Broadband Antenna For Forty Meters

BY HOWARD PHILLIPS,* WB5ACP

This capacity-loaded antenna is resonant across the entire 40 meter band with an s.w.r. of 1.3:1 or less. Its longest element is less than 3/4 the length required for a standard single wire doublet.

THE antenna described here is designed for operation on 40 meters. However, the principles can be used to design a short, broadband antenna for any desired frequency. The operating principle of this single-band broadband antenna is similar to the operation of a multiband multiple doublet. The reason for the "shortness" of this broadband antenna lies in the "capacity hat" effect of the fanned-out ends.

The need for broadbanded radiating systems has increased with the sub-band reapportionment which accompanied incentive licensing. Without a broadband antenna, efficiency is sacrificed on some mode if a combination of phone/c.w./RTTY operation is attempted.

Design

The design of this antenna is based upon the design of a single-wire doublet. For a half-wavelength single wire doublet, the length of a single leg is given as:

$$L\text{ (feet)} = \frac{234{,}000}{f\text{ (kc)}}$$

where L is the leg length in feet and f is the operating frequency in kc. The change in length required to change the resonant frequency by a given amount is calculated by taking the derivative of the above equation:

$$\frac{dL}{df} = \frac{-234{,}000}{f^2}\text{ (for any frequency)}$$

If this equation is evaluated at $f = 7200$ kc, we have:

$$\frac{dl}{df} = -.0045\text{ feet per kc } (-.06\text{ inches per kc})$$

or

$$-.45\text{ feet per 100 kc } (-6\text{ inches per 100 kc})$$

where the minus sign indicates that an *increase* in antenna leg length decreases the resonant frequency. All the above hanky-panky can be summarized by saying that on 40 meters, if the antenna leg length is changed by 6 inches, the resonant frequency is changed by approximately 100 kc.

The dimensions of the broadband antenna in fig. 1 are chosen so that a pair of legs is resonant every 100 kc from 7.0 mc to 7.3 mc. This requires four pairs of legs. The longest pair is resonant at 7.0 mc and the shortest pair is resonant at 7.3 mc. The operating principle of this single-band broadband antenna is seen to be quite similar to that of a multiple doublet antenna designed to resonate on two or more ham bands. This explains the broadbanded nature of the antenna, but why is this antenna so much shorter than a single-wire doublet?

The fanned-out ends of the antenna enhance two related phenomena: end effect and capacitance loading effect. The two phenomena are present to some extent in all types

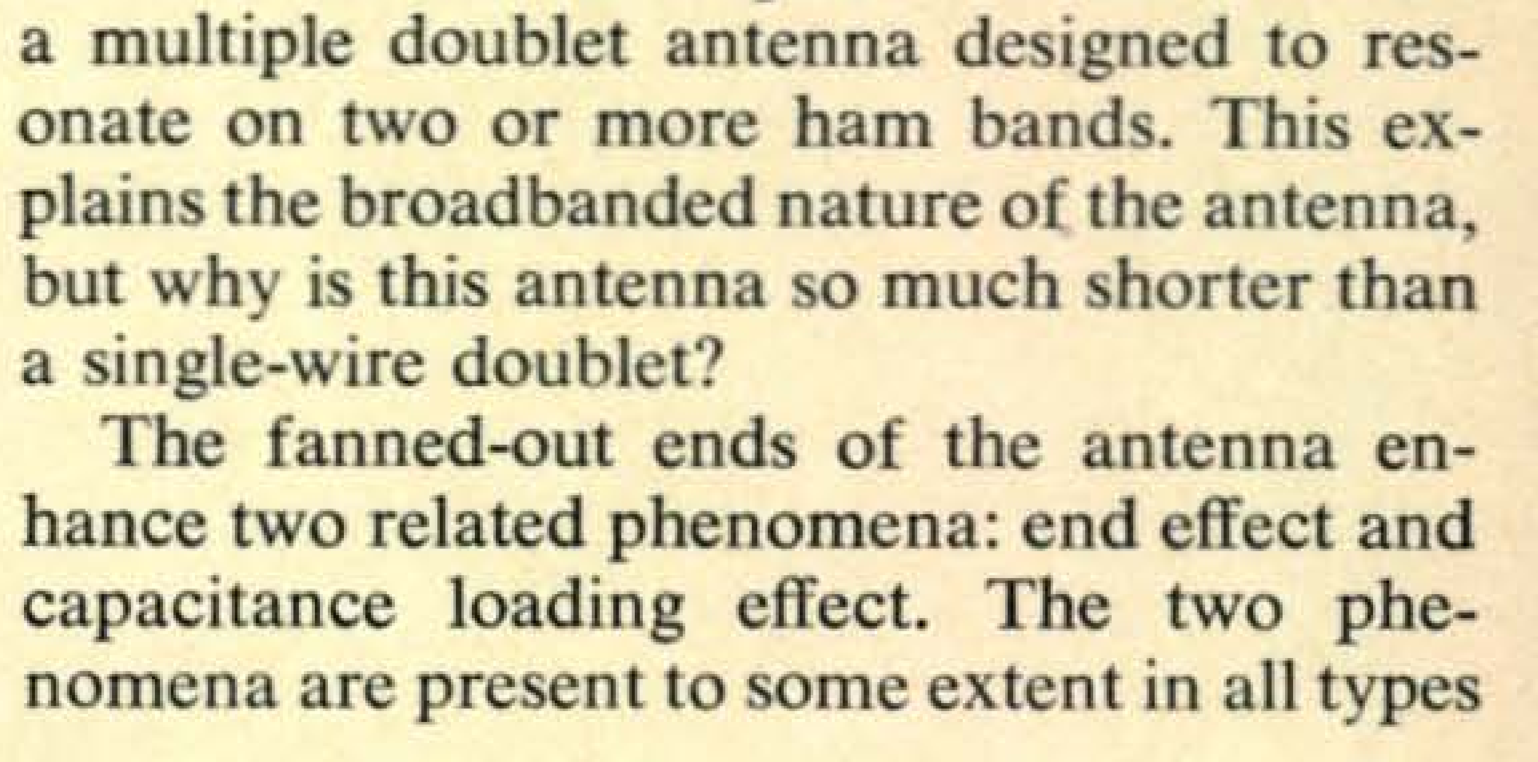

Fig. 1—The forty meter broadband doublet. The length of each half of the unfanned portion of the antenna is 15'9" with the longest half-element length being 24'4".

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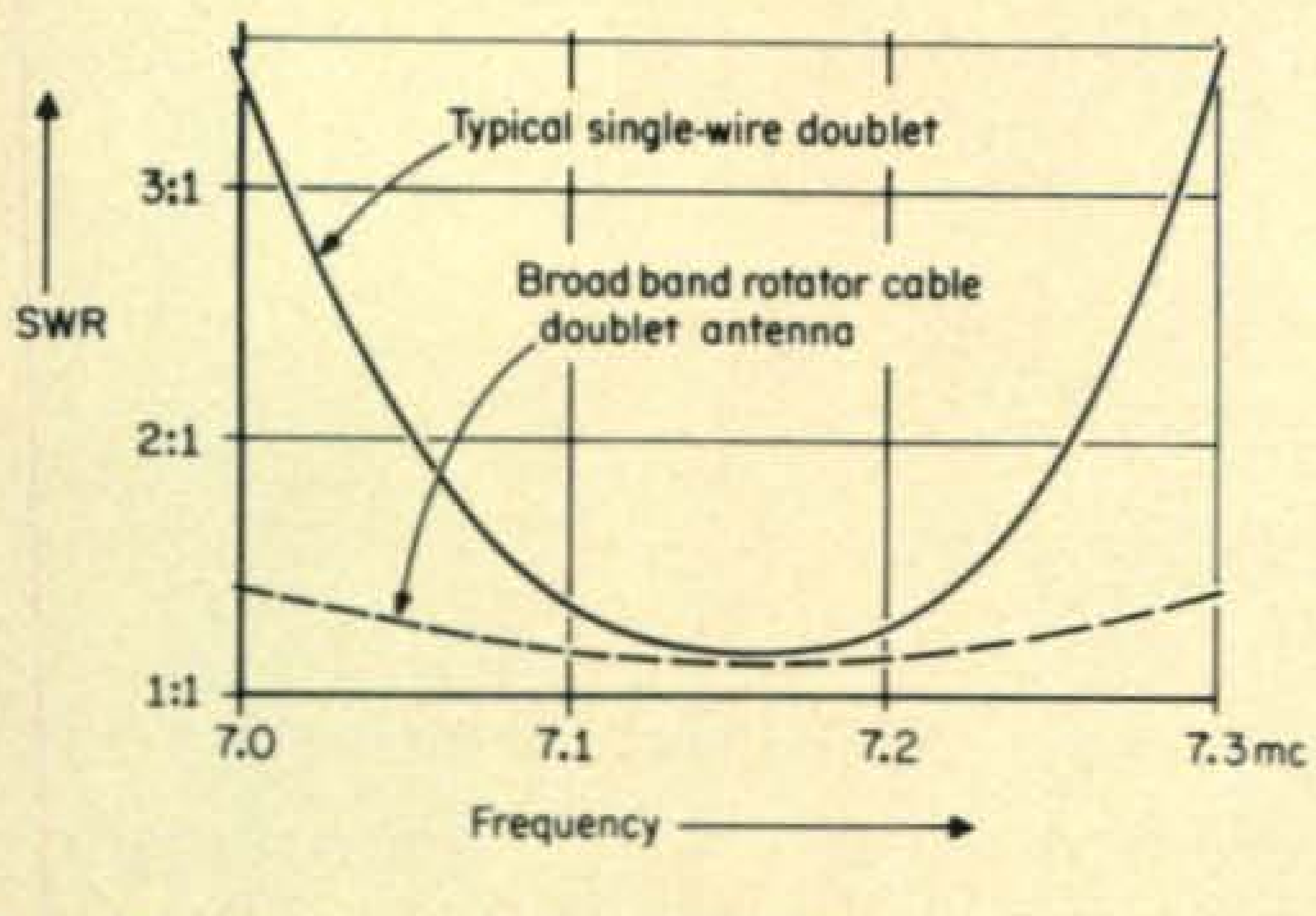

Fig. 2—Measured bandwidth vs. s.w.r. characteristics of the broadband 40 m. antenna and a conventional 40 m. dipole.

of antenna systems. Both effects tend to increase the effective electrical length of an antenna element. Consequently, for any given resonant frequency, the physical length of the antenna must be shortened when the capacitive loading effect is enhanced. For the antenna shown in fig. 1, the fanned-out ends compose a "capacity hat" which significantly reduces the required length of the antenna.

Optimum Bandwidth

For ham operation, it is desirable to have an antenna whose bandwidth covers the entire ham band, but not much more than that. This affords some protection against radiating power outside the band if the transmitter develops any spurious output on frequencies far from the ham band. This situation is achieved by the antenna described by fig. 1. Figure 2 shows a plot of s.w.r. *vs.* frequency for the broadband antenna. The s.w.r. rises sharply outside the 40 meter band, as there are no elements resonant outside the band.

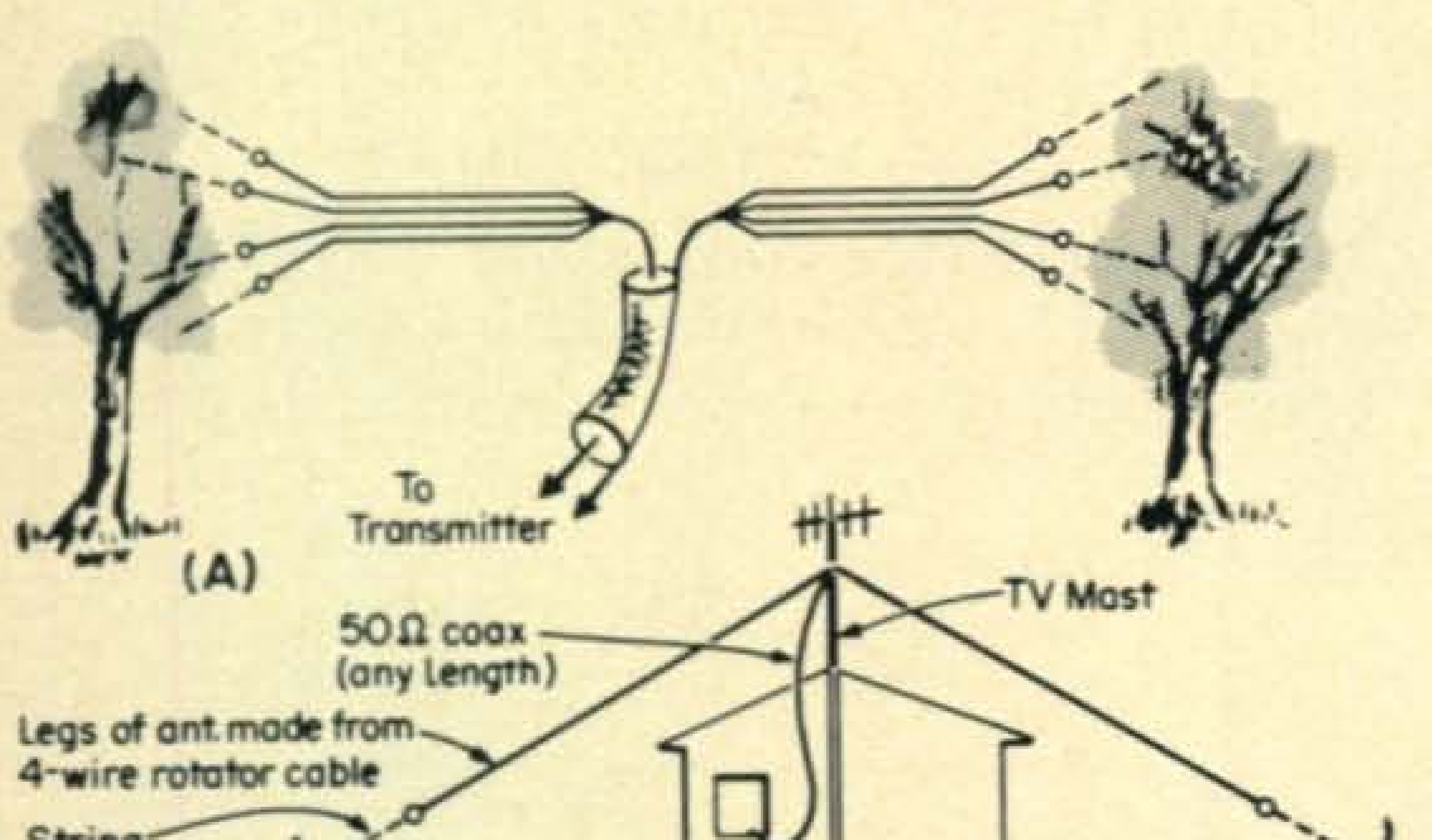

Fig. 3—(A) Using trees as supports for the broadband 40 m. dipole a flattop configuration results. String attached to the ends of the fanned conductors provides convenient insulated support. (B) Supported from the center from a pole or TV mast gives the popular inverted vee configuration.

One by-product advantage of the broadband antenna described here is that since it is resonant across the entire 40 meter band, it is also resonant across the entire 15 meter band (resonant from 21.0 to 21.9 mc). This antenna may be used on 15 meters without the need for antenna switching. It should be noted that since the 15 meter band extends only from 21.0 mc, care must be taken to insure against any spurious output from the transmitter in the range of frequencies from 21.45 mc to 21.9 mc.

Construction

The construction of the broadband 40 m. antenna is illustrated in fig. 1. The length of the longest leg is:

15′9″ + 8′6″ = 24′4″ (length of longest leg).

The length of the longest element (two legs) is forty-eight feet, eight inches, which is considerably shorter than the sixty-six feet required for a standard single-wire doublet for the 40 meter ham band. The antenna is easily constructed using standard 4-wire TV rotator cable.[1] The wires are easily separated and stripped apart in a manner so that the wires remain individually insulated. The fan-out point must be taped to prevent the rotator cable from splitting beyond the fan-out point. The lowest s.w.r. (best impedance match between antenna and transmission line) is obtained if 50 ohm coax is used.

Installation

The antenna can be erected in either a "flat top" or "inverted V" configuration. If desired, a TV mast can be used for a center support (fig. 3A) or, if convenient, the ends may be supported by tree branches as shown in fig. 3B. The leg may be supported by any of the popular methods used for a single-wire doublet (egg insulators with wire, nylon string, etc.) Because of its broadbanded nature, the resonant frequency of this antenna is not affected by surrounding objects as much as single-wire doublet. The resonant frequency and bandwidth are slightly dependent upon the separation angle between the end elements (angle A in fig. 1). However, this angle is not critical provided that it is greater than 40°. Small angles (less than 30°)

[1]Archer rotator cable, supplied by Allied Radio Shack; $3.59 per 100 feet.

are not acceptable, since the small separation causes excessive capacitive coupling between the elements, which in turn causes the end elements to be "shorted together" at radio frequencies. The end elements may be fanned out in any geometry–they need not lie in the same plane.

In actual practice, every antenna should be field tuned if maximum performance is required. The resonant frequency of this broadband antenna is not a critical function of length. Consequently, a broadband antenna such as this requires less trimming than a single-wire doublet. However, if trimming is needed, the reduction in length should be made at the center point, for convenience, rather than adjust the lengths of all eight end elements.

Broadband antenna systems are inherently not critical with respect to their physical dimensions or their surroundings. This can be explained best by considering the effects of height above ground, antenna length, etc., for both a narrowband antenna (such as a single-wire doublet and the broadband antenna. Assuming a 150 kc bandwidth for the narrowband antenna, if the resonant frequency is changed by 100 kc (by a change in height, for example), the operation of the antenna is significantly altered. On the other hand, if the resonant frequency of a broadband antenna (400 kc bandwidth) is shifted by the same amount (100 kc), there is a wide range of frequencies (300 kc) about the resonant frequency for which the operating characteristics remain essentially unchanged. Consequently, the broadband antenna is relatively insensitive to the effects of surrounding objects and to changes in antenna height, humidity, and the fan-out angle.

Performance

As shown in fig. 2, the bandwidth characteristic of the broadband 40 m. antenna compare very favorably to those of a conventional dipole, with s.w.r. being 1.4 to 1 or less over the entire 40 m. band. Performance is comparable to that of a full size dipole or inverted vee and if the multiple supports required for the 8 fanned legs present no problem, the design is ideal for the man who likes to use the whole band. ■