# The GM3VLB

**The author had been searching for a compact beam which could be easily and quickly assembled for portable operations from Scottish islands, because time wasted assembling a complex station on an island means that many lose the chance of a QSO with that island. Here is his solution.**

*Fig 1*

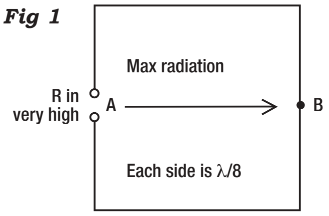
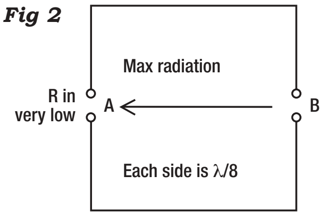


*Fig 2*



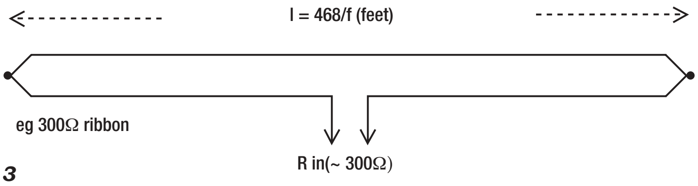


*Fig 3*

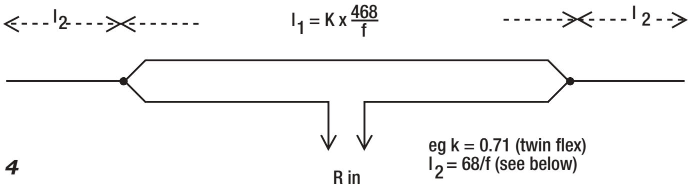


*Fig 4*

***Fig 1: The closed half-wave loop.***

***Fig 2: The open half-wave loop.***

***Fig 3: A simple folded dipole.***

***Fig 4: A 'modified' folded dipole.***

We must assume that if a station is calling you, he/she can hear you (not always the case nowadays of course, when 'listening' means, for some, watching the DX Cluster listings on a monitor and then calling blind, whether you can hear the DX or not!). Let's be honest, a compact beam is unlikely to give you more than 3dB gain – equivalent to half an S-point at the other end. Is it worth the effort?

However, these thoughts did not stop me experimenting. Having done all my DXing, in my previous life as 5Z4KL, with quads or loops, I dug out my old 1970 bible, *All About Cubical Quad Antennas* by the late Bill Orr, W6SAI. I had built and worked /P with half-size loaded two-element quads, but had rejected them due to the narrow bandwidth and initial tuning problems. However, my 1964 edition of the ARRL *Antenna Handbook* made passing reference to half-wave loops. I decided to investigate these further.

## THE HALF-WAVE LOOP

First of all, let me say that theoretical information on the half-wave loop seems to be very hard to come by. A search through some two dozen antenna books at a recent radio rally, produced only *one* reference of any substance (and this originated from the ARRL *Antenna Handbook*).

A half-wave loop is formed by bending a simple half-wave dipole into a loop, the circumference of which is thus a half-wavelength long. The loop can be any shape, from square (with each side λ/8) to circular (of radius λ/4π). In the case of the square loop, there are two possibilities – the closed loop, as in **Fig 1**, or the open loop, as in **Fig 2**, in which the side opposite the feed-point is *open* at its centre.

The current distribution is similar to that along a half-wave dipole. In Fig 1, the input resistance at the feed-point A is high (a few thousand ohms) as the current is minimum at A and maximum at B. In the case of the open loop (Fig 2), the current is maximum at A and minimum at B. The input resistance is therefore low and of the order of a few ohms. Unlike the simple dipole, there is no direction in which radiation is zero. This results in the gain of the half-wave loop being about 1dB less than that of a dipole (-1dBd), but having a front-to-back ratio of some 4 to 6dB in the direction of maximum radiation which, for both configurations, occurs in the plane of the loops and in the directions shown by the arrows. Such a half-wave loop would therefore normally be mounted horizontally.

If there are any readers who are dab hands with *EZNEC* or similar, the author would be most interested to see the radiation pattern of such an open horizontal half-wave loop in the horizontal plane, referenced to a simple horizontal dipole at the same height.

As stated above, the loop can be any shape. It occurred to me that a square loop requires four spreaders whereas a triangular (or 'delta') loop requires only three. This could be an advantage for /P operation. The 'open' configuration input resistance is too low to match 50Ω coax directly. Either some form of matching must be used, or the input resistance must be raised. It occurred to me that a folded dipole does precisely that.

## THE FOLDED DIPOLE

### Simple form

One or more extra conductors half a wavelength long are added in parallel with the original dipole – see **Fig 3**.

The input resistance is raised by the square of the number of conductors. For example, if the folded dipole has two conductors, its input resistance

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# Mini Delta

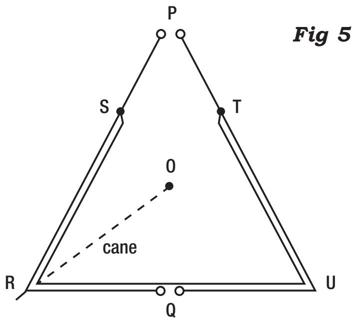

*Fig 5: A folded dipole half-wave loop.*

$\lambda/2 = PSRQUTP = 504/f$

$PSRQ = PTUQ = 504/2f$

$QRS = QUT = 358/2f$ (1)

$PS = PT = 73/f$ (2)

$QR = QU = 504/6f$ (3)

$OR = QR/\cos 30°$ (4)

## EXAMPLE

The dimensions for the GM3VLB mini-delta beam for 20m (14.175 MHz) are calculated as follows:

| | | | |
|---|---|---|---|
| From (1), length of twin-flex needed | $= 2 \times 358/(2f)$ | = 25ft 3in | (i) |
| From (2), length of single flex needed | $= 73/f$ | = 5ft 2in (to the nearest inch) | (ii) |
| From (3), distance to spreader from feed-point | $= 504/(6f)$ | = 5ft 11in | (iii) |
| From (4), minimum spreader length | $= 504/(6f\cos 30°)$ | = 6ft 10in | (iv) |

In practice, these dimensions are modified slightly to allow for final tuning in situ and to allow other loops (in the case of a multi-band beam) to 'fan in' to a common feed-line connection point (via a 1:1 balun). As with all antennas with shortened radiating elements, the bandwidth will be less than that of a full-size beam. I measured this to be about 240kHz with a centre frequency of 14.175MHz - a very acceptable figure for such a small beam. Those who regularly operate CW in the lower reaches of the band allocations, will find that only minor length adjustments are required at the open end. Setting the desired resonant frequency is extremely simple.

rises from 72Ω to around 300Ω (with three conductors, the input resistance would be 72 x 9, ie around 650Ω). Another useful feature is that the bandwidth of the folded dipole is also increased. relative to a simple dipole.

The length, $l$ (ft), of a simple horizontal dipole in free space is given by the formula

$$l = \frac{492}{f}$$

where $f$ is the desired resonant frequency in megahertz (MHz). In practice, due to end-effects, the actual physical length is reduced to $468/f$. If, instead of open-wire line, the folded dipole is made from solid twin-conductor line such as 300Ω TV ribbon or perhaps from 'figure-of-eight' electrical flex, loudspeaker or bell wire, the velocity factor, k, of the line should be taken into consideration as follows.

### Modified folded dipole

The overall length of the folded dipole remains $468/f$, but the length of the shorted parallel section is reduced by the velocity factor, k. The length of this section is therefore given by $468k/f$. See **Fig 4**.

I used the MFJ-259B Antenna Analyser to determine the velocity factor of the figure-of-eight clear lighting flex/loudspeaker wire used in the prototype mini-delta beam, and found it to be approximately 0.71. The length of the 'shorted' section is thus 468 x $0.71/f$, or $332/f$, leaving $136/f$ for the end sections ($68/f$ at each end).

## THE FOLDED DIPOLE HALF-WAVE LOOP

If, instead of bending a simple dipole into a loop (the input resistance of which drops from 72Ω to a few ohms), we take a folded dipole and bend that into a loop and, if its input resistance, now of some 300Ω, drops by the same order of magnitude, it should become a fairly good match to 50Ω coax. This was my reasoning. My knowledge of antenna theory is very limited and I would be happy for anyone to shoot me down in flames! However, the results obtained seem to suggest that this simplistic reasoning works.

### Lengthening effect of the loop

As W6SAI explains in his book on quad antennas, bending a dipole into a loop actually has a lengthening effect (there is no end-effect in this case). Although he suggested that the electrical or free-space wavelength ($492/f$) is increased by a factor of 1.028, my own experiments have suggested an empirical value of 1.024. Applying this to the free-space length produces the figure of $504/f$ for the overall length of a closed half-wave loop. If the velocity factor is now applied, the folded section should have an overall length of $358/f$, while each end-section is increased to $73/f$. These are the design figures I have used.

### The 'Delta' design

As stated earlier, the delta configuration (named after the capital letter 'D' [Δ] in the Greek alphabet) was chosen, as this reduces the number of supports from four to three, for only a relatively small increase in support length. Each spreader is less than seven feet long – very short for a 20m antenna! An individual loop is shown in **Fig 5**. In the diagram, Q is the feed-point. In the formulas that follow, $f$ is the design frequency.

## INITIAL TEST RESULTS

As I operate largely on or about the IOTA frequencies (CW and SSB), I adjusted the resonant frequency of the prototype version of the 20m mini-beam to 14.150MHz. This was done with the mini-delta loop mounted only five feet above the ground on a light aluminium pole replacing the parasol of a patio table. At resonance, an MFJ-259B antenna analyser indicated an SWR of 1:1, indicating zero reactance and an input resistance of 50Ω. The measured bandwidth was about 240Hz (earlier tests on a very much 'Heath Robinson' five-band prototype, had produced very similar results). Raising the loop to 15ft above ground produced only a very slight rise in the resonant fre-

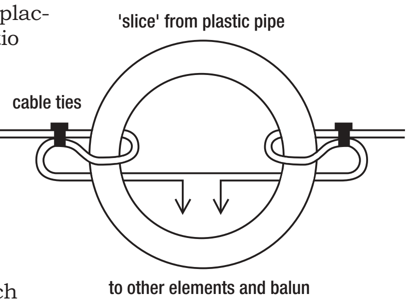

*Fig 6: The mid-point of the folded element.*

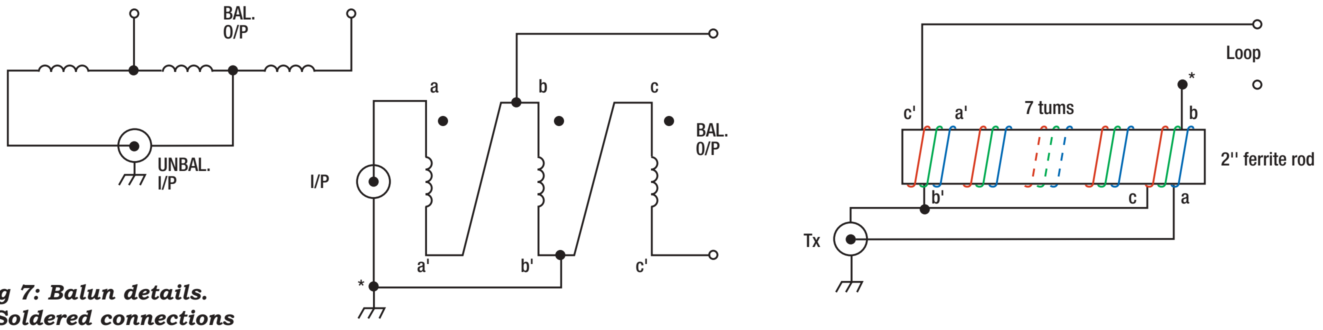

*Fig 7: Balun details.*
** Soldered connections*

quency and no change in the input characteristics. At this height, several QSOs showed no discernible difference in signal strength at the DX end, when compared with my 20m inverted-V dipole 30ft up at its apex. At the receiving end, there was a barely discernible drop of about 2dB on the mini-beam.

## CONSTRUCTIONAL HINTS

A suitable central support should be manufactured. For portable use, this could be a triangular piece of wood or plastic with four tubes to take, say, three garden canes and the short support for the feed-point and balun. Some sort of bracket to take a vertical mast is also needed. The design of this central support is left to the ingenuity and junk box of the individual constructor.

Small cable ties are used to attach the mid-point of the folded element for each band, to a suitable circular insulator as shown in **Fig 6** (such as a 'slice' from 1¼in rigid plastic gas or water pipe, or a car exhaust rubber O-ring).

Distances QR' and QT' should be measured from the O' ring and points R' and T' marked (permanent marker or whatever) on each element.

The spreaders should be around seven feet overall to begin with, to allow for adjustments. They can be trimmed later. They should be measured from the centre of the support and marked for each band.

## EXTRA LENGTHS

PS and PU are increased from 73/*f* by an amount 5/*f* to 78/*f* (corresponding to approximately 2in to 4in, depending on the band). An extra 2in of folded element section (1in for each side) is allowed for wrapping round the ring, after which one side of each element is split and all elements are then tied together and connected by short flying leads to the 1:1 balun. The middle loop (15m for a five-band beam) is an equilateral (equal-sided) triangle, but minor allowances must be made to the other elements to allow them to fan out. Table 1 summarises these allowances and all other relevant dimensions for a five-band mini-delta beam.

## FEED-POINT

The loop is a balanced antenna system and is therefore fed via a 1:1 balun. In its simplest form, this consists of a trifilar winding on a short length of ferrite rod salvaged from a scrapped transistor radio. This is mounted in a small ABS plastic box held securely at the end of a suitable support OQ' (eg wooden dowelling or similar insulating material). Its length OQ' (ie from the geometrical centre of the beam to the centre of the ring) is calculated as follows:

OQ' = Q'R' tan 30° = 2ft 3½in.

In practice, the support rod OQ' is made slightly longer.

To construct the balun, take three 16in lengths of 20 or 22SWG enamelled copper wire (ideally different colours), twist together about 10 times and wind seven turns onto a 2in length of ferrite rod. Make short connections between the windings as shown in **Fig 7**.

The output of the balun consists of short tails passing through the box to a two-terminal connector mounted on its lid. This connects to the common feed-points. A 3ft length of RG-58U coax is soldered to the balun input, taped to the balun support 'boom' and terminated in a 50Ω BNC female in-line connector. This allows connection to an antenna analyser or to the feed-line.

## ANTENNA ADJUSTMENT

Short lengths of nylon fishing line or similar are attached to the loop ends, P, and the lengths of PS and PU are adjusted until resonance occurs at the desired point in each band. If desired, the beam may be rotated in the horizontal plane. The overall appearance of the beam is shown in **Fig 8**, with dimensions given in Table 1. ◆

*Fig 8: The overall construction of the mini-delta beam. The support at Q' is not shown. See Table 1 for element dimensions.*

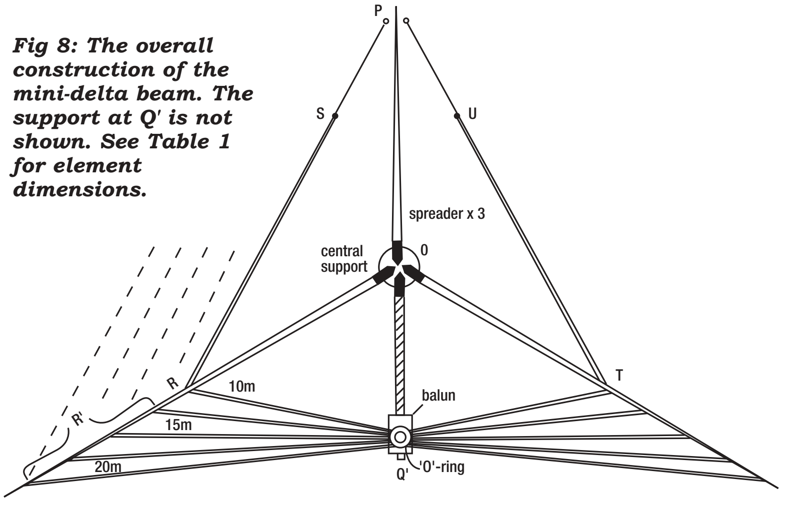

*Table 1: All dimensions and 'allowances' for the five-band mini-delta beam.*

| Design *f* (MHz) | QRS = QTU = 358/2*f* | QR = 504/6*f* | OR = QR/cos30° | Extra for fan-out | Q'R' (QR + extra bit) | SP = UP = 73/*f* | Extra 5/*f* to adjust *f* | SP' = UP' = 78/*f* |
|---|---|---|---|---|---|---|---|---|
| 14.175 | 12' 7½" (+2") | 5' 11" (+1") | 6' 10" | 1¼" | 6' 1¼" | 5' 1¾" | 4" | 5' 4¼" |
| 18.110 | 9' 10½" (+2") | 4' 7½" (+1") | 5' 4¼" | ¼" | 4' 8¾" | 4' 0½" | 3½" | 4' 2¼" |
| 21.225 | 8' 5¼" (+2") | 3' 11½" (+1") | 4' 6¾" | 0" | 4' 0½" | 3' 5¼" | 3" | 3' 7" |
| 24.940 | 7' 2" (+2") | 3' 4½" (+1") | 3' 10½" | ¼" | 3' 5¾" | 2' 11" | 2½" | 3' 0½" |
| 28.300 | 6' 4" (+2") | 2' 11½" (+1") | 2' 5¼" | ½" | 3' 1 " | 2' 7" | 2" | 2' 8¼" |