G5RV Multiband Dipole Antenna

The ubiquitous multiband dipole antenna by Louis Varney G5RV has been with us since 1958. Professor Brian Austin ZS6BKW remodelled and revised the dimensions of the antenna with improved results and ease of construction.

Prof Austin was engaged at the Faculty of Electrical Engineering at the University of the Witwatersrand, Johannesburg, South Africa, when the following article appeared in *RadioZS* of June 1985. *RadioZS* is the jounal of the South African Radio League.

The July 1958 edition of the RSGB Bulletin contained an article[1] by Louis Vamey G5RV on a novel multiband dipole which did not require traps. Diagram 1 shows the antenna, later to become known universally as the "G5RV".

Like so many good ideas, it is so simple. It works as follows: On 20m the flat-top is three halfwaves long. Its feedpoint impedance is therefore low and because the open-wire line is one half-wave length on that band it merely transfers that low impedance to its other end and there presents a reasonable match to the "Twin" feeder to the rig. On 40m the feedpoint impedance is very high (and inductive) because the antenna is now three quarters of a wavelength, but the transmission line transformer is now one quarter-wavelength and so functions as a quarterwave transformer. Hence the high value of the load impedance, ZL, is transformed into a much lower value, ZIN, by the well-known relationship for the quarterwave transformer:

$$\mathbf{Z}_{IN} = \mathbf{Z}_{O}^{2} / \mathbf{Z}_{L}$$

where ZO is the characteristic impedance of the open-wire line,
typically 300-600 ohms.

It is rather like an automatic ATU hanging off the antenna!

On 15m and 10m the antenna/feedline combination were again said to combine to present reasonable impedances to the twin-feeder, which was all that a valve power amplifier with link or pi-coupling ever requires. The tubes of that era coped far better with mismatches than do the solid-state devices of today!

On reflection it soon became apparent that one should be able to improve on the performance of this antenna by using a computer to optimise the lengths of the flat-top and matching transformer such that the impedance presented at the transmitter end of that line more closely matches the 50 ohms, plus or minus a few, that our modem finals will tolerate.

To do this we need to know the feedpoint impedance of a centre-fed dipole antenna as we change its length and as we change the frequency. This can be calculated but is by no means an easy task and a far simpler approach (and one that is probably more reliable) is to use the data which is available in the professional literature. Professor R W P King at Harvard University had fortunately provided us with this information[2] in tabular form. To use it requires only that it be stored in a "look-up" table in the computer. Given the frequency and the length of the antenna, we then have its impedance.

The next step was to consider the role of the transmission line transformer. How long should it really be and is one value of ZO better than another? Without going into any detail here, suffice it to say that Louis Varney's statement, way back in 1958, that ZO was not too critical is in fact not far off the mark. It has been shown[3] that there is a broad peak of ZO values, from about 275 ohms to 400 ohms, which will work adequately. This means that either homemade open-wire line or commercial 300 ohm tape could be used. Do choose the best quality 300 ohm tape though because that sold for FM-band folded dipoles really doesn't weather at all well.

To determine the length of the matching section we use the standard transmission line equation which gives us ZIN if we know ZL , ZO, the frequency and the length of that line. By re-arranging the equation we can find the length at any given frequency and ZO once we've used the "look-up" table to find ZL . Of course, ZIN is fixed by the required standing wave ratio on the 50 ohm cable to the rig. Usually this VSWR may not be more than 2:1, and is always specified by the transceiver manufacturer.

Armed with this information writing the computer program is a fairly conventional procedure and will not be described here. Ideally a single antenna should operate on all the HF bands from 160m through to 10m. That is a tall order though so we would probably settle for a compromise of say five of the nine bands (including the three new ones.) Having chosen that number we then instruct the computer, to change the flat-top length, the length of the matching section and ZO until it finds that combination of the three parameters which yield better than 2:1 VSWR on at least five bands. Clearly this involves an iterative or "going around the loop" procedure and can take a fair amount of computer time, but the results are worth the effort.

The Specifications show the details of the improved, computer-designed, G5RV. You will notice that the flat-top is shorter than Varney's and the matching section is longer. A velocity factor of 0,85 was used for the 300 ohm tape. Particularly important is the fact that this new antenna is designed for use with 50 ohm cable and not the 70-100 ohm twin lead of 1958. No balun is specified simply because neither the theory nor considerable experimentation justified the inclusion of one. Simply interconnect the 300 ohm tape and the 50 ohm coax, taking the normal precautions to keep out moisture.

The graphs show how the antenna performs, both in theory, from the computer predictions, and in practice, when erected horizontally at a height of 13m. It provides an acceptable match on the 7, 14, 18, 24 and 28 MHz bands. The original G5RV was tested by way of comparison (both with the computer and in the field) and found to be far less effective. Only the 14 and 24 Mhz bands produced standing wave ratios of less than 2:1 when fed with 75 ohm cable, as designed. The new antenna was also tested in the very popular inverted-V configuration and the results showed, not unexpectedly, that the frequencies on each band at which the best match occurred were all shifted somewhat lower, but the same general characteristics, as discussed above for the horizontal configuration, still applied. Likewise changing the height above ground from 7m to 13m did not markedly change the situation either. It must be realised of course, that the old dictum "the higher the better" always applies.

Modern technology has been put to work to optimise an antenna conceived empirically nearly 30 years ago and the results should give the old G5RV a new lease of life.

Specifications	**Original Varney Design**	**Improved Computer Design**
Dipole Length	31,1m	28,4m
Transformer Length	10,37m of open wire line, or 8,8m of 300 ohm tape	11,1m of 300 ohm tape with VF = 0,85
Feedline	70 - 100 ohm twin line	50 ohm coaxial cable
Balun	None - Direct connection from transformer to feedline	None - Direct connection from transformer to feedline

Note

Use good quality 300 ohm tape of velocity factor 0,85. The transformer length will be incorrect if the velocity factor is altered, resulting in high SWR.

References

1. Varney, L. (1958) An effective multiband aerial of simple construction.
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2. King, R.W.P. and Harrison, C.W. (1969) Antennas and Waves - A modern approach.
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3. Austin, B.A. (1982) Potential of the G5RV antenna.
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