

Weekend Antennas No. 2 The Versatile Vee Beam

Our second “weekend antenna” project is an aerial that you can use on all eight High Frequency amateur bands (80, 40, 30, 20, 17, 15, 12 and 10m) with an antenna tuner, and which gives significant gain on the five bands from 20m to 10m. It is easy to construct, requiring only wire, spacers and suitable supports, has no trap coils to wind, metalwork, or critical dimensions, and has a low visual profile so many neighbours won’t even notice it!

The Long Wire

A good way to understand the Vee Beam is to start with the humble long-wire antenna, a length of wire at least one wavelength long fed against ground. The far-field pattern of a long wire antenna consists of a number of lobes at different angles to the wire. The number of lobes depends on the length of the wire, in wavelengths, while the strongest lobe is always the one closest to (i.e. making the smallest angle with) the wire. Figure 1 shows the far-field pattern of a wire 2 wavelengths long that runs horizontally along the page and is fed at the left-hand side.

* Total Field
Horizontal Pol
Vertical Pol

EZNEC+

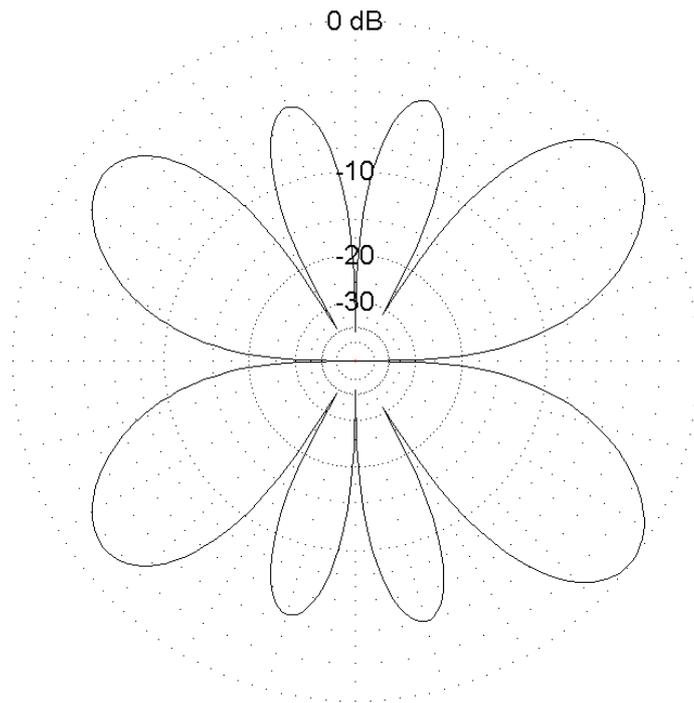


Fig. 1: The far-field pattern of a 2-wavelength long wire

In this case the main lobe is at an angle of about 40 degrees from the wire. As the wire gets longer, the number of lobes increases and the main lobe gets stronger and closer to the axis of the wire. Note that the lobes in the direction from the source to the end of the wire (in our case, from left to right across the page) are slightly stronger (by about 1.5 dB) than the lobes in the other direction.

Long wires have always been popular because of their simplicity and because with the help of an antenna tuner they can be made to work on all bands. However they do have a couple of disadvantages:

1. The antenna starts right where the tuner is, which is typically in the shack, so a significant amount of radiation ends up in the shack, where it can cause havoc with equipment, and does not contribute to your signal.
2. Like all antennas that are fed against ground, a significant percentage of the power applied to the antenna may be lost due to ground losses. Although the losses can be reduced by installing a ground radial system, this defeats the object of a simple antenna system.
3. The pattern has multiple lobes, and the angle of the lobes to the wire depends on frequency, so it is difficult to aim the antenna at a particular geographical area.

Vee Beam Basics

Fortunately all these problems can be solved by the simple expedient of putting two long wires at an angle to each other to form a vee, and feeding the wires against each other using a balanced feed at the apex of the vee. The resulting antenna is called a “Vee Beam”. Figure 2 shows the layout of Vee Beam seen from above.

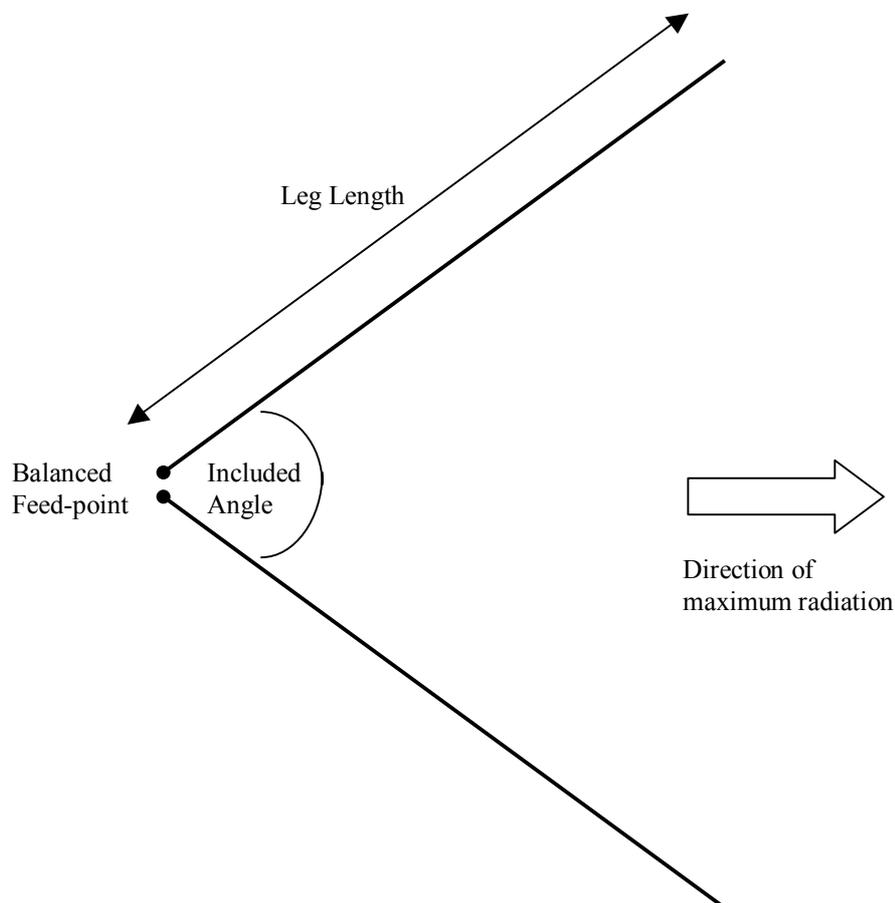


Fig. 2: Layout of the Vee Beam

The two key parameters of a Vee Beam are the *leg length* – the length of each wire, measured from the feed-point – and the *included angle* – that is, the angle that the two wires (legs) make to each other. A Vee Beam will perform well as a directional antenna with a leg length of between 1 and 5 wavelengths. The longer the “legs”, the greater the gain and the narrower the

beamwidth. If the leg length is below about one wavelength, the antenna no longer gives gain in the direction indicated, although it is still possible to match the antenna with a leg length as short as $\frac{1}{4}$ wavelength, where it is effectively a “bent dipole”.

The angle between the legs is chosen so the main lobes of the long-wire patterns from the two wires reinforce each other, giving an additional 3dB gain advantage over a long wire antenna of the same length as one of the legs of the vee. The optimum included angle depends on the leg length, in wavelengths. The table below shows the optimum included angle and the resulting free-space gain (in dBi) and -3 dB beamwidth for various leg lengths.

Leg length (wavelengths)	Optimum included angle (degrees)	Free-space gain (dBi)	-3 dB beamwidth (degrees)
1.0	90	5.3	31
1.5	82	6.8	22
2.0	68	7.8	20
3.0	56	9.0	16
4.0	48	9.9	13
5.0	42	10.5	12

It might appear from the table that the Vee Beam is not a good choice for a multi-band antenna since the optimum included angle will be different for each band. Fortunately, however, the performance of the Vee Beam is not very sensitive to changes in the included angle, so it is possible to find a compromise that will give good results on several bands. One such compromise is to make the leg length about one wavelength at 14 MHz (21.4m), with an included angle of 80°. This gives the following gain and -3dB beamwidth figures for various amateur bands:

Frequency (MHz)	Gain (dBi)	-3dB Beamwidth (°)
14.000	5.3	34
18.068	6.5	26
21.000	7.0	23
24.890	7.5	19
28.000	7.6	18

There is nothing special about a leg length of 21.4m – it was chosen simply to allow comparison with the previous table. As you can see, the gain at 14 MHz (where the leg length is 1 wavelength), at 21 MHz (leg length $1\frac{1}{2}$ wavelengths) and at 28 MHz (leg length 2 wavelengths) are at most a couple of tenths of a decibel off the optimum.

Figure 3 shows the free-space azimuth pattern of a Vee Beam with legs that are one wavelength long at 14 MHz. As with the long wire, the gain in the forward direction (towards the open end of the vee) is about 1.5 dB greater than the gain in the reverse direction. Although the leg length is not critical (in general, the longer the better, up to a maximum of about 5 wavelengths at the highest frequency of operation), it is important that the two legs be the same length to preserve the balance and symmetrical radiation pattern of the antenna.

Total Field

* 14 MHz
 21 MHz
 28 MHz

EZNEC+

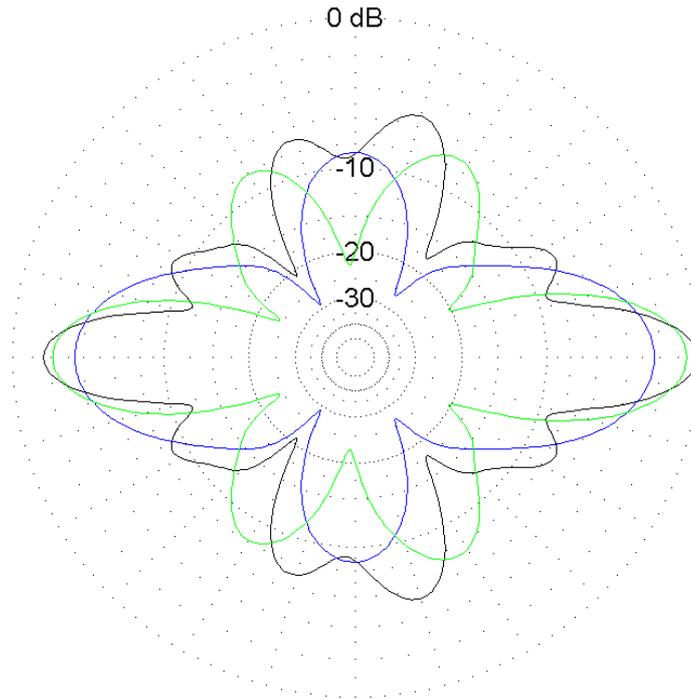


Fig. 3: Free-space pattern of a Vee Beam with 21.4m legs and an included angle of 80°

Feeding the Vee Beam

The Vee Beam needs a balanced feed for best results. This can be obtained either from a remote balanced tuner at the feed-point (if you are lucky enough to own one), or by feeding it with balanced feed-line such as window line or open-wire line to either a balanced tuner or a single-ended tuner with a balun in the shack.

If you use a remote tuner located at the feed-point, then it may be advisable to choose a leg length that is not an integer number of half wavelengths long on any of the frequencies to be used, to avoid presenting the tuner with a very high feed-point impedance. If you feed it with balanced line, then there is no need to avoid these leg lengths, as the feed-line will in any case transform the impedance seen by the tuner. However if your tuner struggles to match the antenna on any bands, then you should increase or decrease the length of the balanced feeder until a length is found that allows the tuner to match the antenna on all bands.

To Terminate or not to Terminate

If both legs of the Vee Beam are terminated by resistors of the correct value (usually about 500 or 600 Ω) connected to ground then it becomes a traveling wave antenna. The input impedance becomes fairly constant (about 600 Ω) across a wide range of frequencies, and the rearward radiation pattern is suppressed making the terminated Vee Beam unidirectional. However this does *not* increase the forward gain of the vee, since the power that would have been radiated in the reverse direction is simply dissipated in the resistors. In fact, the forward gain of a terminated Vee Beam is actually slightly less than for the same Vee Beam without terminating resistors. The termination resistors must be non-inductive and should each be capable of dissipating about a third of the power applied to the antenna. I decided not to terminate my vee, for the following reasons:

1. The forward lobe is aimed along the short path to North America, so the reverse lobe allows me to work the long path.

2. I didn't want any reduction in the forward gain.
3. It simplified the construction of the antenna, as terminating resistors were not required.

Construction

Construction is simple, the only problem being to find three suitable supports (for the apex and the ends of each leg). In my case, I was fortunate to have a couple a suitably positioned trees in the garden to support the ends of each leg; and I erected a 10m wooden mast made from two poles near my shack to support the apex of the vee. I made the antenna and feed-line using two equal lengths of 1mm² panel wire. Each length serves both as one side of the antenna and as one side of the feed-line, so there are no joints to corrode or fatigue. I chose panel wire with green insulation, which blends in with the foliage of the trees, making the antenna quite hard to spot. The two sides of the feed-line are spaced apart using surplus plastic insulators about 5 cm long, which I was fortunate enough to obtain when our club sold off some surplus "junk". The panel wire is secured to the insulators using a drop of quickset epoxy. If you don't have suitable insulators, then you can easily make them from a sheet of Bakelite, Perspex or printed circuit board material (with the copper removed, of course). I fed the feed-line into the shack through a plastic "ventilation brick" in the shack wall, remembering to space it away from conductive objects, and connected it to a W2DU-type balun (a number of ferrite beads slipped over a 30cm length of coax) fed by a very short (50 cm) length of RG213 coax from my transceiver, a Kenwood TS-850S with an internal ATU.



The feed-point of my Vee Beam

So how does it play?

Being an avid (if inexperienced) contester, I decided to put the Vee Beam to the test in the harshest possible environment, the 48 hours of fun and madness called the CQWW International DX contest. I used the vee as my sole antenna for the 2004 CW contest, where I operated on the 40, 20, 15 and 10 metre bands. My overall impressions were good. On the higher bands (10, 15 and 10 metres) it seemed to give my low-power (100W) station some added punch into North America compared to the dipoles I had been using, and I certainly didn't feel under-equipped compared to stations with triband beams. Of course, since the beam is not rotatable and was aimed at North America, I was at a considerable disadvantage when working other parts of the world. Nevertheless, I still managed to put a reasonable signal into Europe, at least when the bands were open, showing that side-lobes do have their uses! On 40m the performance was similar to any low dipole (weak and omni-directional) but I still managed to work 35 DXCC entities, including 9N7BCC in Nepal.

I found that the TS850's internal ATU did not match the vee on all frequencies in the bands, so perhaps a more capable external ATU (preferably balanced) is called for. I also noticed an RFI problem with the shack computer on 10m, which seemed to be caused by the open-wire feeder coupling to the computer keyboard cable. A snap-on ferrite core solved the problem. Other than that, the antenna performed flawlessly, and I made 895 QSOs over the weekend, a couple of hundred more than last year. Now all I need are a couple more Vees pointing at Europe and Japan. Darling, we need a house with a bigger garden...