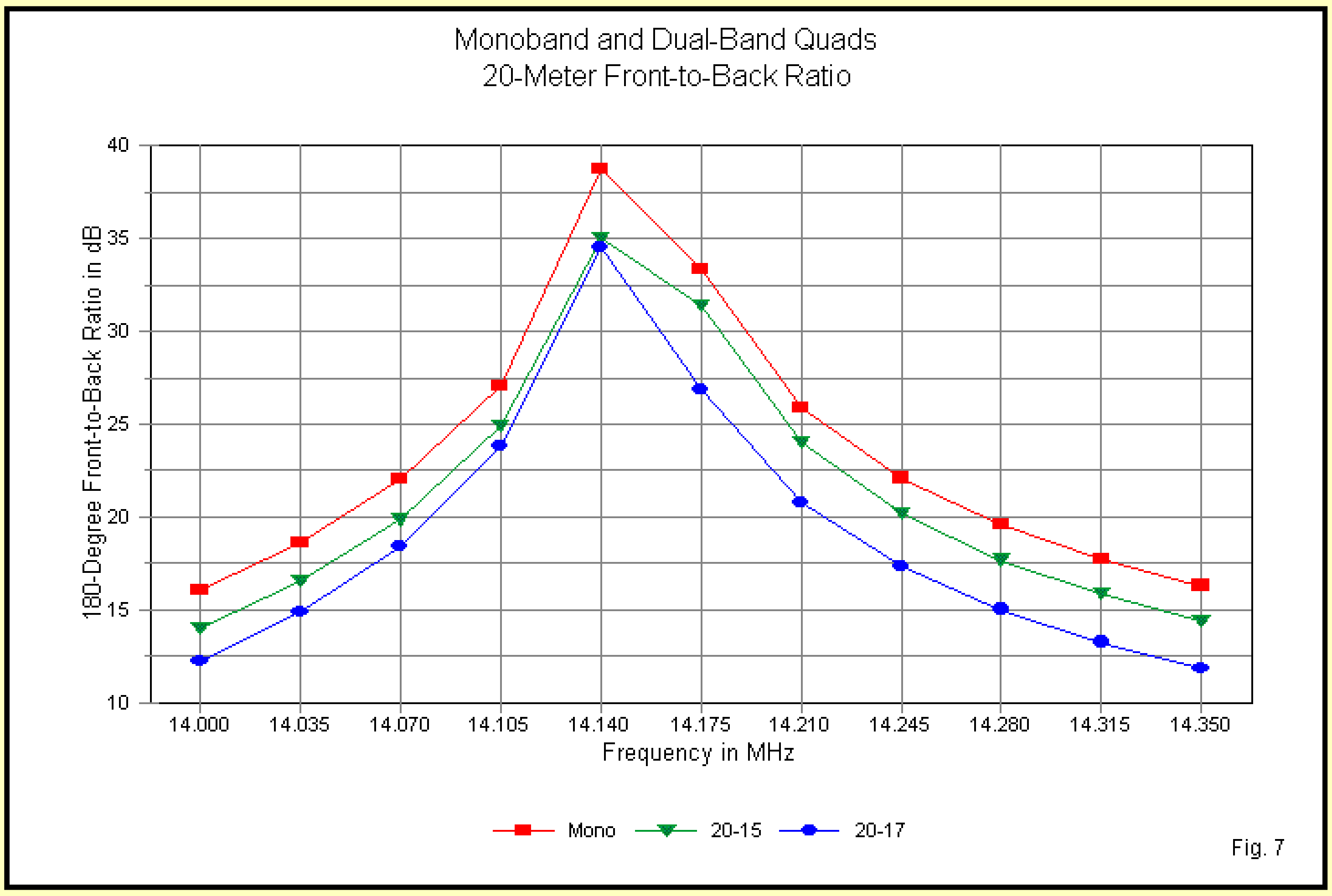


Fig. 7

Within the limits of modeling described earlier, the 20-meter front-to-back curves are nearly congruent. The monoband curve shows the highest peak value and the highest band-edge values. The dual-band quads show slightly lower peak values (although that appearance may be illusory, given the narrow-bandwidth of the actual peak). They also show very comparable band-edge value. However, as we decrease the frequency ratio of the 2 bands, the band-edge values decrease. Note that these remarks apply to the 20-meter loops as outer elements in the band pairings.

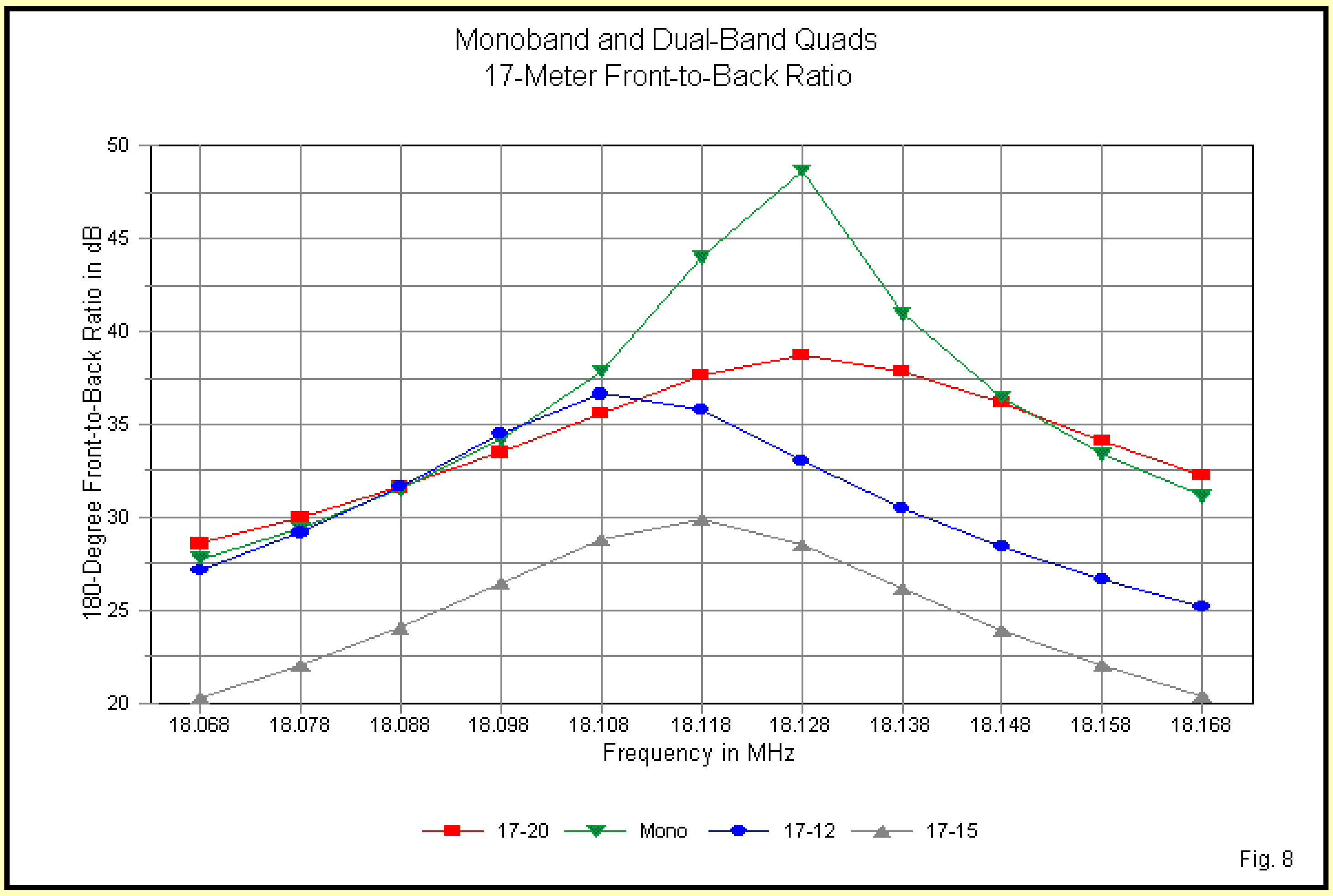


Fig. 8

The front-to-back curves for the very small 17-meter band show the limitations of the data generation technique in **Fig. 8**. The divisions are 0.01 MHz apart, that is, less than 1/3 the increments used on 20 meters. Hence, peak front-to-back ratio displacements that would be invisible on 20 meters show clearly on the expanded 17-meter scale. The one instance where the 17-meter loops are inner elements (17-20) shows a lower peak value but higher band-edge values than the monoband curve. In both cases where the 17-meter elements are outer loop sets, the band-edge values are lower than the monoband values. As well, as the frequency ratio decreases, the overall front-to-back performance suffers, as shown by the 17-15 curve.

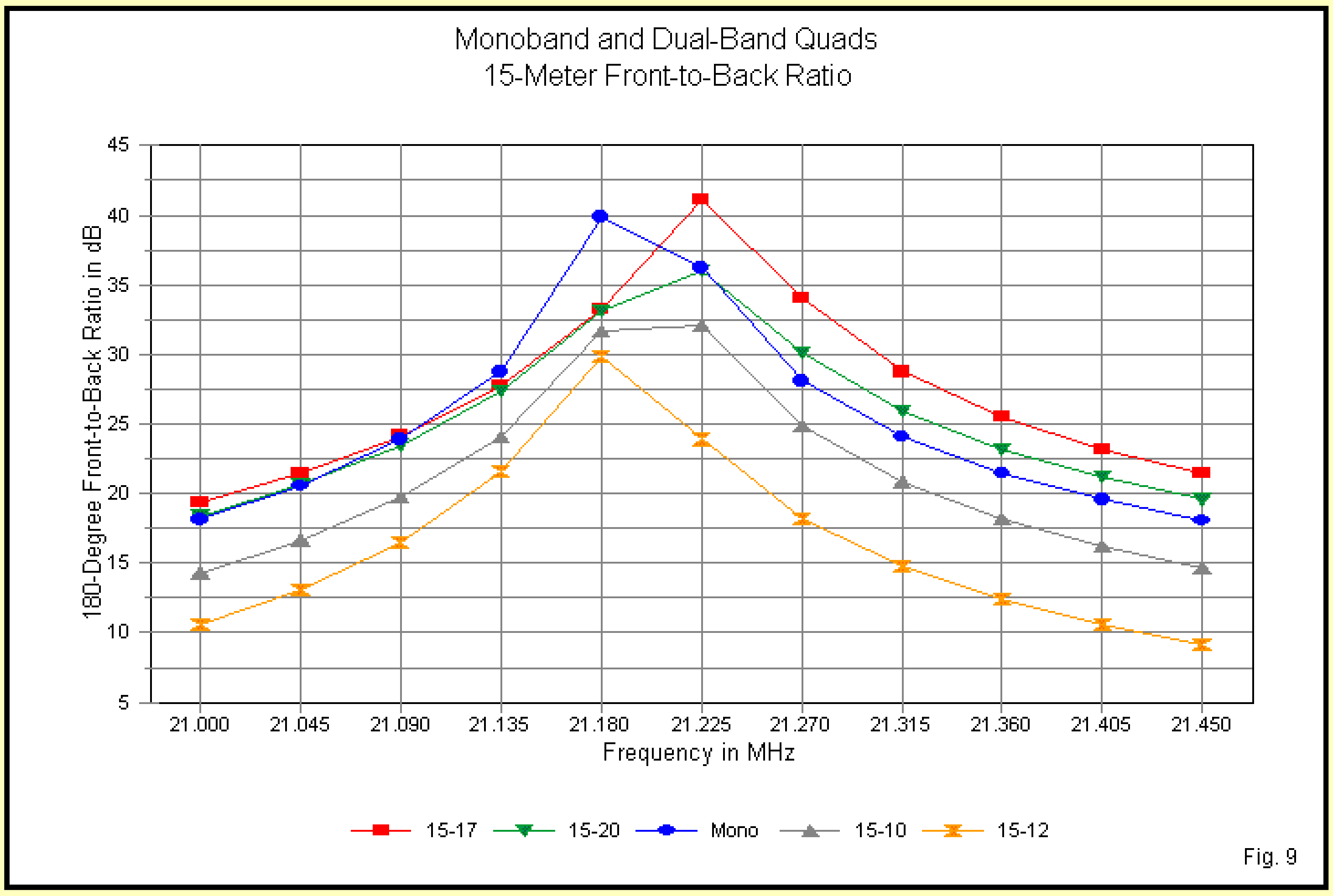


Fig. 9

As we increase the quad frequency, we also encounter limitations in placing front-to-back peaks within the minimum increment of element length change. Hence, not all peaks appear at the 21.19-MHz design frequency, as shown in **Fig. 9**. Nevertheless, the curves continue to confirm and expand the trends already noted. When 15-meter elements are the inner loops, they show slightly higher band-edge values than the monoband beam--although not by an operationally significant amount. As well, the lower the dual-quad frequency ratio, the higher the band-edge front-to-back ratio. On the other side of the monoband curve, when the 15-meter elements are outer loops, we find significantly lower band-edge front-to-back values. The lower the frequency ratio when 15-meter elements are outer loops, the worse the overall front-to-back curve.

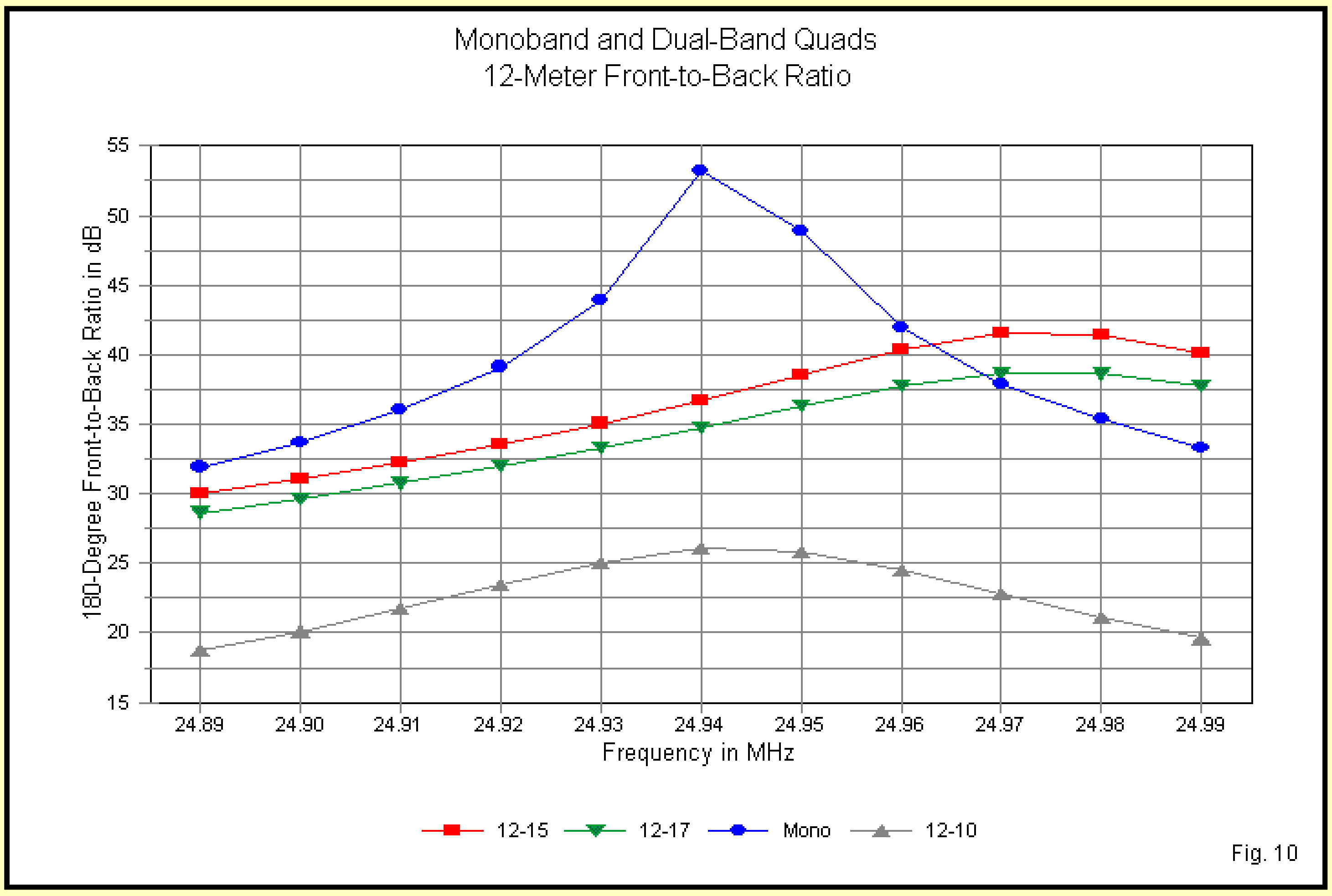


Fig. 10

Unfortunately, the 12-meter band is too small for the graph in **Fig. 10** to tell us much in light of the modeling limitations imposed. The monoband curve and the 12-10 curve are well aligned. The 12-10 curve places the 12-meter elements as outer loops and the frequency ratio is small. Hence, we see the typical degradation of the front-to-back curve. Both instances where the 12-meter elements serve as inner loops have displaced peaks, so we can only guess that the band-edge values would be higher than the monoband values if the curves aligned perfectly. However, it is clear that the 12-meter curve for the 12-15 pair is generally higher than the 12-17 curve with which it aligns. Of course, the frequency ratio of the 12-15 pair is lower than the ratio for the 12-17 pair.

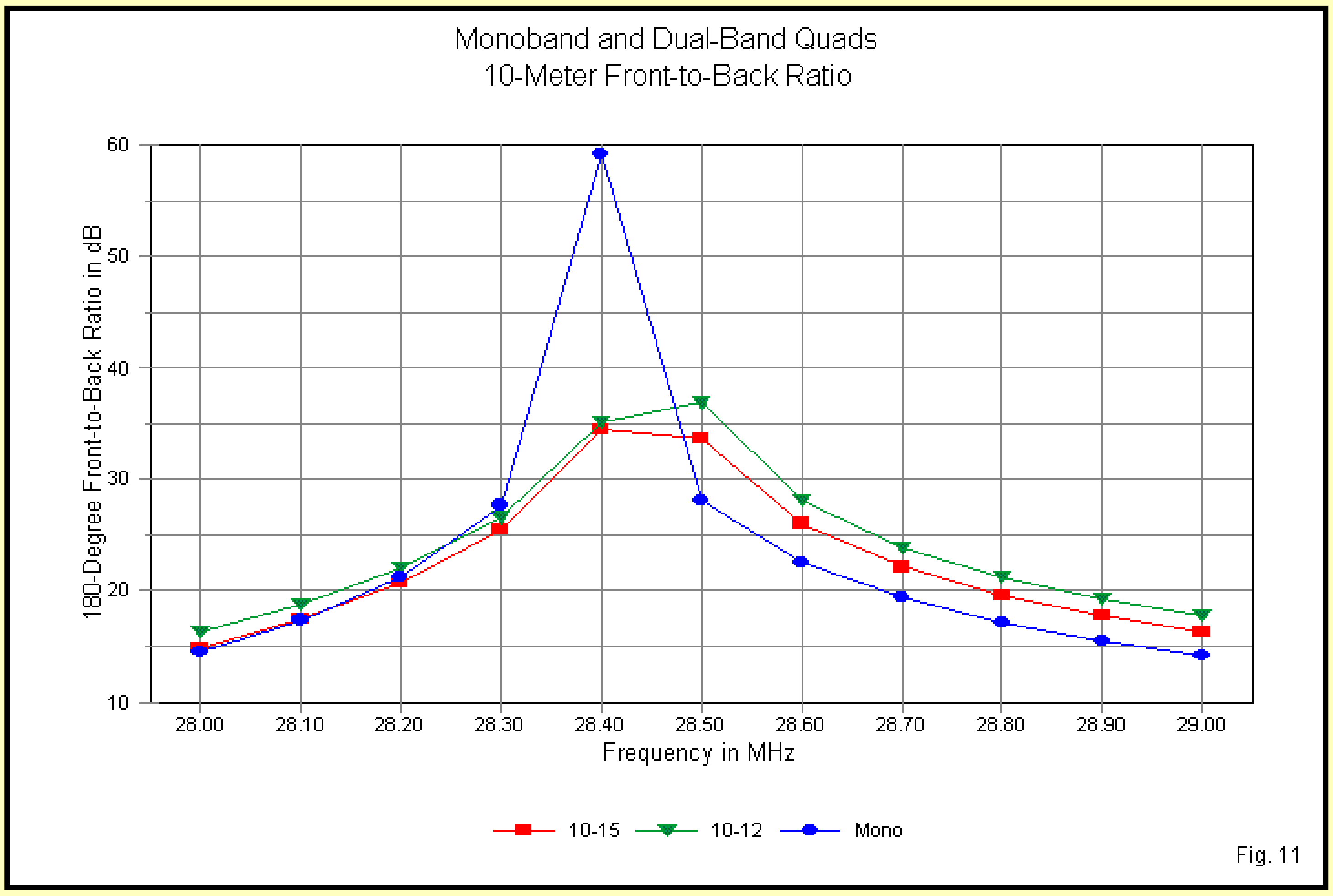


Fig. 11

The mis-alignment of the 12-meter monoband curve with the 2 inner-loop cases is not quite accidental. The 10-meter curves appear in **Fig. 11**. The monoband quad model achieves a very high and steep peak value at the 28.4-MHz design frequency. The 10-12 and 10-15 dual quad pairs have peaks of unknown value near 28.45 MHz. Drawing the peak frnt-to-back ratio downward to the design frequency is a tedious task requiring exceptionally small increments of reflector length change. I have allowed the peak displacement since such tiny changes would be beyond the limits of most home shop facilities. Nevertheless, both inner loop 10-meters element sets show higher band-edge front-to-back values than the monoband quad, if only by a little. As well, the pair with the lower frequency ratio show even more slightly higher band-edge values.

For all of the operating parameters, we have three interests in the curves that appear in the graphs. First, we are interested in whether or not the curves for one band confirm the trends shown by the curves for another band. Within the limits of the sets, we can generally respond affirmatively, with no exceptions so far.

Second, we are interested in the differences in the performance levels depending on whether the elements for a given band form the inner or the outer set of quad loops. Throughout the front-to-back sequence, we have seen the outer loop sets generally yield poorer band-edge front-to-back values than the monoband beam. Because a quad front-to-back peak is so high, but only for a very narrow bandwidth, the band-edge values form a better overall marker of performance in this dimension than the peak value. Remember that a typical short-boom 3-element Yagi may be able to provide a 20-dB front-to-back ratio across any of the wider amateur bands. We tend to obtain slightly better band-edge front-to-back performance when the loops for a band are inner elements for a dual-band quad.

Finally, we are interested in the differences created by the frequency ratio between the loop sets of a dual-band quad. For outer loop sets, decreasing the frequency ratio between bands covered by the beam can result a significant degradation of the front-to-back ratio across the band. Even the wider frequency ratios, such as between 10 and 15 meters, can yield noticeable decreases in the band-edge front-to-back performance. In contrast, when the loop set is an inner element set, the changes are operationally small, with numerically noticeable improvements in the band-edge front-to-back performance as we decrease the frequency ratio.

Feedpoint Resistance

The next set of graphs will reveal the trends that we can expect from the feedpoint resistance as we move the position of elements from outer to inner locations in a dual-band quad and as we alter the frequency ratio between the loop sets in a pair. However, a fuller understanding of the overall feedpoint impedance requires attention to this section and to the next section that covers feedpoint reactance.

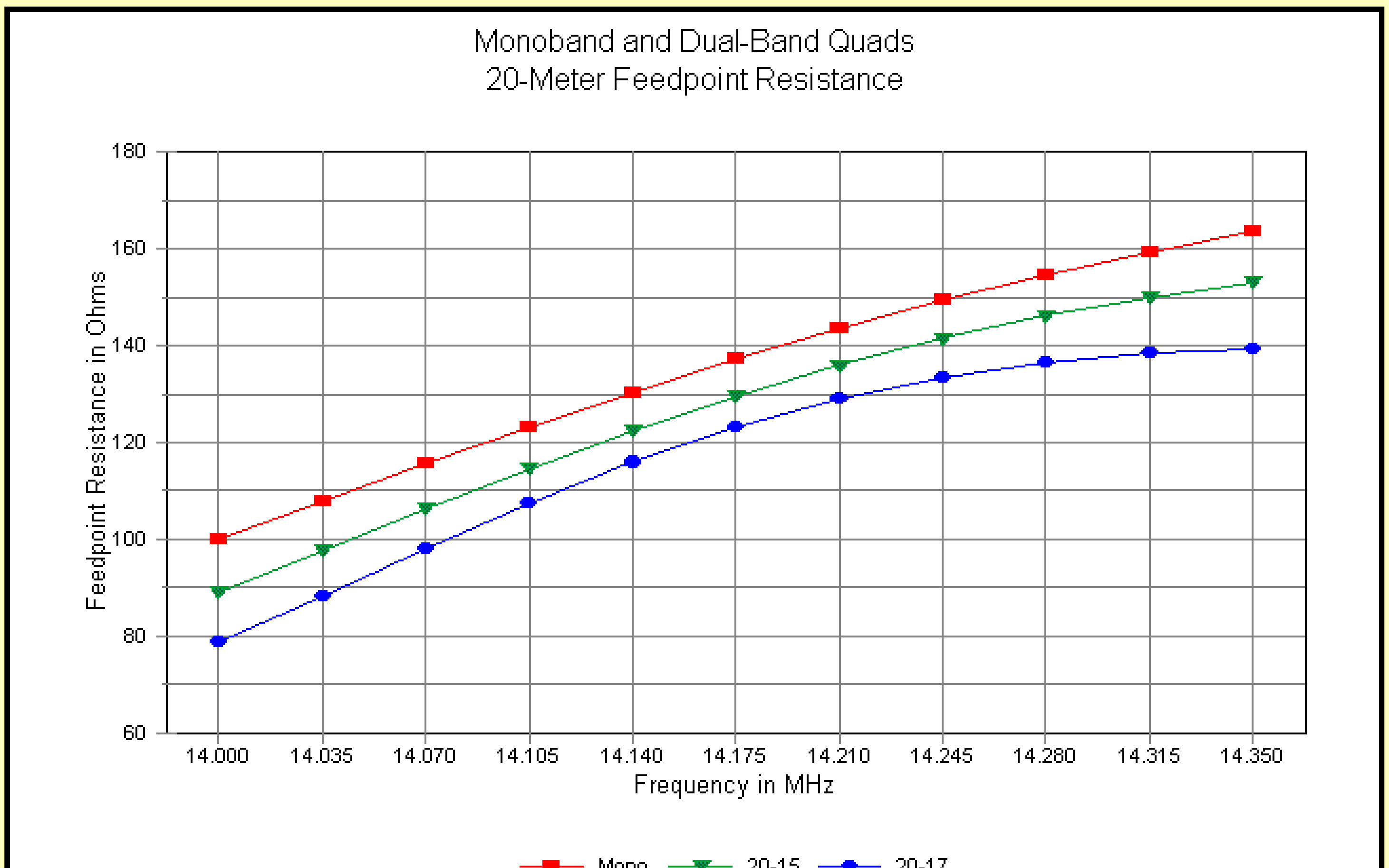


Fig. 12

Both dual-quad curves for 20 meters in **Fig. 12** represent outer locations relative to the other band involved. Both curves show a systematic decrease in the feedpoint resistance relative to the monoband value. The lower the frequency ratio between the bands, the greater the decrease in feedpoint resistance in the outer loop. As well, the lower frequency ratio produces a less linear curve.

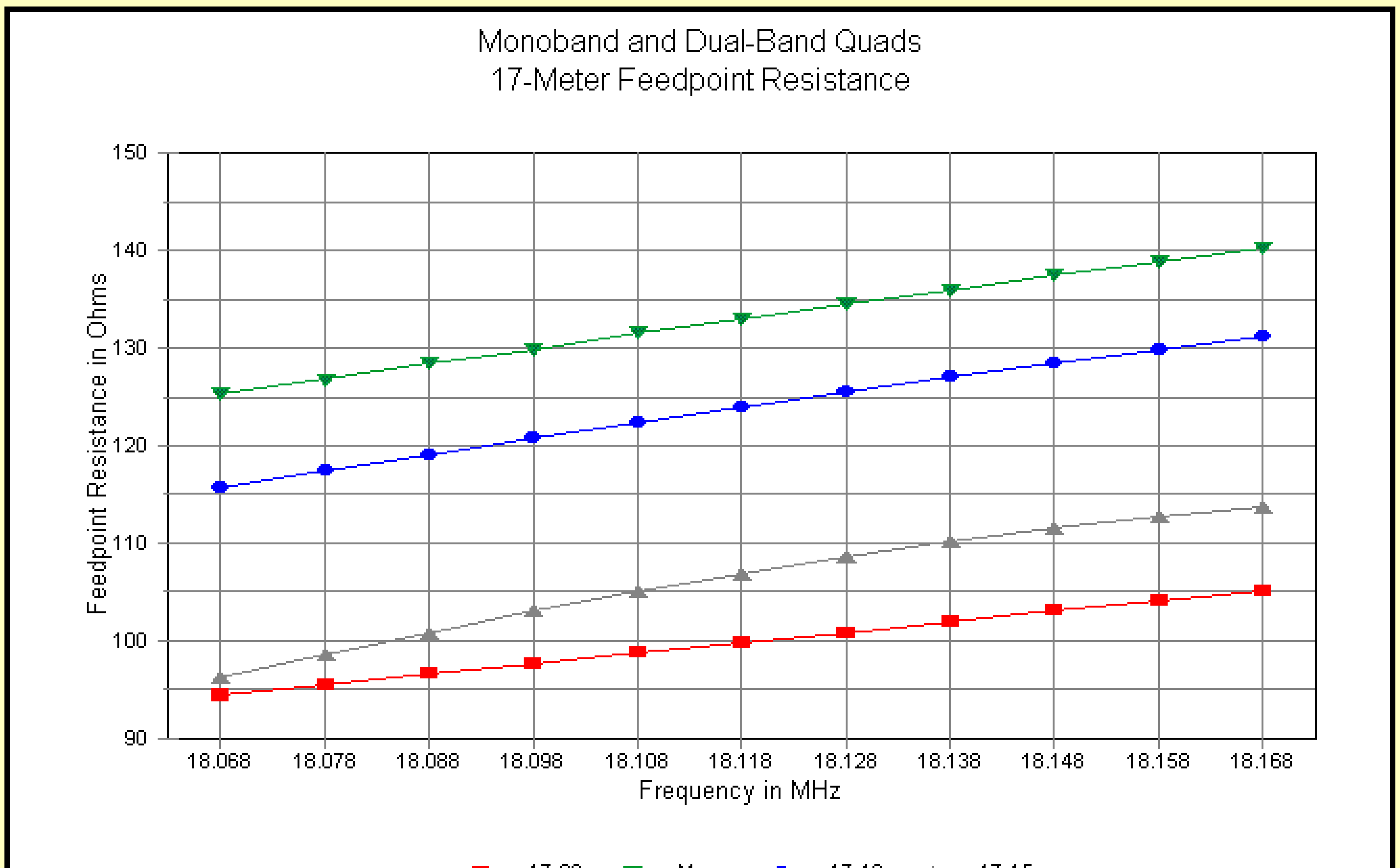


Fig. 13

The 17-meter resistance curves in **Fig. 13** tend to confirm the patterns that we noted for the 20-meter resistance curves, As well, the new graph introduces the first instance of a curve for the loop set using an inner position. The curve is for a low frequency ratio (17-20), and it shows a progression of resistance values that are also lower than those for the monoband quad. In fact, they are the lowest in the graph.

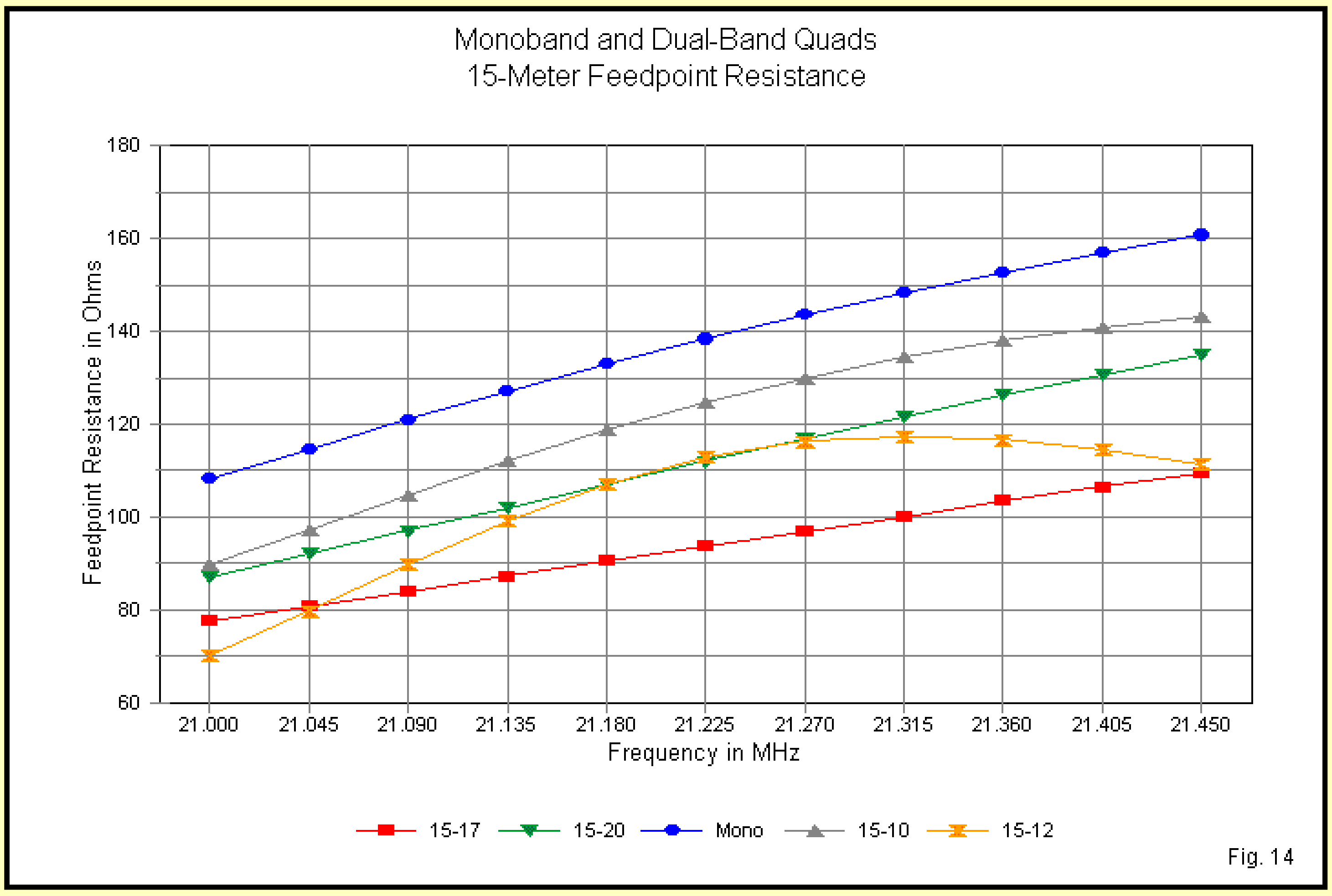


Fig. 14

Fig. 14 provides the resistance curves for 15 meters. All dual-band quad resistance values are well below the monoband values. When the 15-meter elements form outer loops, they show the same patterns that we saw on 20 and 17 meters. The curves show a growing non-linearity as we decrease the frequency ratio between the bands, and show in addition a greater reduction in value as we decrease the frequency ratio. When the 15-meter elements form inner loops, the curves are more linear, but decreasing the frequency ratio increases the reduction in the resistance values relative to the monoband quad.

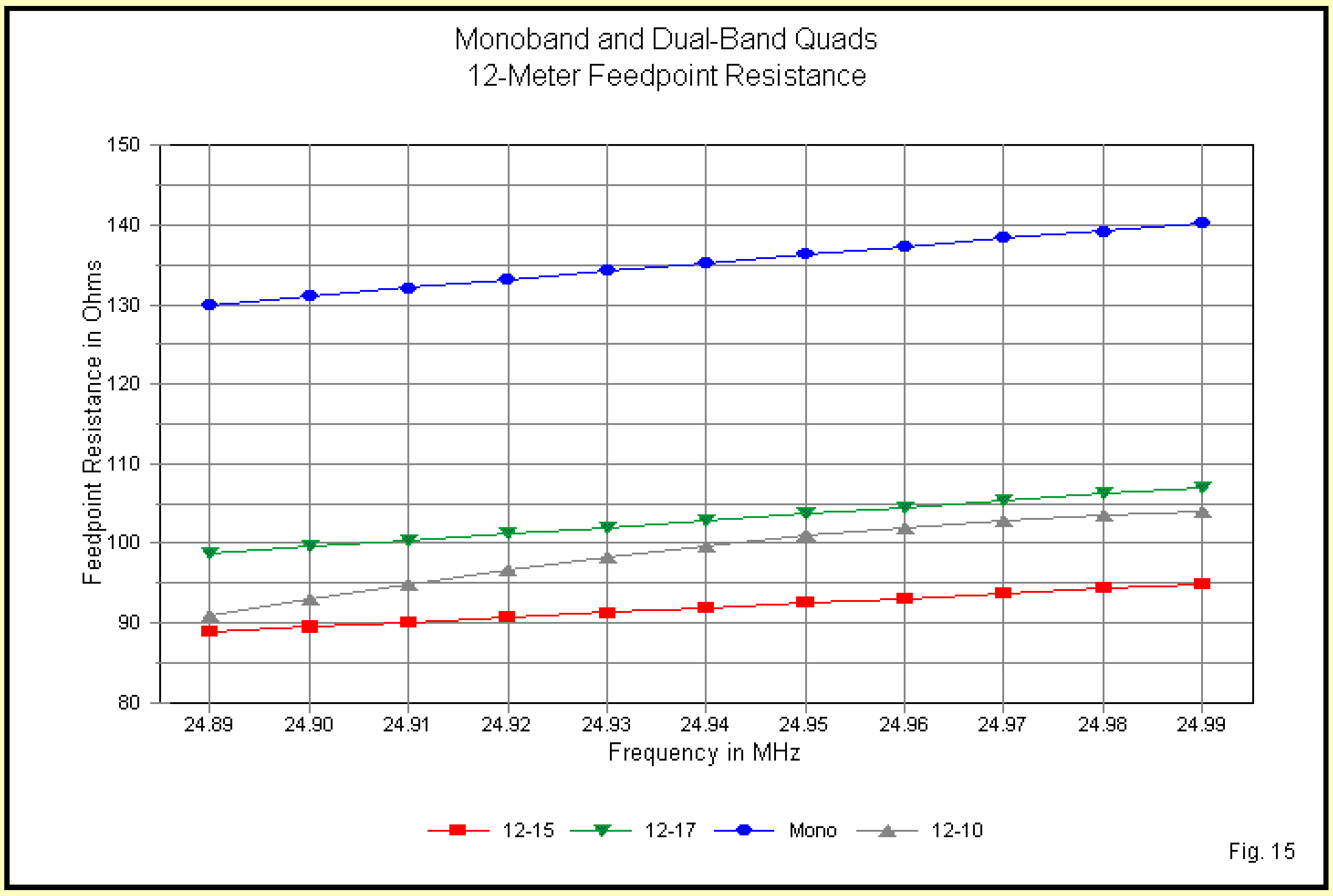


Fig. 15

The narrow 12-meter band, shown in **Fig. 15**, allows us to examine the region of feedpoint resistance near the design frequency. In all cases, the dual-quad resistance is at least 30 Ohms lower than the monoband value. As well, lower frequency ratios produce greater resistance reductions. Near the design frequency, the low-ratio inner loop curve has the lowest resistance. However, the low-ratio outer curves would show (as on 15 meters) a non-linear shape such that wider band edges would show values as low or lower than when the loops form a low-ratio inner element set.

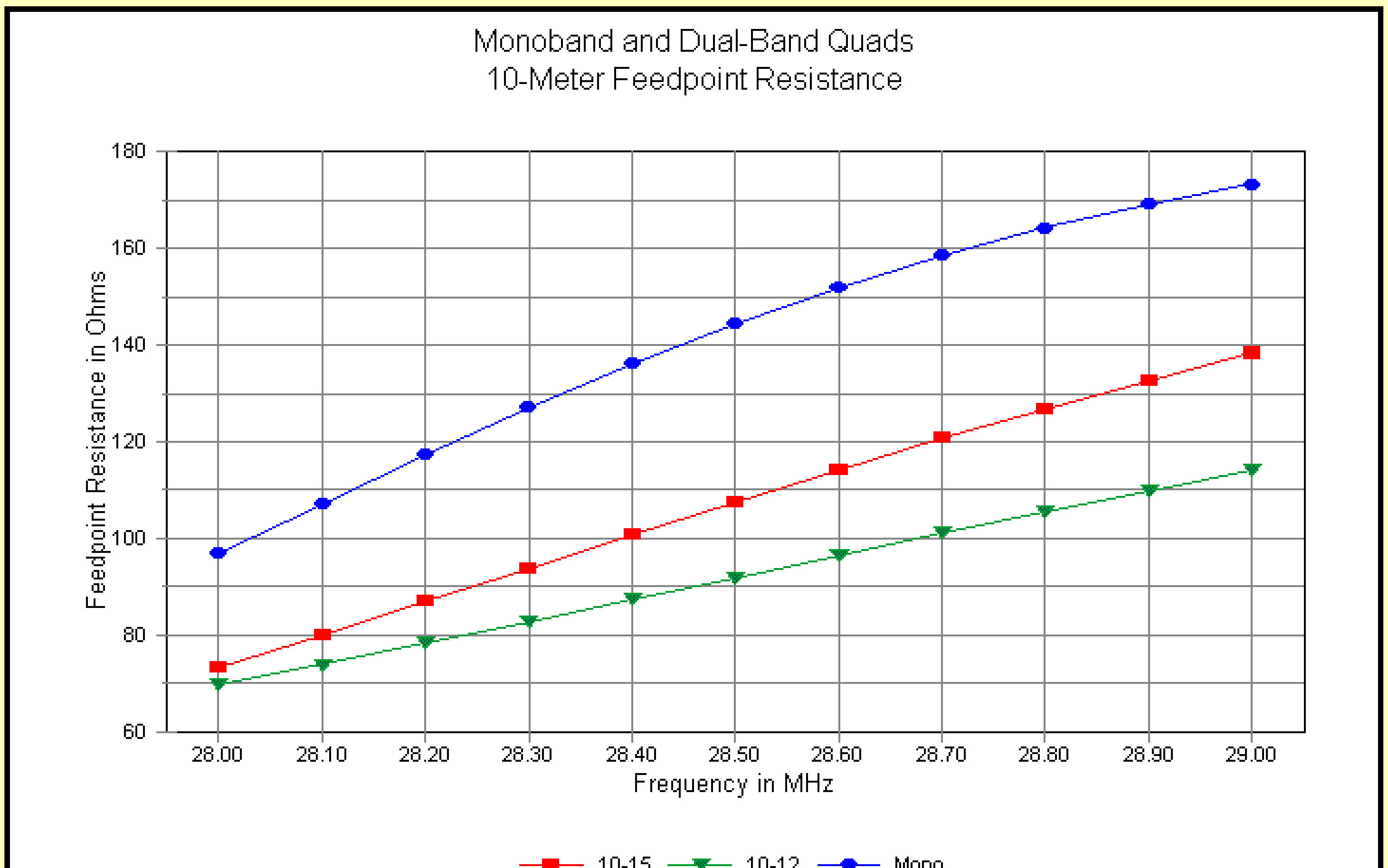


Fig. 16

The 10-meter graph in **Fig. 16** allows us only to examine dual-band quad feedpoint resistance when the loops are at inner positions. However, the band is wide enough at 3.5% bandwidth to reveal that even the monoband curve will show some non-linearity. In contrast, the inner-position dual band quads with 10-meter elements are more linear than the monoband curve with respect to feedpoint resistance. Once more, the lower the frequency ratio between the bands in the array, the greater the reduction in feedpoint resistance relative to the monoband values.

The reductions in feedpoint resistance accompany dual-band quad elements regardless of whether they occupy inner or outer positions. The lower the frequency ratio between loops, the greater the reduction in resistance. This condition leads to attempts to design multi-band quads for direct feeding with 75-Ohm feedline. Whether this tactic is completely feasible depends to a great degree on the reactance excursions across the bands.

Feedpoint Reactance

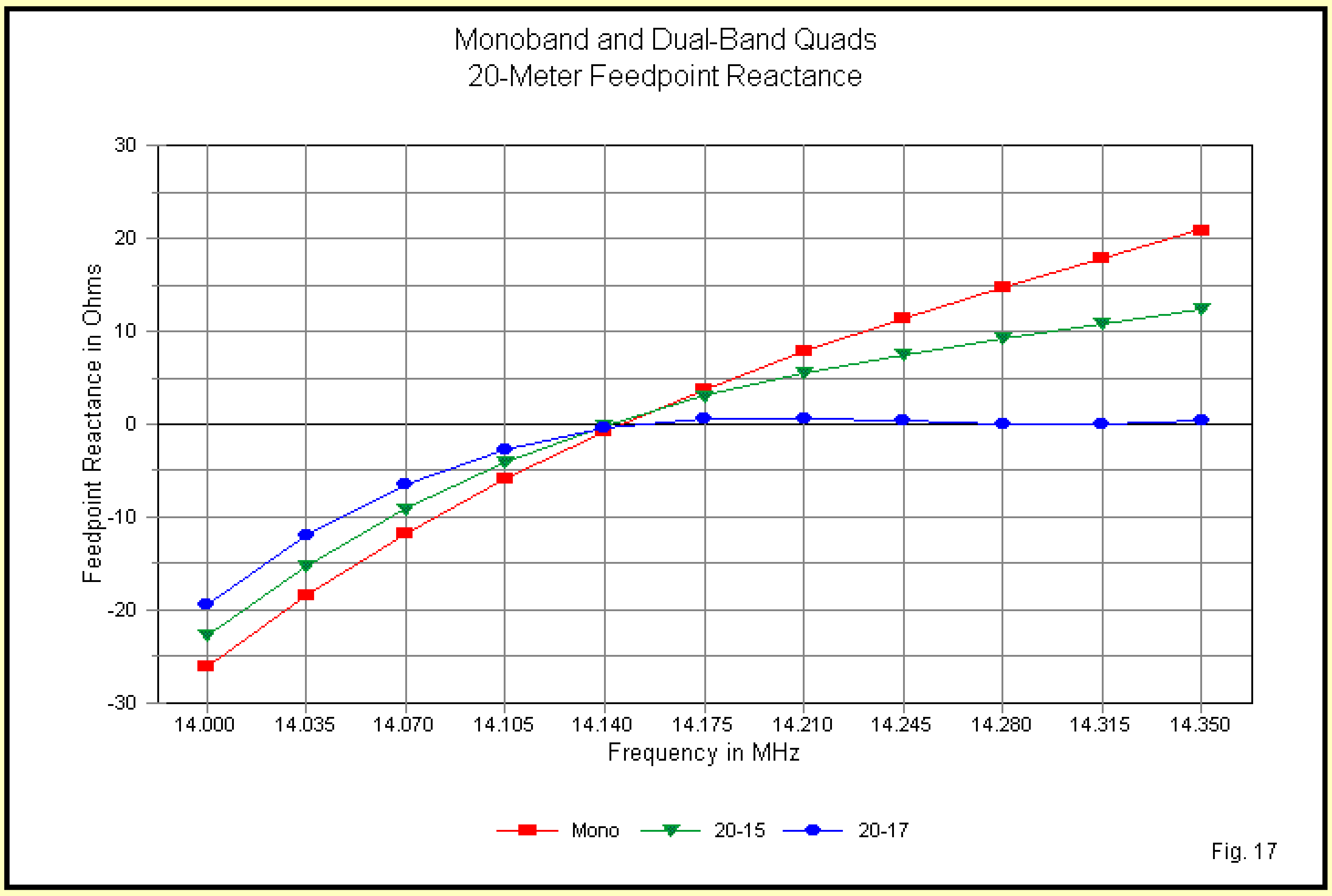
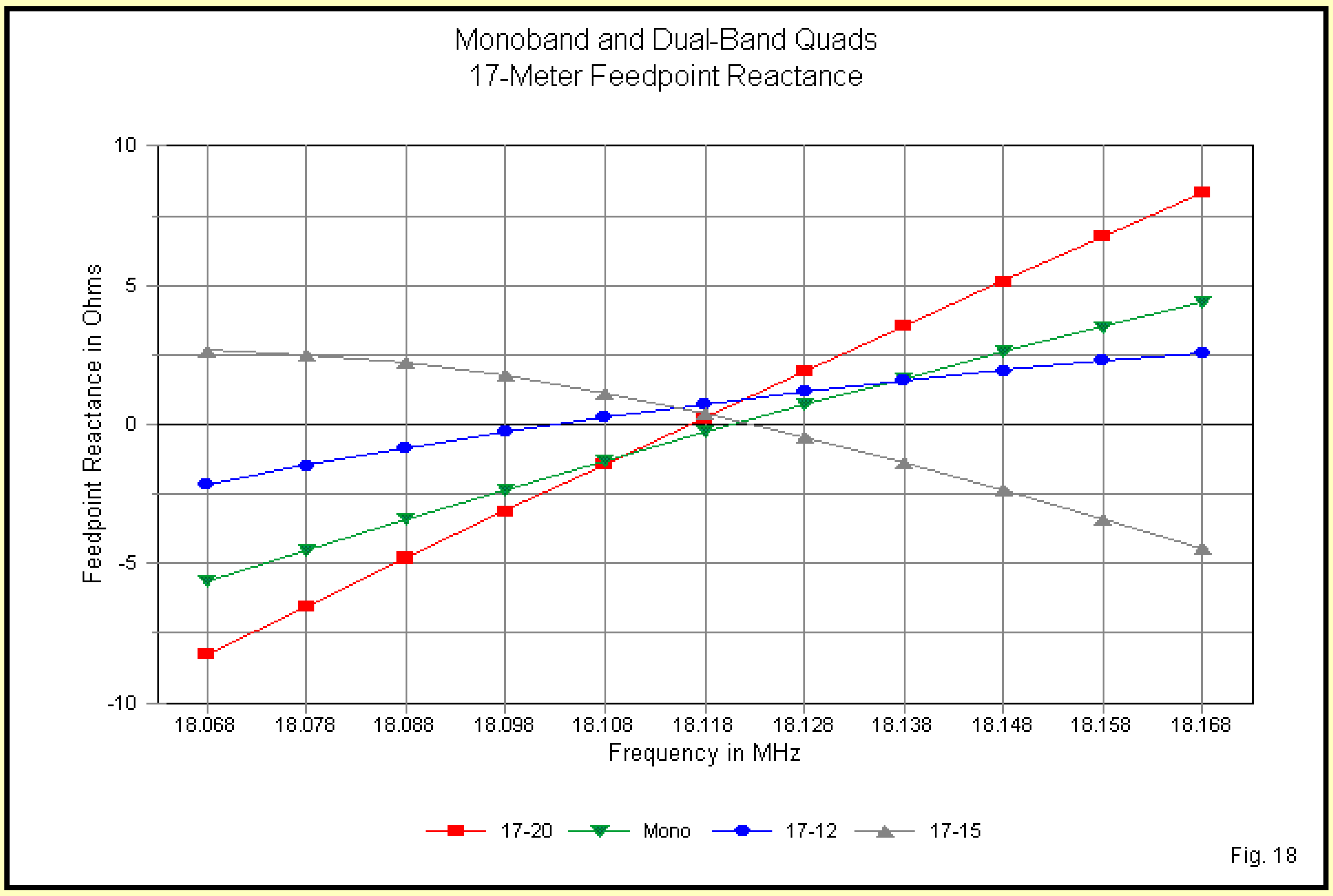
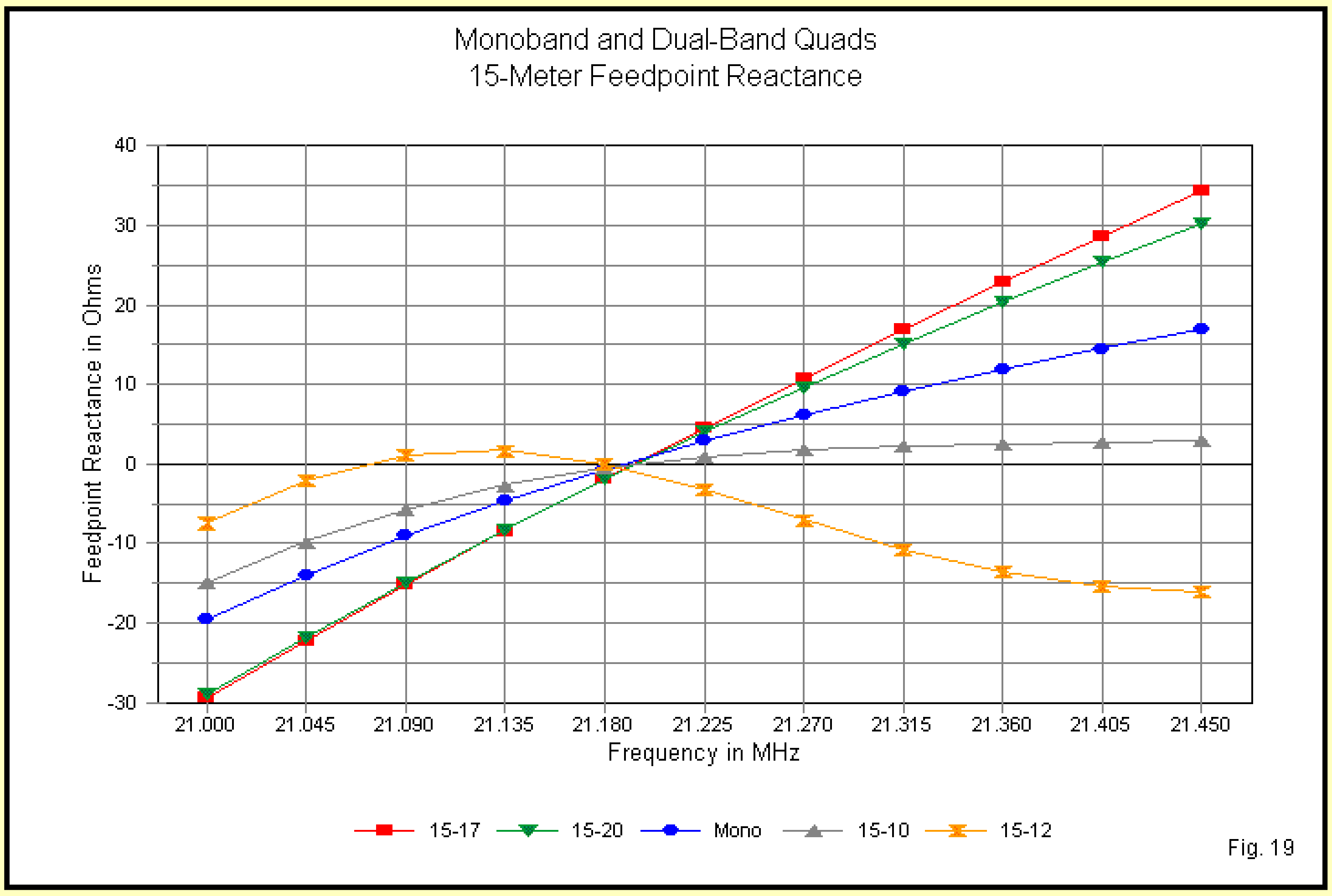


Fig. 17

On 20 meters, as shown in **Fig. 17**, the monoband quad shows the greatest range of reactance. The other curves represent dual-band quads where the 20-meter loops have outer positions. The high-ratio curve for 20-15 has a slightly smaller range of reactance than the monoband curve due to the small non-linear shape. If we decrease the frequency ratio, as in the case of 20-17, the reactance curve flattens, limiting the total range of reactance change across the band. Each of the dual-band reactance curves is accompanied by a reduction in feedpoint resistance. The SWR relative to the resonant source impedance is a complex function of the ratio of reactance to resistance. The reduced range of reactance change offsets the reduction in resistance on 20 meters. Hence, the SWR curves for 20 meters tend to be similar in all 3 cases.



17 meters is so narrow, as shown in **Fig. 18** that we may by-pass curve shape and focus on basic properties. When 17-meter elements are outer loops with a high frequency ratio (17-12), the curve shows the flattening that we saw in the 20-meter loops. Likewise, when the 17-meter elements are inner loops (17-20) we see a higher slope to the reactance curve. However, when the 17-meter elements have an outer position with a low frequency ratio to the other band (17-15), the curve has a reverse slope. This situation provides an expanded view of the reactance behavior in the corresponding 20-meter case in which we saw a major bend in and flattening of the reactance curve as it passed the design frequency.



The 15-meter reactance curves in **Fig. 19** confirm the reactance behavior and allow us to view them over a greater bandwidth. When the 15-meter elements are inner loops, we find a steeper rate of reactance change than we find in the monoband curve. The change in frequency ratio between the 15-17 and the 15-20 cases produces only a small difference, with the lower frequency ratio showing the slightly steeper curve. More interesting are the curves for the 15-meter elements when they take an outer position. The 15-10 curve shows a slightly steeper rate of change below the design frequency. (This region also yields lower values of feedpoint resistance.) For the best SWR curve relative to the resonant impedance, one might wish to purposely detune the 15-meter driver to maximize the flatter portion of the reactance curve across the SWR passband. However, when we reduce the frequency ratio by pairing the 15-meter elements with 12-meters elements, we obtain greater self-limiting of reactance on the low side of the design frequency. Above the design frequency, the reactance shows a fairly steep reverse curve, that is, a curve showing increasing capacitive reactance with increasing frequency.

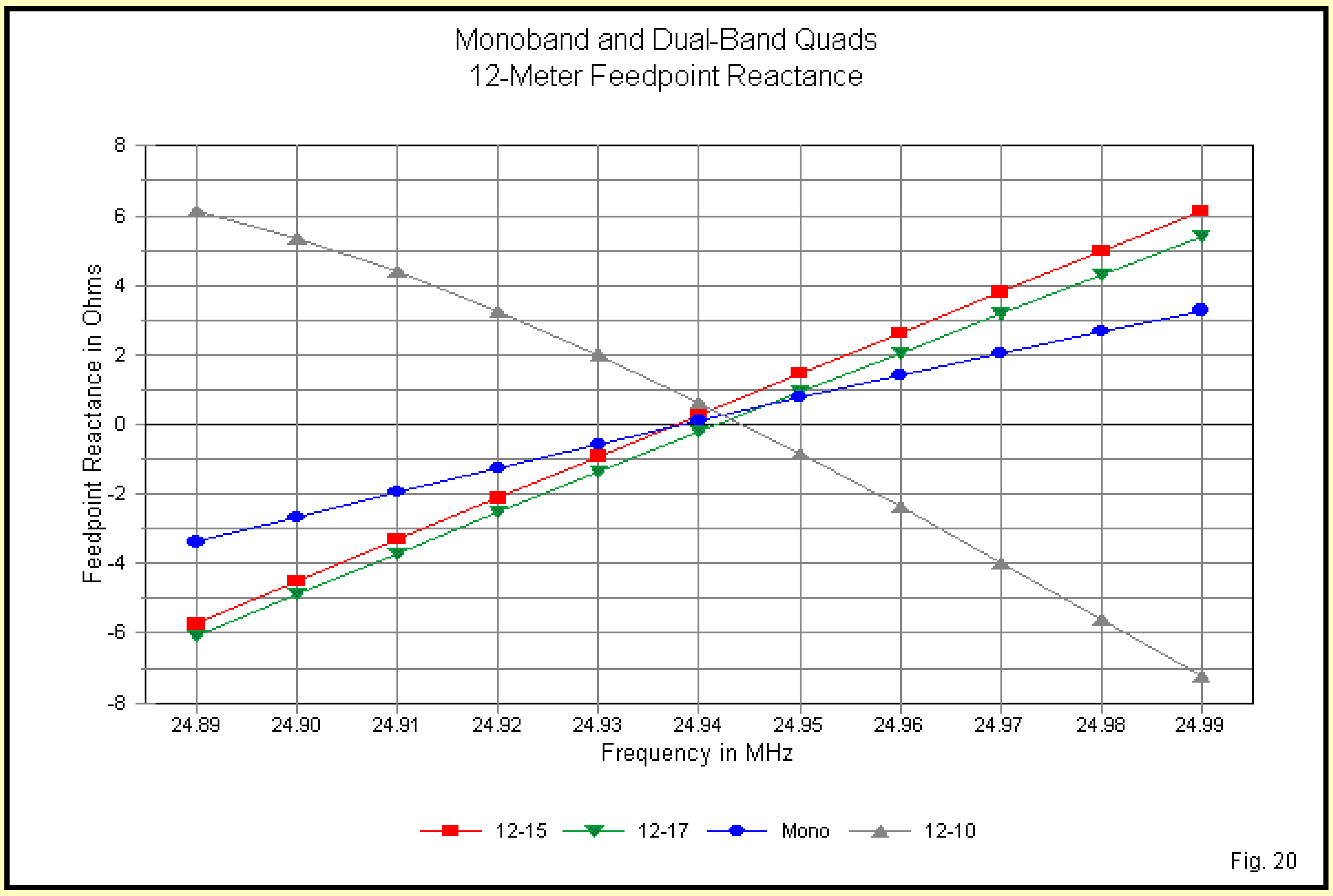


Fig. 20

On 12 meters, as shown in **Fig. 20**, we find the expected behavior of the 12-meter loops when they have inner positions. The reactance change across the band is higher than for the monoband quad. However, when the 12-meter loops have an outer position with a low frequency ratio (12-10), they show a dramatic reverse curve across the narrow confines of this band. Indeed, the total change is higher than for any other case, although we should note that the maximum reactance excursion is only about 13 Ohms for the 100 kHz passband.

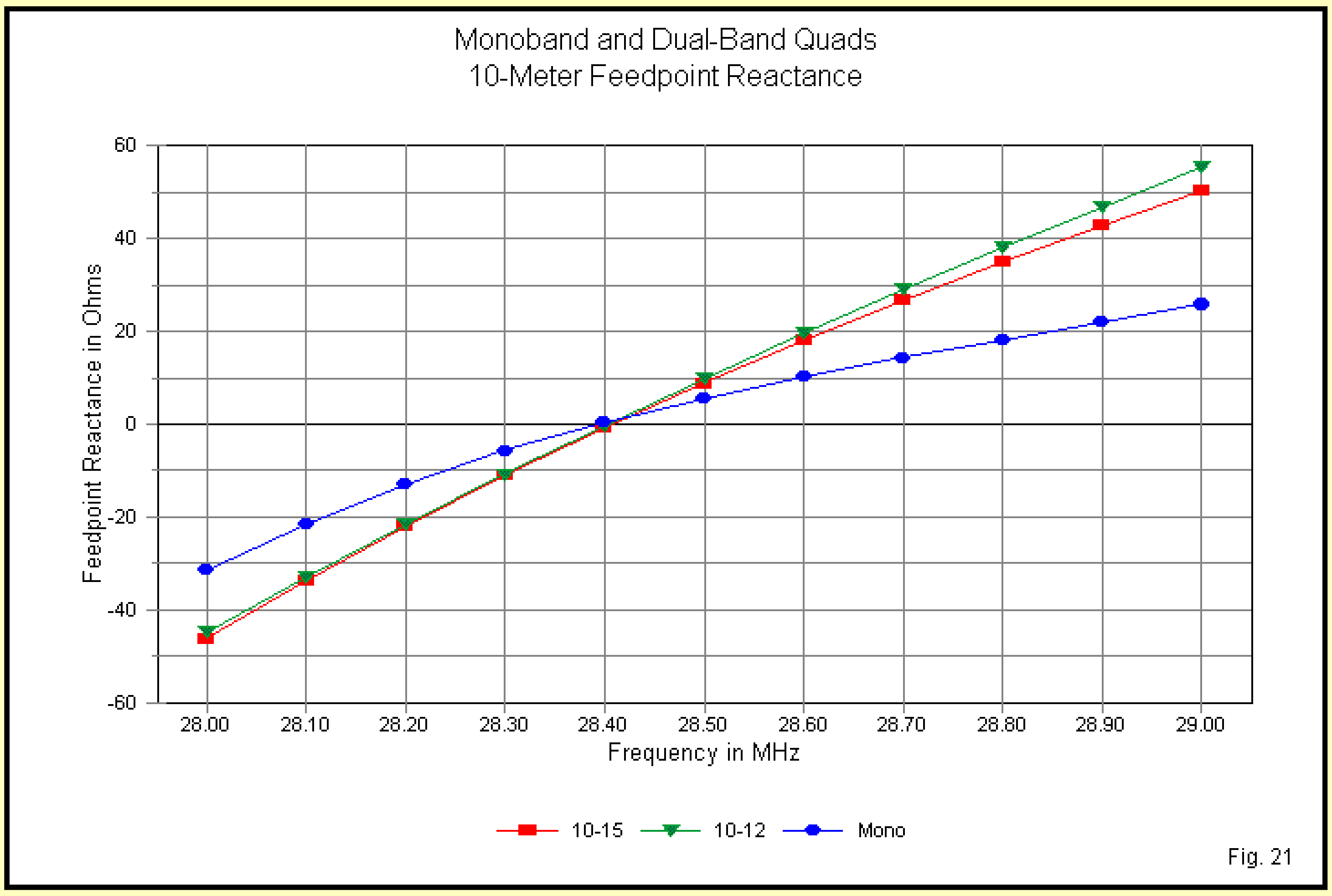


Fig. 21

The 10-meter curves in **Fig. 21** lose all drama because both dual-quads place the 10-meter elements in inner positions. Hence, the curves are nearly linear with a steeper slope than the monoband curve. The lower frequency ratio curve (10-12) shows a slight, nearly negligible, steeper slope than the higher frequency ratio curve (10-15). In both cases, the 1-MHz passband yields a total reactance change close to 100 Ohms.

The reactance curves for dual-band quads present patterns that are considerably more complex than the patterns for many of the other operating parameters. When we use higher frequency ratios between bands in a multi-band quad, the behaviors are more nearly regular, relative to a monoband quad. Outer-position loops show flatter reactance curves, while inner-position loops show steeper curves. Hence, we may expect to have more difficulty covering all of 10 meters with an acceptable SWR than we encounter on 20 meters. However, the outer position curves are less than linear, and that non-linearity increases as we decrease the frequency ratio between loops. The reverse curves with an increasing capacitive reactance as the frequency climbs offer considerable design challenges to the quad builder.

Conclusion

We have taken a long look at dual-band quads using both higher and lower frequency ratios between bands. Our goal has been to detect reliable trends in major performance categories and in loop dimensions. The individual sections provide the best summaries of those patterns. In many categories of performance, the inner and the outer positioning of quad loops tend to produce reverse tendencies. However, the tendencies do not usually fully counter-balance each other for similar frequency ratios. Moreover, as we saw in the case of reactance excursions, the inner and the outer position curves do not always form reverse versions of each other.

For the novice multi-band quad designer, there is a temptation to loosely believe that if we create a 3-band or a 5-band quad, the loops surrounded by other loops will simply neutralize the influences of the adjacent loops. However, the cautions that I just enumerated suggest that the surrounded loop may require more design effort, not less, in order to balance the unequal effects of the both inner and outer loops. The feedpoint resistance and reactance require special attention if we are to allow full coverage of all bands. The feedpoint resistance declines in the presence of any other loop (within the range of frequency ratios covered in these notes). If we cannot effect a suitable reduction of the total reactance change across the wider bands, the feedpoint SWR referenced to the resonant resistance will show a degraded curve.

Dual-band quad trends are instructive. However, they are not complete. For example, we have worked exclusively with spider-design quads that maintain a prescribed element spacing based upon calculations performed in wavelengths, not in feet or inches. Hence, these notes may or may not be applicable to planar quads that use a fixed physical distance between all drivers and reflectors. As well, these notes are only suggestive in terms of what actually accurs in 3-band and 5-band quads. As a data compendium, these notes represent only the barest beginning of systematic studies in the behavior of multi-band quad beams.

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