ANTENNAS - ANECDOTES - AWARDS

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IT HAS BEEN A LONG, LONG TIME!

It was 31st May 1937 when I received my licence as G8PG. Nineteen months later I passed the examinations to become a Merchant Navy Radio Officer, and on 21st January 1939, set off on my first voyage. On 3rd September 1939 I received the signal that WW2 had begun. The next 6 years saw service in many places, and some narrow escapes. I was back ashore by the end of 1945 and G8PG was on the air again by mid-1946. There followed a period of coast station, aircraft ground station and part-time military radio work, then a change to being a Technical Author and later Technical publications manager. Also part-time teaching of students for the ham licence.

By 1971 I was getting just at little bit bored with ham radio when, on a whim, I bought a second hand PM3A QRP rig. One weekend using that rig brought all my enthusiasm back and made me a confirmed QRP man! A couple of years or so later George, G3RJV, announced he was forming G-QRP C, and I became Member 004. George soon had me working at things like the Award Scheme, Winter Sports etc. Later came the work with QRP people in many countries to produce an international framework for QRP working covering calling frequencies, power for various types of emission and so on. After that came a period of slowly establishing relations with QRPers in the then Soviet Block countries and seeing their QRP movements grow in strength and freedom. This brought one into contact with some wonderful people (too many to name here) and was enormously rewarding. Add to that all those met through antenna work, Award applications and other contacts and it has been a wonderful experience. Now with me having reached the age of 87 and my call the age of 70 it is time for someone younger to take over and for me to say

72 73 **ES CU QRP SN I HOPE**

(But remember without the vision of G3RJV it would never have happened)

The ZS6BKW Antenna – from the horse's mouth

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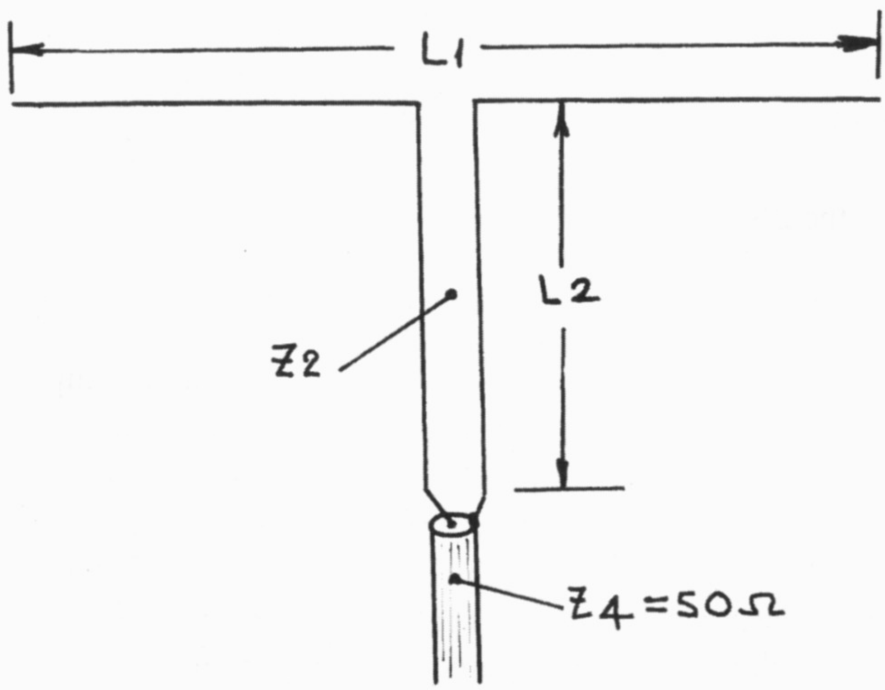
Imagine my surprise when told by a friend who'd caught his Sprat early that my old call sign featured prominently within issue No. 129. Sure enough, when I opened my copy, there it was: ZS6BKW that I'd not used in twenty years. Then I realised that it was my antenna and not me that was under the spotlight and so I suppressed my welling pride and read on with interest! How, I wondered had the antenna fared when Martyn G3UKV put it to the test? (See reference 1). Gratifyingly, it stood up very well and seemed to meet some useful needs. It might therefore also be useful if I provided a little background information about the antenna and also commented on how sensitive or critical the particular lengths and impedances of the ZS6BKW happen to be.

As pointed out by G3UKV, the basic ZS6BKW antenna is related to the famous G5RV first published in the RSGB Bulletin in 1958 by Louis Varney (ref.2). The G5RV is based on a clever idea in which a length of transmission line is used as a type of automatic ATU to produce an acceptable impedance match to a low impedance line on a number of HF bands. The beauty of the configuration is that it lends itself to careful analysis and therefore to optimisation. And that's where I started when I first looked at it seriously more than twenty years ago.



In my analysis of the G5RV configuration using both the Smith chart and my own computer program written in the early 1980s (and more recently using EZNEC) I always called the antenna proper L1 while the "series section matching transformer", that length of transmission line hanging down from its centre, is called L2 and its characteristic impedance is Z2. These details are illustrated in Fig 1.

Since 50 ohms is the impedance of coaxial cables most commonly used these days, rather than the 72-ohm twin-lead that Varney had in mind, I chose to make Z4 equal to 50 ohms. To qualify as a multiband antenna the combination of L2 and Z2 must be able to transform the impedance presented by L1 at its centre to some value relative to Z4 that'll satisfy some defined SWR criterion on all the bands of interest. I chose the upper SWR limit to be 2:1. This probably means that the antenna could be used without any other form of ATU since it's around about the point where the protection circuits kick in. My design target was clearly to have this happy state of affairs occur on as many HF bands as possible. G3UKV's measured results in Sprat Nr129 showed how well the antenna actually performed in practice. His finding that it also worked on 6m is an added bonus that I'd not considered but, as will be seen, it is certainly true that it does.

Anyone using the classical G5RV without an ATU will know that it only matches well on two of the HF bands: 14 and 24MHz. On all the others the SWR is never better than 3 or 4:1 and on most of them the best match actually occurs beyond the band limits. To be able to design the antenna (i.e. choose L1, L2 and Z2) so that the optimum match occurs within as many bands as possible requires a knowledge of the impedance at the centre of L1 on all HF bands. Such data were available in tabulated form in 1980 when I commenced my analysis, though probably not in 1958 when Louis Varney did his. Nowadays they can easily be determined by NEC and all its variants. Since L2 is just a transmission line it will act as an impedance transformer and the very best way of visualising that impedance transformation process is to use the Smith chart. For those who might be interested to see how this was done I refer you to my paper published in 1987, (ref. 3).

That paper also described how the Smith chart was used to design the antenna system and the beauty of the method is that one can see almost at a glance which combinations of L1, L2 and Z2 will work and then, if needs be, change them to suit particular objectives. Any method that allows such visualisation of what is a complex process has lots going for it and that was most certainly the case here. Since computers are supposed to do just what you tell them to (!), one can then write a program that'll test every sensible combination of those variables at will, and that is what my program did. And it was the Smith chart that made all this happen reasonably quickly by providing the "sensible combinations" to start with. What emerged were the dimensions of the antenna system that has since become known, at least in some circles, as the ZS6BKW.

It will've been noted from G3UKV's article that both L1 and L2 in the ZS6BKW differed from those in the G5RV. Whereas L1 was about three half wavelengths long and L2 a half wavelength on 20m in Louis Varney's antenna, in mine they bear no simple relationship either to each other or to a particular amateur band. It turns out from the analysis that the optimum lengths of L1 and L2 are about 1.35 and 0.62 on 20m. In addition, there is a range of values of Z2 that will produce the best match on five HF bands and over the widest possible bandwidths within those bands. The obvious question you will ask is how critical are these particular lengths. Fig 2 shows the limits of L1 and L2 that'll produce a better than 2:1 SWR on five HF bands. It must be remembered that those lengths of L2 in Fig 2 take no account of the velocity factor of the transmission line used in practice. So its actual physical length will be shorter than those shown here by an amount equal to that velocity factor, or about 0.9 for typical slotted lines.

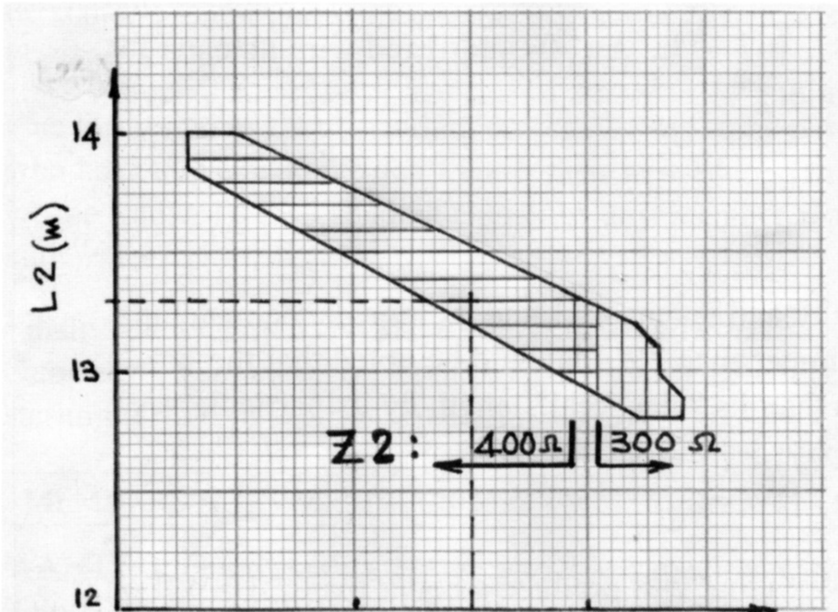


Fig 2 also shows the sensitivity of the multiband match to the value of Z2. It was clear from the analysis that 400 ohms was about optimum, though Z2 = 300 ohms is marginally better for the longest lengths of L1. If values of L1 and L2 close to the extremities within Fig 2 are chosen, the effect is to narrow the bandwidth over which matching will occur in some of the HF bands.

A very effective combination is shown in Fig 2 where L1 = 28.5m; L2 = 13.3m x V.F; and Z2 = 400 ohms. When erected horizontally at 10m above typical urban ground this antenna produced a better than 2:1

SWR on five HF amateur bands, viz. 40, 20, 17, 12 and 10m. The frequencies yielding the best match, and the 2:1 SWR bandwidths on each, are shown in the following table.

Band	40	20	17	12	10
Centre Freq. (MHz)	7.10	14.20	18.10	24.92	28.97
SWR min.	1.1:1	1.1:1	1.3:1	1.4:1	1.4:1
Bandwidth (kHz)	360	270	380	260	400

What about 6m? Martyn G3UKV's discovery that the ZS6BKW also matched well on the 6m band intrigued me so I tested it with EZNEC and sure enough it does. This particular version above produced its best match at 51MHz with SWR= 1.5:1. It also had a whopping gain of 12dBi with four major lobes at about 20 degrees to the wire in azimuth and tilted up at 25 degrees from the ground when the antenna was 10m high. Such features may well be useful to some.

So, if you want a simple antenna that will work on five HF bands without an ATU and on all of them with one, then maybe this is it.

References.

1) Martyn Vincent, Sprat, 129, Winter 2006, 32 -33, "The ZS6BKW Multiband HF Antenna Revisited".
2) Louis Varney, RSGB Bulletin, 34, 7, 19-20, 1958, "An effective multiband aerial of simple construction".
3) Brian Austin, J.IERE, 57, 4, 1987, 167-173, "An HF multiband wire antenna for single-hop point-to-point applications".

Captions

Fig 1: The configuration of the multiband antenna L1 and its impedance matching section L2 of characteristic impedance Z2. It should be noted that the physical length of L2 is less than its "electrical" length by its particular velocity factor VF; i.e. L2 (phys.) = L2 (elec.) x VF.

Fig.2: The lengths of L1 and L2 (elec.) that will produce a better than 2:1 SWR on five HF bands between 7 and 28 MHz. The hatched areas indicate the value of Z2 required to achieve this optimum matching condition. L1 < 29m requires Z2 of 400 ohms whereas antennas longer than 29m work better with Z2 of 300 ohms.

The ZS6BKW Multiband HF Antenna Revisited

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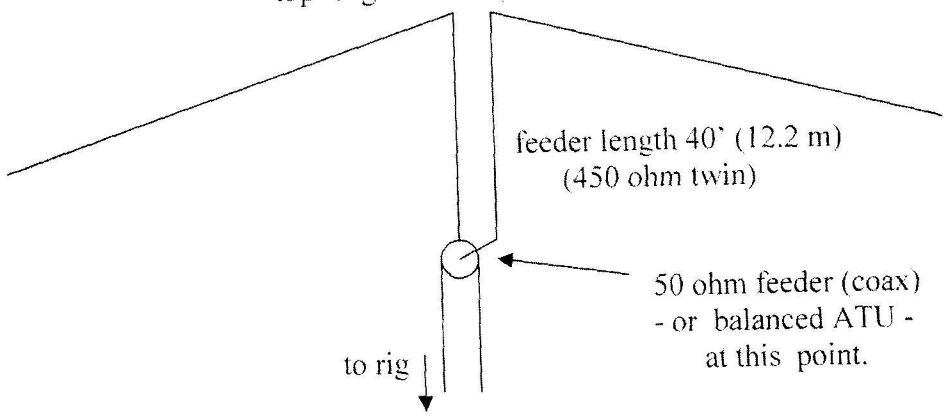
This is the antenna for you guys who want to get on HF effectively, and haven't too much space or cash to throw around. Actually, it's a design from ZS6BKW (aka GOGSF), similar to the G5RV, but it actually resonates on five bands, (well 6, actually) and doesn't rely on a tuner (ATU) to make it work. The design appeared in TT (RadCom) Jan and Feb 1993, but is also in Pat Hawker's "Antenna Topics" (publ. RSGB 2002) It's only 90 ft long (27.51 metres), with a 40 ft (12.2 m) downlead.

So, it's a cousin to the G5RV (which only resonates on 14 & 24 MHz), but better as it needs no ATU on 40, 20, 17, 12, 10 and 6 metres. When Telford DARS were doing the 50MHz Trophy contest down at Bridgnorth, I took the necessary bits along to tryout this antenna. For simplicity, I set it up as an inverted-vee configuration. The reason was simple - you only need one support to hold it up, not two. I also had the club's MFJ Antenna Analyser with me so that I could see what was happening. I recorded the data - see below.

Incidentally, all centre fed antennas can be supported by just one mast, with the ends left to droop down. The 'rule of thumb' is that the angle at the apex should never be less than 90 deg, otherwise cancellation between the two halves occurs. Furthermore, as it is the current peaks along an antenna that do most of the radiation, having the centre at the highest point is a positive advantage, rather than supported at each end with a big droop at the centre (current point nearest to ground). This is another reason for not being too fussy about the ends of a centre-fed antenna being lower, or bent around. It will have minimal effect on radiation efficiency. The only thing is never have the ends dropping right down to ground level - because the ground will seriously de-tune the antenna and it will not work - believe me, I've tried it. Just a yard or so off the deck makes all the difference. Simply have end insulators (or plastic strips etc), then wire or twine to the tying-off points. This effectively raises the ends of the antenna sufficiently clear of the ground. So, the 'BKW can be horizontal (two supports) or inverted-vee layout (single support), as shown. Incidentally, the same applies to a simple dipole.

The antenna wire can be solid copper, stranded, insulated or not. A lot of rubbish is printed about the merits or otherwise of different sorts of wire.
It's largely hogwash. Wire is wire at these frequencies. Wet string?. ..well that's a different matter ....
In the original design, 300 ohm twin was used, but I prefer the 450 ohm stuff. It's much stronger and losses, especially in wet weather, are lower when impedances are high down the line. Back in 1985, 450 twin wasn't readily available, there was only 75 and 300 twin, or the option of making your own open-wire feeders (which actually are the best of all- around 600 ohm, but these do tend to twist or get caught in trees etc! Yes - bitter experience and soldered joints here too!)



Finally, if you want to use it on other HF bands (3.5, 10,21 MHz), an ATU (just like at the bottom of your '5R V !) will do the business, but preferably at the bottom of the 450 ohm feeder with a balanced output, not after a length of 50 ohm coax, if you've had to use it to reach your rig. Of course for 1.8 MHz (160m), you could short out the feeder twin, and feed it like a Marconi antenna, with a suitable ATU. Not very clever, however.

Here are the MFJ figures I recorded on the test antenna:-

Best in-band freq:	SWR	"R" at feedpoint	Notes
3.38 MHz (80m)	7:1	20	tunes easily with A TU
7.00 MHz (40 m)	1:1	40	puurrfect
10.1 MHz (30 m)	high	high	needs atu
14.06 MHz (20 m)	1:1	40	wonderful
17.85MHz(17 m)	1:1	50	below 1.3:1 in 18MHz band
21.00 MHz (15m)	high	high	needs atu
24.69 MHz (12 m)	2:1	100	OK, even without an *ATU*
28.62 MHz (10 m)	1.3:1	60	No sweat!
50.27 MHz (6 m)	1.3:1	60	A surprise: 6m. too!

Just to show the "proof in the pudding", I used it on 7 and 14 MHz, and got excellent reports, as one would expect with a half-decent antenna! Didn't have time to use it on all bands, but I leave that to you - to tell everyone how good it is.

Note from G8PG – G0GSF (ex-ZS6BKW) only lives 2 miles from my home QTH.

AWARD NEWS

Worked G QRP Club 140 Members G3ZNR. Well done OM.

Very best New Year wishes to all AAA readers from Gus, G8PG.

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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3. Austin, B.A. (1982) Potential of the G5RV antenna.
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