A multi-band inverted-V dipole for portable operation

PART ONE

At the time of writing, the author had activated 148 islands, 136 of these in the last eight years for the SCOTIA (and IOSA) Scottish island award programmes (for further information, see his website www.gm3vlb.com). Operating time is generally limited, with most operations (many of which have been ‘solo’) being of 1 or 2 days’ duration. The majority of Scottish islands are uninhabited, and often inhospitable. Landings may have to take place in a strong Atlantic swell, and from very small craft such as a dinghy or RIB. (rigid inflatable!). The time-consuming assembly of complex rotary beams has heretofore never been considered. Likewise, any amplifier would necessitate both a larger and heavier generator and more fuel. Even if used in conjunction with a beam, such a setup would be unlikely to give more than a few dB gain over the Kenwood TS-50S running 100W into a well-matched inverted-V near the sea. In practice, it has been found that 50W (½ an S-unit) would be unlikely to give more than a small, focal gain over the Kenwood TS-50S. In this first part of a two-part article, GM3VLB describes one of his latest designs, which has been tried and tested. The principal advantage of the inverted-V dipole is that it requires only one, central, support. The main ‘mast’ used by the author is ex-army and comes in a convenient shoulder bag containing eight 1m long fibre-glass poles, two sets of guys (three at the centre and three at the top) and a simple pulley system (an ultra-light-weight version using a ‘roach pole’ has also been constructed). The mast is easily erected by one person, even in a howling Hebridean gale, and supports the antenna, which acts as a resonant λ/2 inverted-V dipole on each of the 20m, 40m and 80m bands. The antenna can also be used on the 15m band, where it behaves as a 3λ/2 dipole (3λ/2 means ‘one and a half wavelengths’ – 21.150MHz is 3 x 7.050MHz, so λ/2 on 40m is 3λ/2 on 15m.

A second, lighter, multi-band inverted-V covering 10m, 12m, 15m, 17m (and 30m with end extensions) supported at about 7m by a roach pole, is also available. (The author has recently tested another design of the same overall length as the 20/40/80m version, but with a slightly different configuration and in which the 20m dipole is 3λ/2 long, giving a small, though useful gain on this band and with two additional main lobes, giving increased global coverage – see the Appendix next month for details.

As stated above, these antennas are complemented by a variety of multi-band verticals, most of which can also be used /M on islands with vehicular access.

BASIC DESIGN CONSIDERATIONS

The multi-band dipole is set-up in inverted-V configuration, ie the central feed-point is at the apex of the A at the top of the mast, with the two halves sloping down to points about 60cm (2ft) above the ground. On 20m and 40m, it is designed to be resonant mid-way between the IOTA CW and SSB frequencies generally favoured by island operators and (corresponding in this case to 14.150MHz and 7.050MHz). On 80m, the design frequency is 3.772MHz. A switched linear balun transformer at the feed-point (giving a choice of two ratios, either 1:1 or 2.25:1) allows impedance matching as well as unbalanced coax-to-balanced dipole operation. The feed-line consists of a 13.6m length of 50Ω RG-58 coax (75Ω coax was used, unwittingly, for several years - see below). This is a velocity factor-corrected half-wavelength on 40m, two half-wavelengths on 20m and three on 15m. On these bands, the coax simply reflects the impedance at the load end – in this case, the input to the balun. On 15m, 20m and 40m, this is reasonably close to 50Ω, thus providing a good match to 50Ω coax and thence to the TS-50S. On 80m, at a height of only 8m (0.1λ), the textbooks would suggest an input impedance of only a few ohms. In practice, it would seem to be quite a bit higher than can be measured on 50Ω. However, at the time of the early experiments, the author did not possess an antenna analyser. A lower value of around 20Ω was therefore assumed (had the physics teacher not repeatedly said ‘never assume anything boy’?). A 2.25:1 balun was designed to raise this to nearer 50Ω to provide a better match for the coax and the TS-50S. When the system was tested using this balun, the VSWR was, indeed, as predicted. Switching over to the 1:1 balun resulted in an unusable VSWR! All worked perfectly - except the maths!

One day, some years later on the island of Rum, a coax fault occurred. The spare coax was installed. Result? High VSWR on 80m! With the help of island partner Alex, GM0DHZ, and whilst battling the most intense infestation of midges ever experienced, everything was tried and tested...to no avail. Later, whilst repairing the faulty coax, it was noticed to be of slightly larger diameter. It had been made from a length of RG-59 salvaged from the author’s 524 days in the X-output 1960s! It was 75Ω coax and not 50Ω as originally thought!

So why did it work? Well, it’s amazing how you can ‘prove’ something with the wrong mathematics! Now, by working backwards, and applying what was believed to be the correct quarter-wave transformer formula, but the terms of which had been inadvertently transposed, the actual antenna impedance had been ‘proved’ to be 33.75Ω – this had seemed entirely reasonable!

In fact, no-one had challenged this ‘proof’ until a few weeks ago when Dale, WB6BYU, in Oregon e-mailed me saying (ever so diplomatically!): “You’re wrong mate! The formula should be: Z_{frig} = Z_{load} x Z_{rig}.

If we again work ‘backwards’ using Z_{rig} = 50Ω and Z_{coax} = 75Ω, we get
Z_{load} = 112.5\Omega.

Remembering our 2.25:1 balun, the antenna input impedance must in fact be 112.5/2.25 = 50\Omega!

WB6BYU said that his own experiments indicated the input impedance was nearer this value and, if this was the case, all that was required was to use the 1:1 balun and 50\Omega coax! This, in fact, is the case! This just shows that you shouldn’t always believe what you read! Thanks, Dale…

**ATU or no ATU?**

Clearly, the antenna system is resonant and matched and an ATU is therefore not normally required on any of these bands (e.g. 15m, 20m, 40m or 80m). The author is basically ‘anti-ATU’, but does carry a very small homebrew T-match ATU consisting of two 200\mu F semi-variable capacitors, modified to have a shaft, and a switched 40-turn toroid + 6-turn fixed coil assembly – this is primarily used to tweak the GM3VLB multi-band fishing rod verticals which are also essentially resonant. See the ATU photograph.

**Details of the ATU**

Referring to Fig 1:

L1: 25mm diameter, 6 turns / 18SWG tapped at 2, 4 & 6 turns.
L2: T130-2 toroidal core, 40 turns / 18SWG tapped at 2, 4, 7, 10, 14, 19, 25, 32 & 40 turns.
NB: Do not be tempted to connect X to Y as this creates shorted turns which are not permissible when using toroidal cores.

**Winding the Balun**

**Fig 2** shows the circuit diagram of the dual-ratio balun, and **Fig 3** the constructional details. Stretch four 45cm lengths of enamelled 20 or 22SWG copper wire from a vice to remove any kinks. (Different colours are ideal). Twist these together about eight times. Wind eight turns onto a 10mm diameter ferrite rod, about 6cm long (perhaps salvaged from a transistor radio?), holding the ends in place with tie-wraps (for example). With tag-strip fixed to the ends on the windings (not shown), use further enamelled wire to make three links between a1 and b, b1 and c, and c1 and d (make these links as short as possible). All links and joints should be soldered – do not rely on purely mechanical connections.

**Construction of the Dipole Legs**

There are two insulators (see the photograph and **Fig 4**) on each leg, made from suitable plastic (test in a microwave oven first!) about 60 x 20 x 5mm, each with a hole at each end to take a small S-hook attached to the small strain-relieving thimbles (**Fig 5**) at the ends of each element. A central brass bolt and wing nut allows a particular element to be connected or not (a plug and socket arrangement, or 1/4in spade connectors could also be used). The lower ends of the 20m and 40m elements are soldered to the heads of the bolts whilst the upper ends of the 40m and 80m elements have 13 – 15cm ‘tails’ with U-shaped tags to fit under the wing-nuts. The thimbles can be pro-
fessional, metal or plastic, or can be otherwise improvised.

Band changing is simple – simply lower the dipole, disconnect the unwanted segment(s) and hoist the aerial up again - two minutes at most!

**NEXT TIME…**

GM3VLB looks at the numbers behind the design, the nature of the ground and the height of the antenna ends above it. Dimensions are given for the bands in use.

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