HF Inverted Vee with Dipole Augmentation

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***Abstract*— In the amateur radio community, a common practice is to center-feed a dipole resonant in the 75-meter band (say at 3.9 MHz) with high-impedance ladder line, and use the same antenna on all eight amateur bands between 3.5 and 29.7 MHz with the aid of an antenna tuning unit. The dipole is typically 125-135 feet in length. Some users have employed longer "reflector" wires and/or shorter "director" wires in combination with the basic dipole element in an attempt to enhance the antenna's overall performance. This article reports a variation which has not been seen elsewhere in the published literature, namely, an inverted vee antenna is used as the driven element and a 75-meter half-wave dipole is then used to augment the gain of the inverted vee. The result is an antenna with higher gain across the HF spectrum at elevation angles of interest to practical communicators. The configuration reported here is not claimed to be optimum in any sense. Rather, the objective is to encourage others to apply CEM analysis to additional variations and report progress as it is achieved.**

I. INTRODUCTION

This is a specific case study, reported because the results are believed to be of interest and useful to practical radio communicators operating in the HF spectrum. The configuration is an inverted vee antenna as the driven element with a 75-meter half-wave dipole added to augment the gain of the inverted vee. EZNEC 4.0 antenna software by Roy Lewallen, W7EL, was used for the numerical analysis in this study. Real ground with $\sigma = 3$ mS and $\epsilon_r = 12$, typical of West Alabama soil, was assumed for all computer runs.

The (x,y,z) coordinates in feet of the wire ends are as follows: (a) for the dipole, end 1 is at (0,53,41) and end 2 is at (0,-83,57), and (b) for the inverted vee, which is off-center fed, end 1 is at (1,54,41) and end 2 is at (1,-84,57) with the feed point at (-36,0,10). The dipole and inverted vee ends are in close proximity, but not connected. The end elevations are different because they reflect the actual heights used in a prototype antenna, which has been constructed and used regularly for an extended period of time. The inverted vee feed point is off-center because it is the point closest to the transmitter location - only fifteen feet of transmission line are required to connect the transmitter to the antenna. There a 5-inch gap at the center of the dipole, and a section of 600Ω open-wire ladder line extends from the center feed point straight down to a height of 8 feet, where the two conductors are shorted. The transmission line and antenna are both constructed of #14 stranded copper wire. The active transmission line feeding the inverted vee is the same type 600Ω open-wire ladder line. The vee-dipole geometry is shown in Figure 1 below.

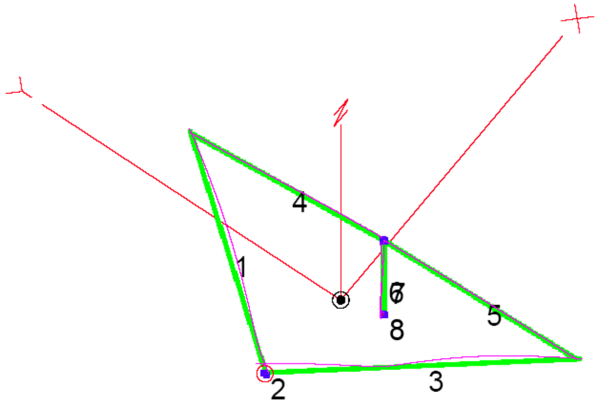

Fig. 1. Inverted vee - dipole configuration.

II. CEM ANALYSIS RESULTS

Note that the +x axis is toward the East, and the +y axis is toward the North. In the elevation plots that follow, for an East-West slice $(\varphi = 0°)$, East is to the right side of the plot, and West is to the left. Similarly, for North-South $(\varphi = 90°)$, North is to the right and South is to the left.

Performance at all eight HF amateur bands is too much data for presentation here. Four frequencies were selected for illustration purposes, two toward the ends of the HF spectrum, and two in between: 3.885, 7.290, 14.286, and 29.0 MHz. Elevation patterns for the dipole alone, which was the antenna previously in use alone, are superimposed on plots for the composite "inverted vee augmented with a dipole" antenna. The results are given successively as Figures 2 through 9 below.

Note that, in each of Figures 2-9, the "primary" trace is the inverted vee - dipole antenna, and the other trace is for the dipole alone at the frequency and azimuth angle specified in the figure caption.

Figures 2-9 occupy the next four pages. Discussion resumes after that.

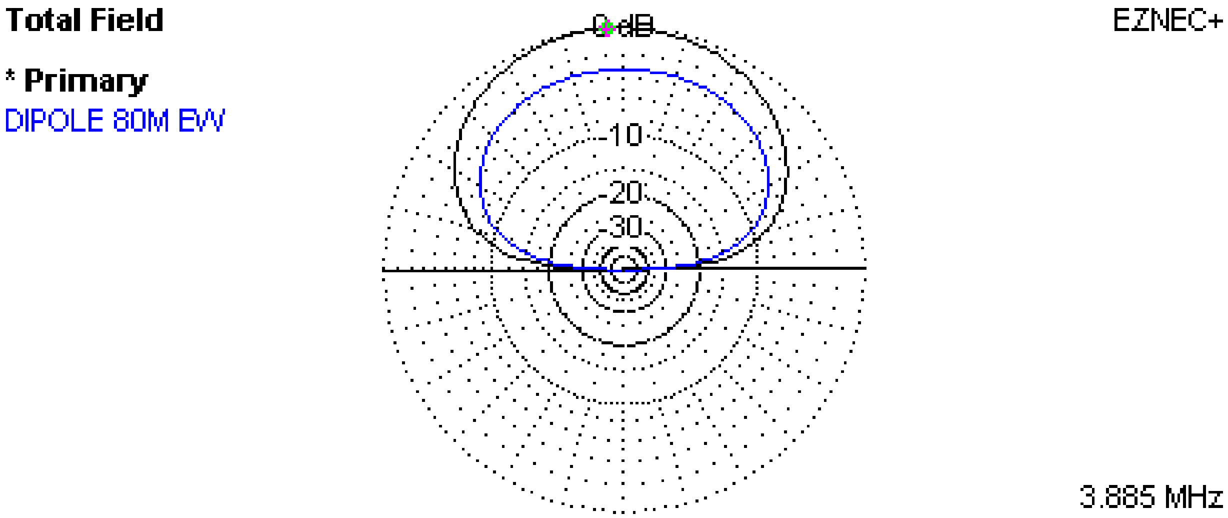

Fig 2. $\varphi = 0^\circ$elevation plot, 3.885 MHz, outer ring 9.39 dBi.

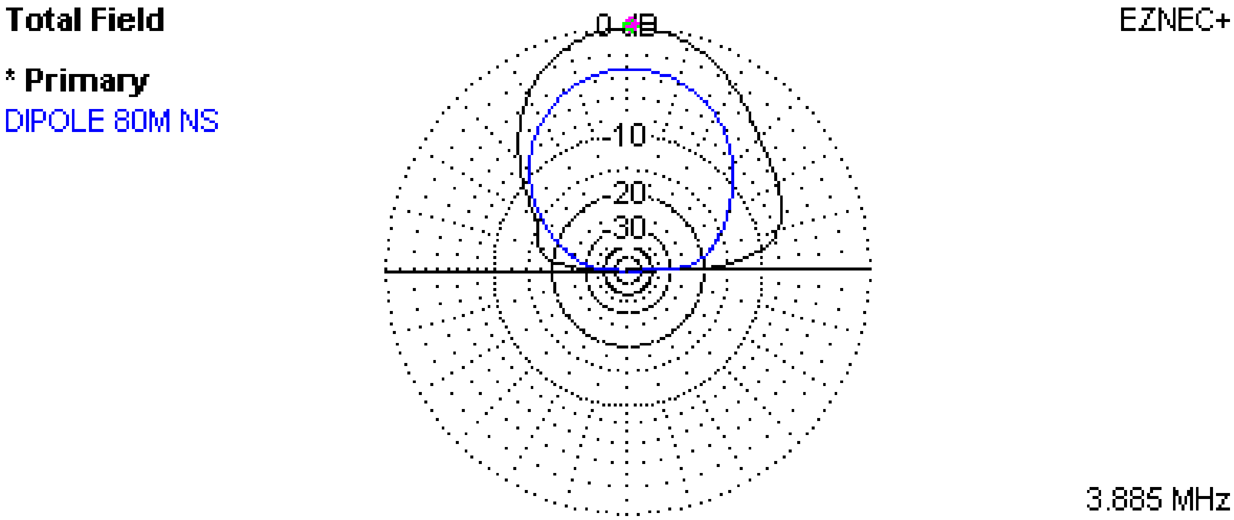

Fig 3. $\varphi = 90^\circ$ elevation plot, 3.885 MHz, outer ring 9.38 dBi.

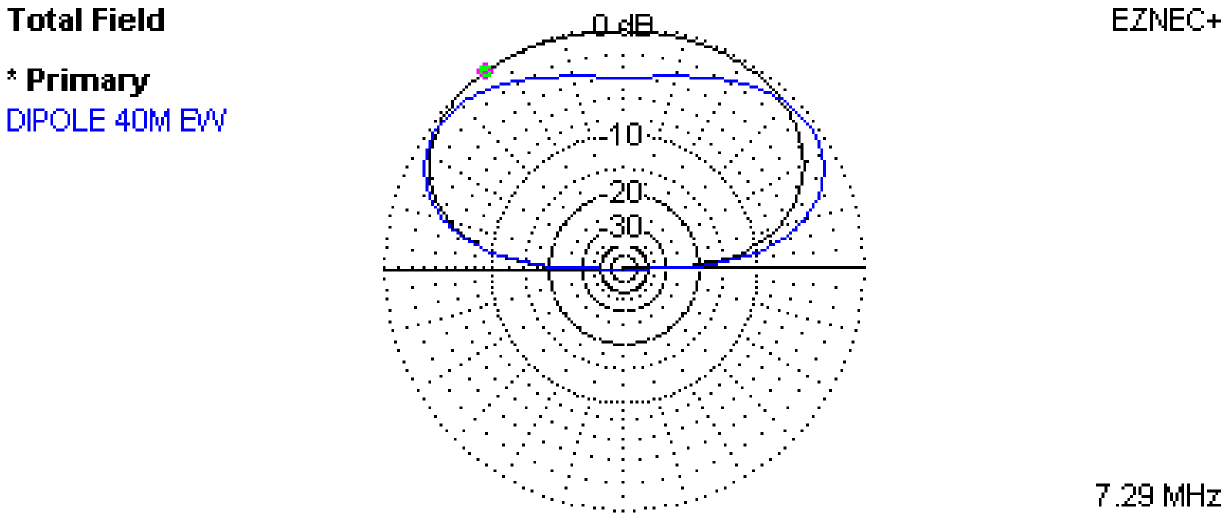

Fig 4. $\varphi = 0^\circ$elevation plot, 7.290 MHz, outer ring 7.91 dBi.

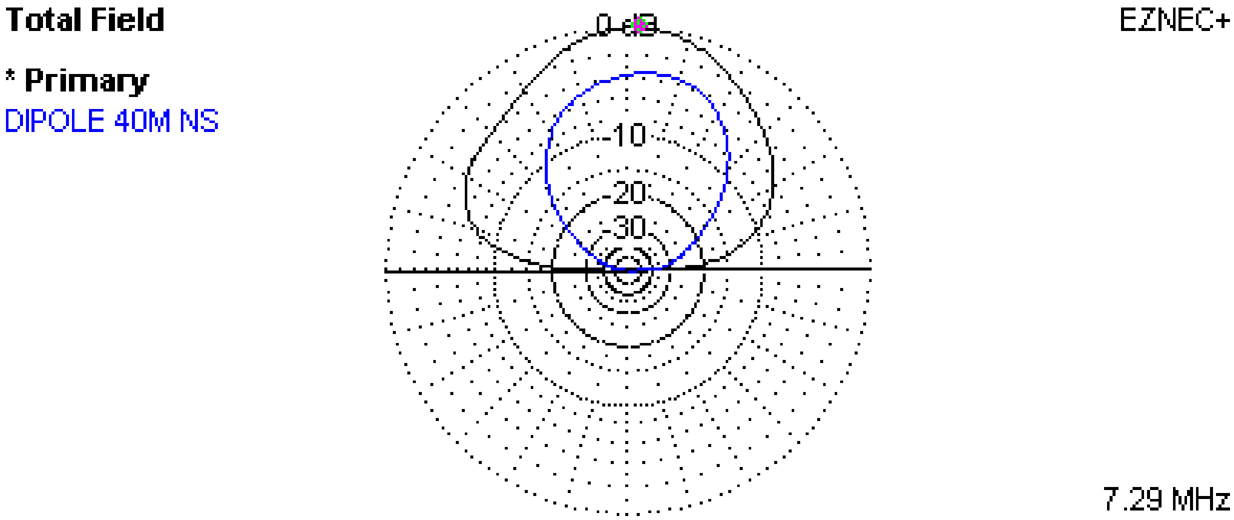

Fig 5. $\varphi = 90^\circ$ elevation plot, 7.290 MHz, outer ring 7.7 dBi.

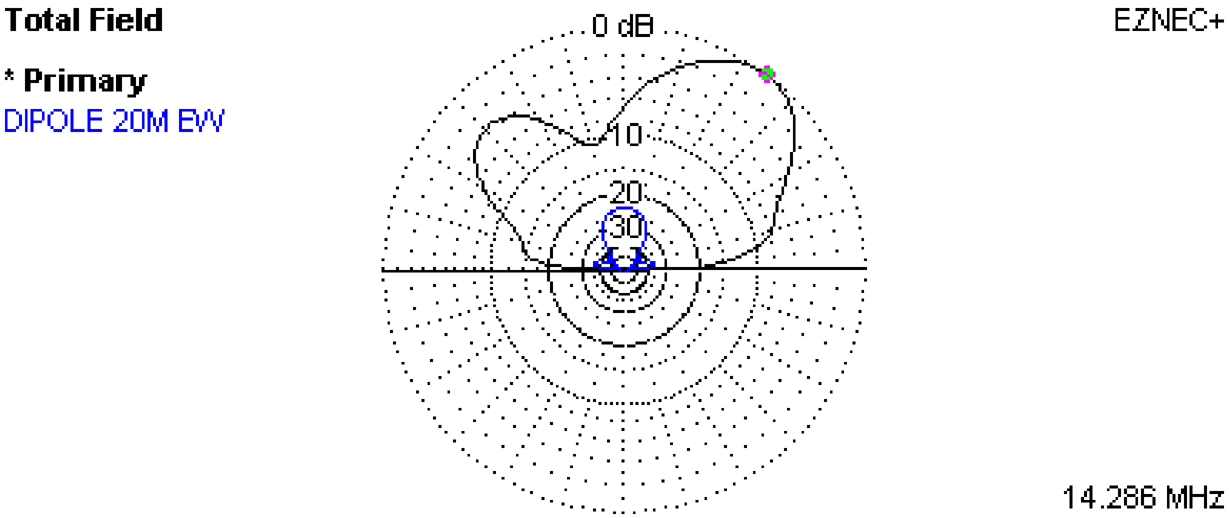

Fig 6. $\varphi = 0°$elevation plot, 14.286 MHz, outer ring 9.8 dBi.

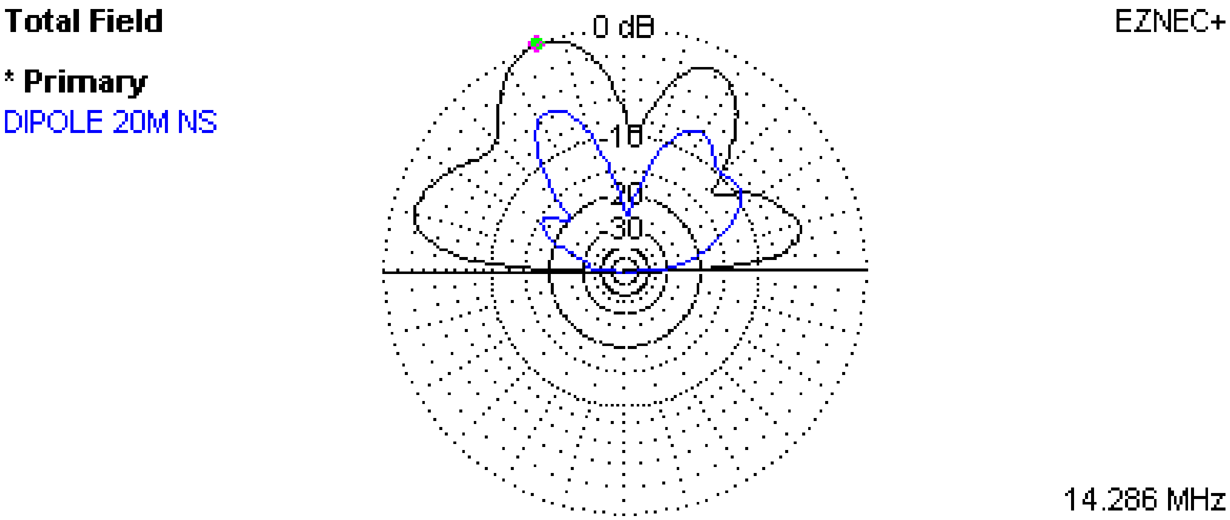

Fig 7. $\varphi = 90°$ elevation plot, 14.286 MHz, outer ring 10.56 dBi.

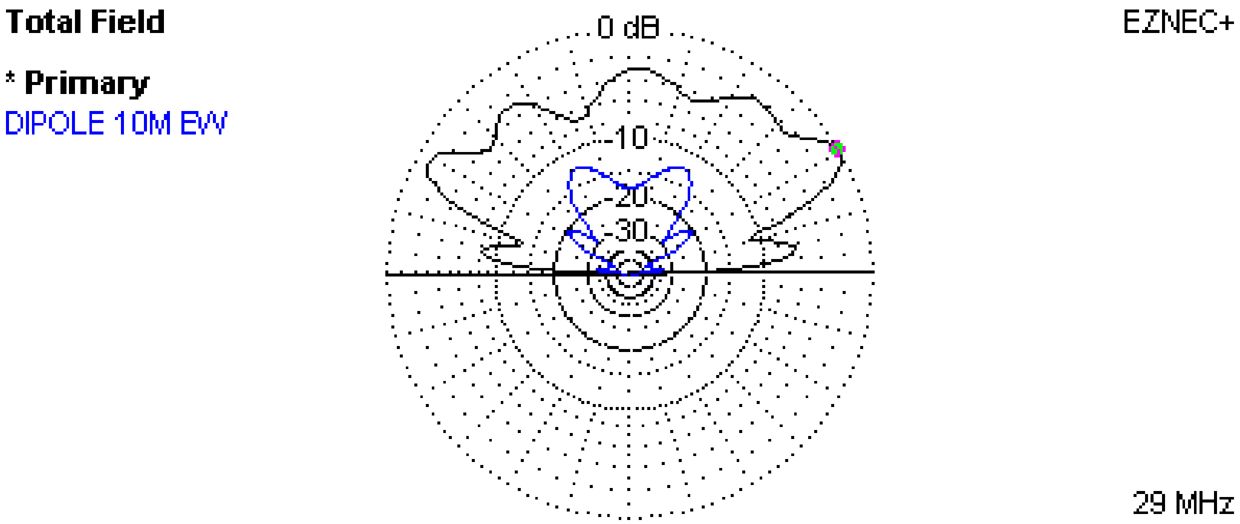

Fig 8. $\varphi = 0^\circ$elevation plot, 29.0 MHz, outer ring 8.91 dBi.

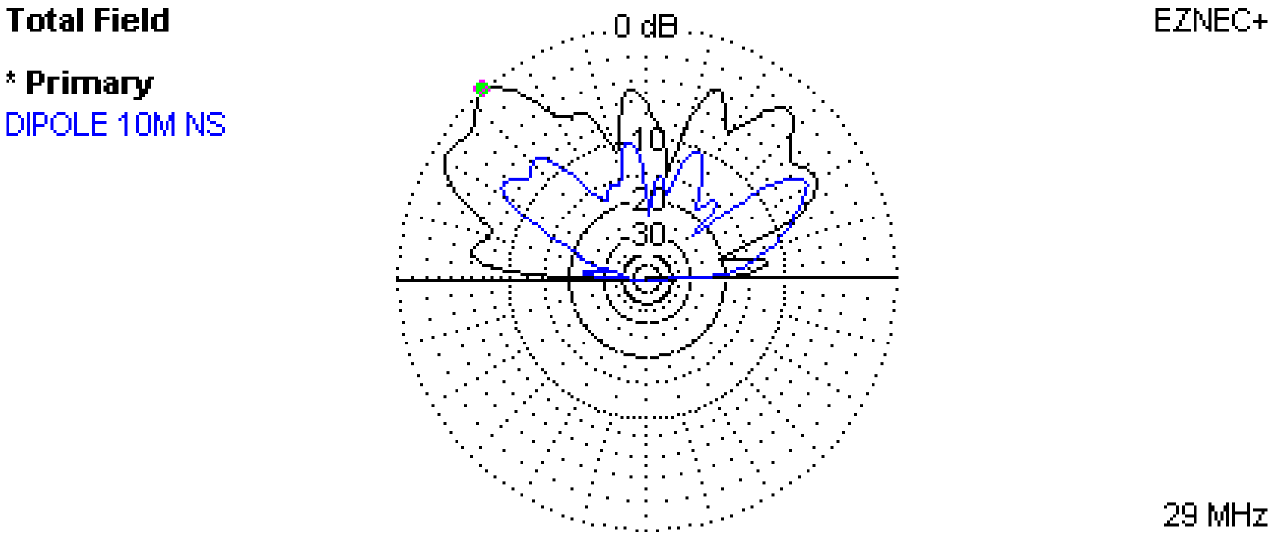

Fig 9. $\varphi = 90^\circ$ elevation plot, 29.0 MHz, outer ring 9.38 dBi.

III. RADIATION PATTERN REMARKS

The preceding figures (2-9) give four East-West and four North-South elevation plots comparing the inverted vee - dipole combination versus the dipole alone (before the vee was added and made the driven element) at the four frequencies 3.885, 7.290, 14.286, and 29.0 MHz.

Three general comments apply. First, because the southern end point is almost twenty feet higher than the northern end point, the antenna configuration has a slight "sloper" behavior favoring radiation toward the North. For example, from Fig. 5 the dipole is almost 6 dB stronger toward the North at elevation angle 45°. Second, the inverted vee - dipole combination geometry is not symmetrical North-South or East-West, and thus one would expect asymmetric patterns with the effect more pronounced at the higher frequencies. Third, the feed point for the inverted vee is notably close to ground at a height of only ten feet, and the presence of real ground was taken into account throughout the CEM analysis of this antenna. Again, a low feed point was selected so that the transmission line feeding the antenna could be made very short.

At 3.885 MHz, the antenna elevation in fractional wavelengths is small, so its gain is highest straight up. However, for practical communications purposes, there is still quite adequate radiation at elevation angles down to $25^\circ - 30^\circ$. The vee-dipole combination is superior to the alternative of using the dipole alone at all angles, and shows a particularly useful increase for long-distance communication links at elevation angle 15° toward the North.

The $\varphi = 0^\circ$ plot of Fig. 4 for 7.290 MHz shows one of the rare instances where the dipole alone would be superior, and this occurs at elevation angles less than 60°. So, if the user's principal interest was high-angle radiation for links of shorter distance, the vee-dipole has the advantage.

Results at 14.286 MHz require some clarifying comments. The dipole is 2λ at this frequency, and so its azimuth pattern (at, say, 20° elevation) exhibits the well-known four-leave clover appearance with lobes toward the Northeast, Northwest, Southwest, and Southeast. The lobes all peak right at 9.0 dBi. For the given geometry and taking into account real ground, the nulls in the $\varphi = 90^\circ$ (North-South) plane are moderately deep, and the $\varphi = 0^\circ$ (East-West) plane are deeper. N-S and E-W slices were selected because they are of greatest interest in the actual deployment of this antenna, and limited space here precludes the presentation of additional patterns. Therefore, Figs. 6 and 7 perhaps imply an unfair advantage for the vee-dipole combination but, nonetheless, the vee-dipole variation is indeed generally superior.

At 29.0 MHz, both antennas are both electrically large and significantly elevated. In various azimuth plots, the dipole exhibits radiation characteristics that change considerably with elevation angle. At 30° elevation, the dipole pattern has two major lobes roughly North-South and a pair of sidelobes positioned about 20° North and South of the x-axis $(\varphi = 0^\circ)$. Toward the North at elevation angle 30°, the dipole alone is competitive with the composite antenna but, otherwise, the vee-dipole combination is still clearly superior in overall radiation performance.

IV. VSWR

A plot of VSWR at the inverted-vee feed point from 3.5 to 29.5 MHz is given as Figure 10 below.

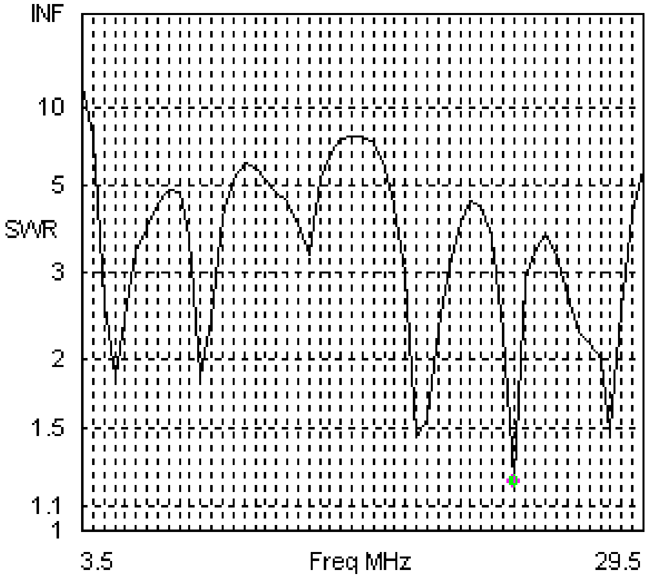

Fig. 10. Vee-dipole combination VSWR.

The notable feature is that SWR is below 10:1 over almost all the HF spectrum, only exceeding that value at the low-frequency end. Further, the SWR is below 5:1 from approximately 17.75 to 27.5 MHz. At HF, a 10:1 SWR is quite acceptable if open-wire feeders are used in conjunction with a high-quality antenna tuning unit. Open-wire transmission line lengths up to 200 feet have been found acceptable, and losses for the fifteen foot length of this study are insignificant.

V. CONCLUDING REMARKS

The inverted vee - dipole antenna described here has been found by CEM modeling to be superior to the classical dipole multiband antenna across the HF spectrum. When the rf feed is moved from the old dipole to the vee, the dipole open-wire transmission line need not be removed but simply truncated and shorted at about eight feet above ground, keeping it available for reactivation if the future, if so desired.

Adding the vee is convenient, as the original dipole end supports/anchors can be also be used for the vee ends, and the vee feed point can be located in close proximity to the transmitter with need for only a modest ten-foot high support. For this study, a fiberglas WonderPole^{TM} push-up mast was used to support the vee feed point.

It is assumed that the user will use 450Ω or 600Ω open-wire feeders, and use of coaxial cable with a balun is not recommended.

This is a specific case study, and is intended to stimulate CEM modeling of variations by practical radio communicators who continue to favor the HF spectrum for their operations.