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# A multi-band inverted-V dipole for portable operation – PART TWO

**In this concluding part of a two-part article, GM3VLB considers the dimensions of his inverted-V for several bands.**

Before giving the dimensions for the inverted-V, here are some fundamental considerations.

### (1) Length of a λ/2 dipole

Readers will be familiar with the following rule of thumb formulae which apply to *horizontal* dipoles either in free space or at least a half-wavelength above ground. If f is the design resonant frequency in MHz, we have the situation represented by **Equation 1**.

In practice, the length is shorter than this due to the so-called 'end-effect' of the insulators and their supports. **Equation 2** gives the physical situation.

Each leg of a λ/2 horizontal dipole is thus half of this, or 71/f metres long. For example, for a λ/2 dipole resonant on or about 14.150MHz , the length of each will be 71/14.15 or 5.02m (16ft 5in). This is about 0.95 of the free-space length of 5.30m (17ft 5in).

Thus, the relation of the physical and free-space lengths are related by **Equation 3**.

However, what is generally not made clear in the literature is that, as the ends are lowered towards the ground into what is known as inverted-V configuration, the resonant frequency *drops* – the antenna becomes too long! To maintain the original resonant frequency, the length of the inverted-V must therefore be *reduced*. This is probably the cause of much head scratching when trying to tune inverted-Vs. The author's experiments on inverted-V dipoles suggest the empirical formula given in **Equation 4**.

It is regrettable that the literature does not make this clear.

### (2) Effect of height of the ends above ground

The above figures are not 'cast in stone'. They are very much dependent on the resonant frequencies chosen, the height of the mast and the 'apex half-angle', all of which in turn determine the height of the end insulators above the ground. In the author's case, with the frequencies chosen, a mast height of 8m and an apex half-angle of 68°, the end insulators of the 20/40/80m inverted-V are about 60cm (2ft) above ground.

*Doubling* the height of the end insulators above ground to 120cm (4ft) *increases* the resonant frequency to 3.830MHz (an increase of about 1.8%), whilst *lowering* them by 60cm (2ft) to ground level *lowers* the resonant frequency to 3.690MHz (this time a decrease of about 1.8%). It is apparent that the 80m antenna can be fine-tuned by increasing or decreasing the height above ground of the end insulators (achieved by longer or shorter cords).

The author feels this is another aspect of inverted-V antennas (with end insulators close to the ground) which is rarely, if ever, made clear. (Note: In each case, we are changing the capacitance of the antenna ground. Bringing the ends closer to ground increases the capacitance, thus decreasing the resonant frequency, and *vice versa*). There is negligible effect on 20m and 40m.

### (3) Nature of the ground

The figures derived in this article refer to 'average' ground, if there is such a thing. Experience suggests one should, where possible, avoid solid rock, sand or severe undulations in the line of the antenna. Sometimes, however, choice is not an option, and variations in proximity to ground and in its conductivity, may affect the resonant frequencies and input impedances, and have, on occasion (rarely, fortunately), caused some serious head-scratching!

### (4) Dimensions

**Table 1** gives the lengths of each leg of a 20/40/80m inverted-V dipole. These lengths are the distances between the fixed end-points (in effect, the wing-nuts, or in the case of the lower end of the 80m segment, the centre of the end insulator). The 20m- and 40m-band frequencies are based on the average of the IOTA CW and SSB frequencies for the 20m and 15m bands, respectively.

As previously stated, the 15m band is available on the 20/40/80m version by using the 40m dipole as a 3λ/2 dipole for 15m. Similarly, the 20m dipole has been used (40/80m disconnected) as a 3λ/2 dipole on

Equation 1

$$\text{Free-space total length of a } \lambda/2 \text{ horizontal dipole} = \frac{492}{f}\ (\text{ft}) \text{ or } \frac{150}{f}\ (\text{m})$$

Equation 2

$$\text{Physical total length of a } \lambda/2 \text{ horizontal dipole} = \frac{466}{f}\ (\text{ft}) \text{ or } \frac{142}{f}\ (\text{m})$$

Equation 3

$$\text{Physical length of a horizontal dipole} = 0.95 \times \text{free-space length}$$

Equation 4

$$\text{Physical length of a } \lambda/2 \text{ inverted-V dipole} = 0.91 \times \text{free-space length of a } \lambda/2 \text{ horizontal dipole}$$

Equation 5

$$\text{Length of each leg of a } 3\lambda/2 \text{ inverted-V dipole} = \frac{212}{f}\ (\text{m})$$

10m, by adding about 2.4m each side and allowing these additional lengths to hang freely from the 20/40m insulators.

**Table 2** gives the lengths of each section in each leg of the 10/12**/15/17/30m version of the multi-band inverted-V.

## CONCLUSIONS

This form of inverted-V allows multi-band operation with one antenna from portable locations. It might be argued that it is perhaps not quite so convenient for the home location. This said, how often is rapid and frequent band changing required, even at home?

The author (together with 'Island' partners Alex, GM0DHZ, and Keith, MM0BPP,) has made over 100,000 QSOs from a great variety of island locations. With the inverted-V described, he has never needed to use an ATU, other than in exceptional circumstances such as an antenna system fault (broken conductor, or corrosion, or in an extremely adverse location. A site near the water (ideally *over* the water) and close to the landing point is always chosen in preference to height above sea level. Apart from anything else, the latter reduces the distance the equipment has to be carried.

The formulae and dimensions proposed are the result of much experimenting and experience. They appear valid whether the antenna is near the sea or far removed from it, and represent a good starting point for anyone contemplating putting up an inverted-V. There is no doubt that such an antenna will out-perform a horizontal dipole whose centre may be sagging well below the height of the end supports, an unfortunately all-too-familiar sight. If using a 10 to 17m inverted-V, ensure that the apex angle is *not less* than 110° (with the 20/40/80m version atop an 8m mast, the apex angle will generally be greater than 130°). In limited space, one can 'swing the ends round' slightly.

## FINALLY

In his past life as 5Z4KL in the 60s and 70s, the author frequently and successfully used the ubiquitous G5RV, in its familiar form using 300Ω ribbon cable and 75Ω coax, always in inverted-V configuration, and often in the bush at heights as low as 6ft above the ground. Valved rigs were very forgiving – not so today's solid-state 50Ω output rigs and amplifiers. Prior to using a G5RV dipole as a multi-band antenna, you would be well advised to read the work done by ZS6BKW (see *Practical Wire Antennas*, by John Heys, G3BDQ) on improving this antenna, and the reasons for doing so. This book also gives guidance on the design of a doublet – arguably a far better multi-band alternative for the solid-state home station – using G5RV's own dimensions, chosen to avoid unwieldy reactances.

**Table 1: Lengths of each leg of an inverted-V dipole.**

| Band (m) | Chosen design frequency (MHz) | Balun switch position | Feedline (13.6m of 50Ω coax) | λ/4 (68/f, m) | 'extra' length in each case (m) |
|---|---|---|---|---|---|
| 20 | 14.150 | 1:1 | 2λ/2 | 4.81 (15ft 9in)* | |
| 40 | 7.050 | 1:1 | λ/2 | 9.65 (31ft 8in)* | 4.84 (15ft 11in) |
| 80 | 3.772 | 1:1 | λ/4 txfmr | 18.03 (59ft 1in)* | 8.38 (27ft 5in) |

* These are lengths on either side of the feed-point – the overall length is double this.

**Table 2: Lengths of each section in each leg of the 10/12**/15/17/30m version of the multi-band inverted-V.**

| Band (m) | Chosen design frequency (MHz) | Balun switch position | Feedline (13.6m of 50Ω coax) | λ/4 (68/f, m) | 'extra' length in each case (m) |
|---|---|---|---|---|---|
| 10 | 28.250 | 1:1 | 4λ/2 | 2.41 (7ft 11in) | |
| 12** | [24.940] | 1:1 | ~7λ/4 | [2.73] (8ft 11in) | [0.32] (1ft 0in)** |
| 15 | 21.150 | 1:1 | 3λ/2 | 3.22 (10ft 7in) | 0.81 (2ft 8in) |
| 17 | 18.113 | 1:1 | ~5λ/4 | 3.75 (12ft 4in) | 0.53 (1ft 7in) |
| 30 | 10.125 | 1:1 | ~ 3λ/4 | 6.72 (22ft 0in) | 2.97 (9ft 8in) |

** In practice, the extra length (with its own 'U' spade terminal) for the 12m band (relative to 10m) is taped to the side of the 15m section and the appropriate spade terminal is connected to the end of the 10m section depending on whether 12m or 15m is selected.

**Table 3: Dimensions for the 20/40/80m version depicted in Fig 6.**

| Band (m) | Chosen design frequency (MHz) | Balun switch position | Feedline (13.6m of 50Ω coax) | λ/4 (68/f, m) | 'extra' length in each case (m) |
|---|---|---|---|---|---|
| 40 | 7.050 | 1:1 | λ/2 | 9.65m (31ft 8in) | |
| 20 | 14.150 | 1:1 | 2λ/2 | 14.98m (49ft 2in)# | 5.33m (17ft 6in) |
| 80 | 3.772 | 1:1 | λ/4 txfmr | 17.91m (58ft 9in)## | 2.93m (9ft 7in) |

\# NB: The length of the 3λ/2 dipole is greater than 204/f ( 3 x 68/*f*). This is because the shortening due to end-effect affects only the outer 1/2-wavelengths of the 3λ/2 dipole. The *ARRL Antenna Handbook* suggests that the length of a *horizontal* 3λ/2 dipole is about 442/*f* metres rather than 426/*f* (3 x 142/*f* ). In the absence of any accurate, theoretically-based formula, the author applied simple proportion and predicted an empirical value of 212/*f*. This gave a length of 14.98m for each leg of the 3λ/2 inverted-V dipole, which is indeed almost exactly the value of the length he obtained by experiment! The author would therefore suggest the use of **Equation 5**.

\## The additional length for 80m resonance is about 4in less than predicted by the 1/2-wave formula (68/*f*) previously proposed. This is negligible on 80m. In any case, the ends of the 80m dipole are folded back on themselves approximately 40 - 50cm (18in) to allow precise adjustment of the 80m resonant frequency *in situ*. The author passes the wire through one half of a twin terminal block connector (preferably with brass screws), then through the egg (or other insulator) and back into the connector block. This allows easy adjustment, without cutting the surplus wire.

FIG 6



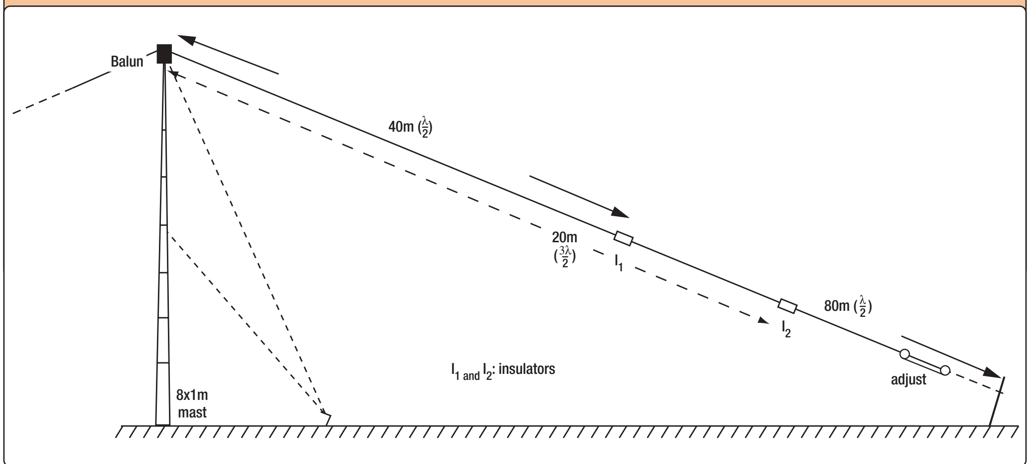


Fig 6: Alternative configuration for the 20/40/80m antenna, which is 3λ/2 on 20m.

## APPENDIX – a new configuration

Since drafting this article, the author has tested another configuration for the 20/40/80m version of his multi-band inverted-V dipole. It occurred to him that, by making the innermost dipole the 40m one, the next 'segment' could be used to extend this to a 3λ/2 (three half-wavelengths) on 20m. The length of the third segment on each side is adjusted accordingly to allow resonance as before on the 80m band. Dimensions are given in **Table 3**. ♦