THE DUAL-BAND FOLDED DIPOLE

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A folded dipole is generally regarded as being a single-band antenna. However, a simple modification can both improve the bandwidth of the antenna on its design band as well as allow operation on a higher frequency band, also as a folded dipole antenna.

FOLDED dipole antennas are favored by many amateurs because their bandwidth characteristic is broader than a simple single-wire dipole and they can be constructed from commonly available materials. Such a dipole using 300 ohm twinlead for both the flat top portion and for the transmission line is a common example. The main drawback to such an antenna is that it is basically a single-band affair. The only exception is when the antenna is operated on odd harmonics of its fundamental, the same as a simple dipole. Thus, a 40 meter folded dipole can be effectively used on 15 meters since the center impedance on 15 meters is about the same as on 40 meters. The disadvantage of such operation is that the radiation pattern changes. On 40 meters, maximum radiation is broadside to the line of the antenna while on 15 meters a cloverleaf radiation pattern results. It is not possible to obtain maximum radiation in the same direction on both bands.

Folded Dipole Impedance

An interesting point to examine and fundamental to use of a dipole on two bands, other than the 40 and 15 meter exception mentioned, is what determines the impedance of a folded dipole. The antenna consists simply of two dipole elements connected in parallel, only one of which is directly connected to the transmission line. If the same amount of power is delivered to the folded dipole as to a simple dipole, half of the current which flowed in the single wire of the simple dipole must flow in each wire of the folded dipole. For this to occur, the impedance of the folded dipole must be four times that of a simple dipole. This assumes that both wires of the folded dipole are the same conductor size so that equal currents flow in each. If the conductors are not equal in size, the total current is not split equally between the conductors and the impedance is no longer simply four times that of a simple dipole.

This situation is illustrated by the graph of fig. 1. As the size of one conductor becomes larger or smaller than the other and depending on the spacing between conductors, the impedance stepup either becomes more or less than four to one. The most pertinent situation is when the impedance stepup is exactly four to one, by virtue of the conductor diameters being the same. Notice that this situation occurs for any value of conductor spacing to conductor diameter ratio or, in other terms, for any value of impedance of a transmission line which may constitute the flat-top portion of a folded dipole antenna. It is not necessary to use 300 ohm twinlead for the flat-top portion of a folded dipole to produce a match to a 300 ohm transmission line. In fact, almost any twinlead of any impedance but with equal diameter conductors will serve as the flat-top section. Of course, in the usual folded dipole it is convenient to use

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the same line for both the flat-top section and transmission line but it should be noted that the terminal impedance of the flat-top section is not a function of the impedance of the line used for its construction.

Improving Folded Dipole Bandwidth

Various methods have been used to improve the bandwidth characteristics of folded dipoles on their fundamental frequency. Instead of directly connecting the dipole element ends together, capacitors having a value related to the capacitance per foot rating of the transmission line used for the flat-top can be used. Stubs can also be placed at the ends of the dipole elements. The theoretical basis for the bandwidth improvement produced by these means seems to be a bit obscure but, nonetheless, numerous amateurs have found them to be effective.

One interesting method of bandwidth improvement involves the placing of direct jumpers across the conductors of the flat-top portion as illustrated in fig. 2. The jumpers are placed a quarter-wave from the center of the antenna with allowance made for the velocity factor of the line used for construction of the flat-top. Thus, when the flat-top is considered as a transmission line, the closed-end quarter wave stub (which part of the flat-top forms) reffects an open circuit to the center of the antenna and no effect is noted at the antenna terminals. However, when the antenna is operated off of the frequency at which the entire flat-top resonates as a ½λ element, the stub produces a reactance opposite to that of the entire flat-top section alone and the antenna bandwidth is improved. In a sense, the flat-top portion of the antenna serves both as a radiating element and partly as a frequency corrective stub.

Dual-Band Operation

If a folded dipole with flat-top shorting connections is operated at a frequency such that the portion of the flat-top between shorting connections forms a ½λ dipole, the configuration shown in fig. 3 results. The inner portion of the antenna forms a conventional ½λ folded dipole. The sections of the flat-top portion beyond the shorting connections form a closed-end stub. However, since whatever reactance they present at the shorting connections is ineffective due to the direct short they have no more effect than if a capacitor were placed across a short circuit. The flat-top portion of the antenna is capable of a dual resonance—once at a frequency

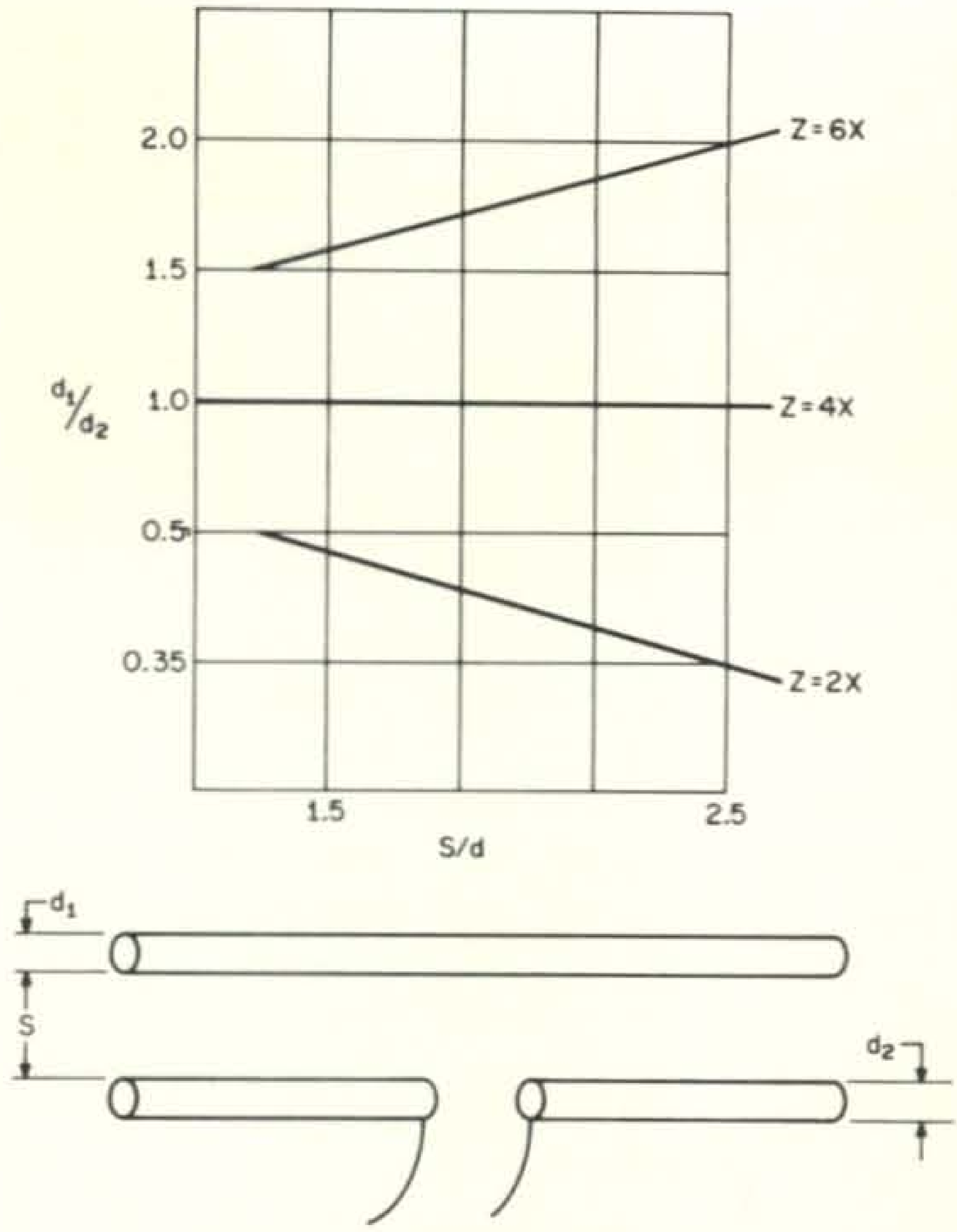

Fig. 1—Variation of the terminal impedance of a folded dipole antenna as a function of conductor diameter and the spacing between conductors.

where the physical length of the entire flat-top portion constitutes a ½λ length and once where the physical length of the flat-top portion between shorting connections constitutes ½λ length.

The practical usage of the advantage of dual resonance of the flat-top depends on the velocity factor of the line used to construct the flat-top. For instance, if standard 300 ohm twinlead would be used to construct the flat-top, its velocity factor would be about 0.82. If the antenna for 20 meters were made 33 feet long and shorting stubs placed 13.5 feet from each side of the center of the antenna, a second resonance of the flat-top would occur at a frequency where 26 feet constituted ½λ or 18 mc. Obviously, such a resonance is not useful for amateur oper-

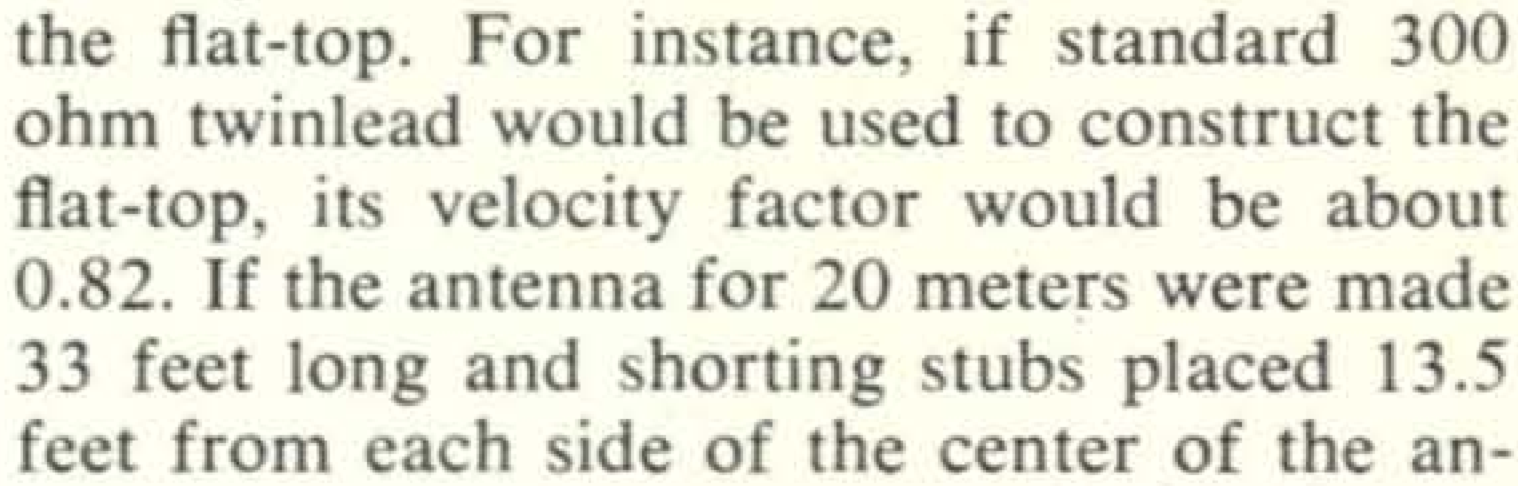

Fig. 2—Placement of shorting connectors not only improves bandwidth of folded dipole on fundamental frequency, but forms basis for use of antenna on a secondary frequency.

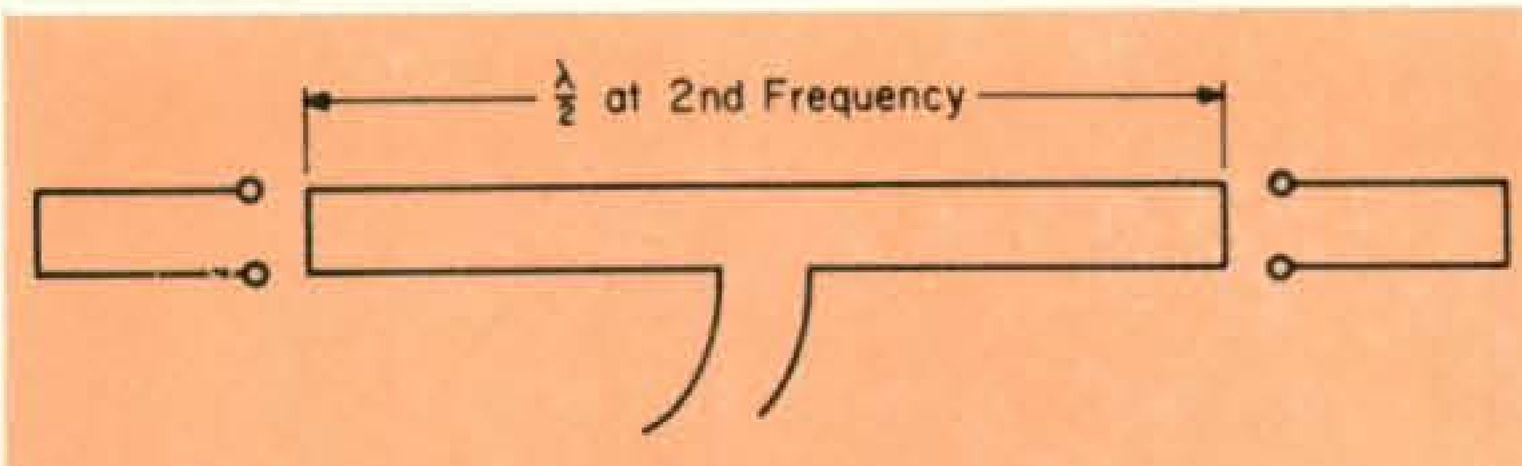

Fig. 3—Operated on frequency which corresponds to center portion of antenna shown in fig. 2 becoming ½λ long, another folded dipole is formed where end portions are ineffective in determining resonant frequency because of shorting connections.

ation. However, if the flat-top of the same antenna were constructed of 75 ohm twinlead, the velocity factor would be about 0.67. The shorting connections would be placed 11 feet from either side of the antenna center. The center 22′ portion of the antenna would then resonate nicely in about the middle of the 15 meter band. Thus, both 20 and 15 meter coverage would be achieved without compromise performance on either band and with completely automatic bandswitching. Although the flat-top portion is constructed of 75 ohm twinlead, it still presents an exact match to a 300 ohm transmission line on both bands as explained previously.

Thus, by choosing a twinlead with the proper velocity factor, and disregarding its impedance as a transmission line, a folded dipole antenna can be produced that will operate on two distinct frequency bands. Figure 4 shows the attenuation and velocity factor figures for some common types of twinlead. It should be noted that velocity factor is a function of the materials used in construction of the twinlead and an exact value should be obtained from the manufacturer of the twinlead used. The major manufacturers of twinlead, such as Amphenol and Belden, can supply exact data on each of their twinlead transmission lines.

The typical velocity factor figures shown in fig. 4 will allow the construction of a variety of antennas such as a 20 meter dipole operative on 15 meters, a 15 meter dipole operative on 10 meters, an amateur band antenna also resonant on one of the international broadcast bands or WWV frequency, *etc.*

One major advantage of this form of dual-band antenna is that the radiation pattern remains the same on both frequencies at which the antenna resonates, that is, broadside to the line of direction of the antenna. If the antenna is constructed to resonate both in an amateur band and a nearby international broadcasting band, which is used for DX spotting, there will be no confusion as to in which direction a band opening is at its best.

Although theoretically possible, the velocity factor of the commonly available twinlead transmission lines do not allow the construction of an antenna which will resonate on bands with a 1 to 2 frequency ratio such as 80 and 40, 40 and 20 and 20 and 10 meters. This would require the use of a transmission line for the flat-top portion of the antenna with a velocity factor of about 0.5. Many transmission lines approach this figure, but the author has been unable to find any commonly available commercial transmission line which would be suitable.

Summary

Taking advantage of the shorting connection feature made possible by the velocity factor of a dipole constructed from twinlead transmission line, offers an unique method of dual-band antenna operation. The idea might be expandable to a tri-band antenna if the basic dipole is operated on an odd multiple of its fundamental frequency. No experiments or theoretical analysis of such operation has been tried and the idea can only be offered as a basis for experimentation. The basic principle should also be applicable to the driven element of a beam antenna and thus allow dual-band beam operation without any loading reactances being necessary in the driven element. ■

Transmission Line	DB/Attenuation/30 Mc	Velocity Factor (Approx.)
300 ohm TV Twinlead	0.86	.82
150 ohm TV Twinlead	1.1	.77
75 ohm TV Twinlead	2.0	.68
75 ohm Transmitting Twinlead	1.5	.71

Fig. 4—Typical characteristics of various types of twinlead. Exact characteristics vary with manufacturer.

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