

Weekend Antennas No. 3
A Magnetic Slot for 40 Metres

As we approach the solar cycle minimum, the lower frequency bands become increasingly important for DXing. Many amateurs use wire antennas on the 40m band and below, typically the horizontally polarized dipole and its variants such as the inverted V, W3DZZ and G5RV.

One of the limitations of all horizontally polarized antennas is that the elevation angle of maximum radiation depends largely on the height of the antenna above ground – in general, the higher the antenna above ground, the lower the angle of maximum radiation. Since effective DX communication requires a low takeoff angle – typically around 10 degrees or so – horizontally polarized antennas that are intended for DX communication should be mounted as high above ground as possible, preferably half a wavelength or higher. This poses a problem for the low bands, since raising an antenna half a wavelength above ground on the 40m band requires a support about 20m high, which is more than many amateurs can manage. The required height becomes quite excessive on the 80 and 160-metre bands.

This is not to say that horizontally polarized dipoles and their variants don't have their uses on the low bands. They can be very effective for local and middle-range communications, for example around South Africa. They just aren't great for DX.

Fortunately, vertically polarized antennas provide a good alternative for low-band DXing. Because ground reflections are in-phase for vertical antennas, they are capable of good performance at fairly low elevation angles (depending on the conductivity of the ground) even when mounted fairly low. Most vertically polarized antenna designs also have a null in the pattern overhead the antenna, which reduces the amount of energy that is radiated at high takeoff angles, allowing more to be concentrated at the low takeoff angles needed for DX. Vertical antennas are also less responsive to high-angle signals when receiving, which can help to attenuate local noise and QRM.

When most of us think of vertical polarization, the antenna that first comes to mind is the vertical monopole, especially in its quarter-wave vertical form, which is usually fed against ground on the lower bands (by this I mean that the braid of the coax is connected to ground, while the inner conductor is connected to the radiating element). This raises a problem of its own: ground is quite lossy at radio frequencies, so unless a good system of ground radials is installed, much of the power supplied to the antenna may end up warming earthworms instead of carrying your dulcet tones to distant continents.

Since installing an extensive system of ground radials sounds too much like hard work, my preference is to use a vertically polarized antenna that is *not* fed against ground, and avoid the need for ground radials at all! There are many types to choose from: "ground-plane" verticals, vertical dipoles, the half-square, and so on. My choice for this week's column is a vertically polarized rectangular loop known as the "Magnetic Slot" because it is simple to build, not too large (and especially not too high), offers good performance with some gain, and has a feedpoint impedance of 50 ohms.

The Magnetic Slot

The Magnetic Slot is simply a rectangle one wavelength in circumference that is about three times as wide as it is high. In other words, it is a rectangle approximately 3/8 wavelength wide and 1/8 wavelength high. It is fed in the middle of one of the vertical sides, where the impedance is approximately 50 ohms. Figure 1 shows the layout of the antenna

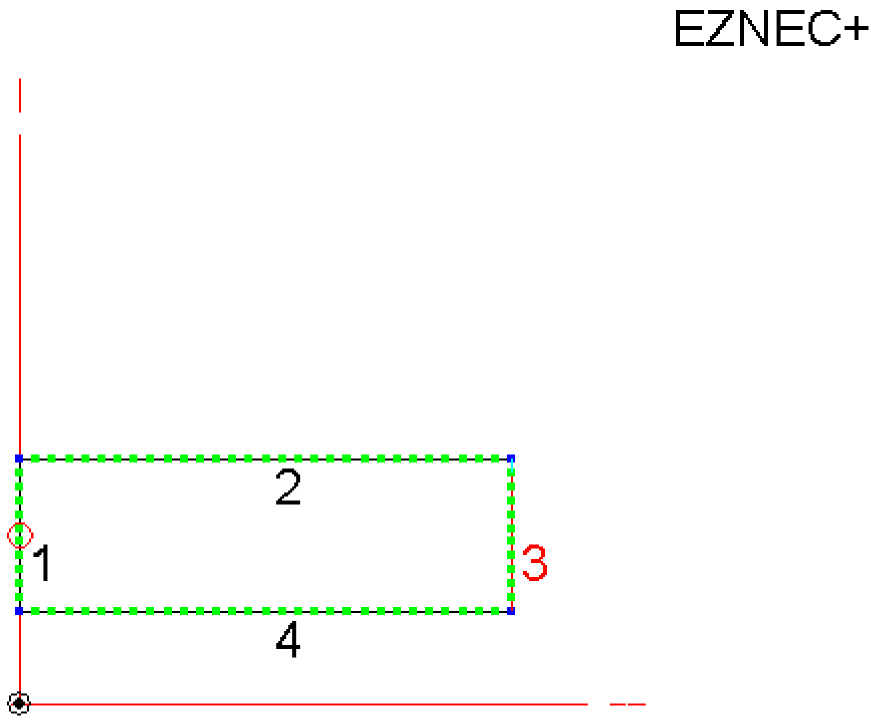

Figure 1: Layout of the Magnetic Slot Antenna

The figure was drawn using EZ-NEC antenna modeling software[1]. The rectangle represents the antenna wires, while the circle on the left hand vertical wire is the antenna feedpoint. The antenna functions as two 1/8 wavelength vertical radiators spaced 3/8 wavelength apart. The vertical wires carry in-phase currents, with a current maximum in the middle of each of the vertical wires. The currents in the horizontal wires change direction at the midpoint of the wires, where there are voltage maximums. As a result the radiation from the horizontal wires is largely self-canceling, so the radiation pattern of the antenna is dominated by the radiation from the vertical wires.

Note that the antenna is not shown right at ground level. As with all antennas, some distance from ground is desirable to minimize losses resulting from the antenna's near field causing currents to flow in the ground medium. In this case, the base of the

[1] www.eznec.com

antenna is 3m above ground, placing it high enough to minimize danger to people and animals. The top of the antenna is 8m above ground, a more realistic proposition for most amateurs than the 20 metres or so required by horizontal antennas.

The antenna pattern is bi-directional, with the strongest radiation at right angles to the plane of the antenna (in other words, "into the page" and "out of the page" in Figure 1). Figure 2 shows the elevation pattern of the antenna in its most favoured direction.

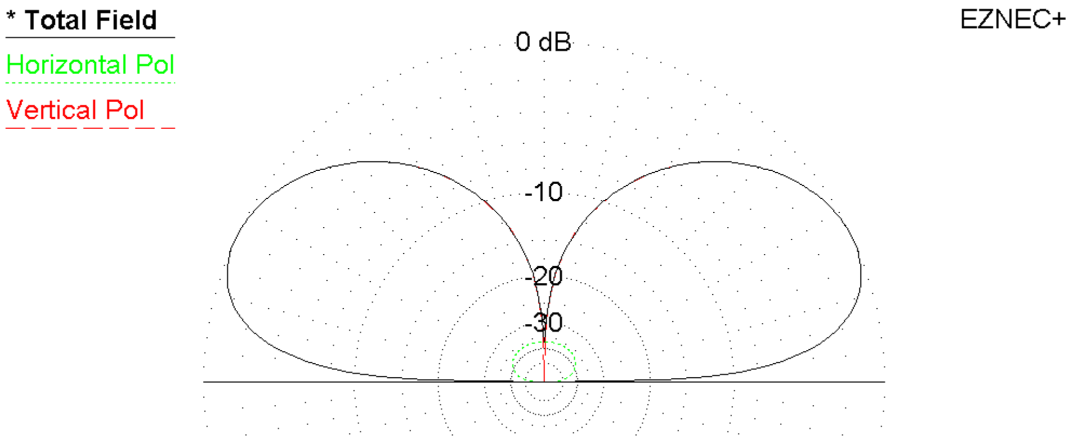

Figure 2: Elevation Pattern of the Magnetic Slot Antenna

The maximum gain is 1.8 dBi at an elevation angle of 25 degrees. The gain at an elevation angle of 10 degrees, which gives an indication of DX performance, is –0.6 dBi. Although this doesn't sound all that impressive, compare this with Figure 3, which shows the elevation pattern of a 40m half-wave dipole 8m above ground (the same height as the top of the magnetic slot).

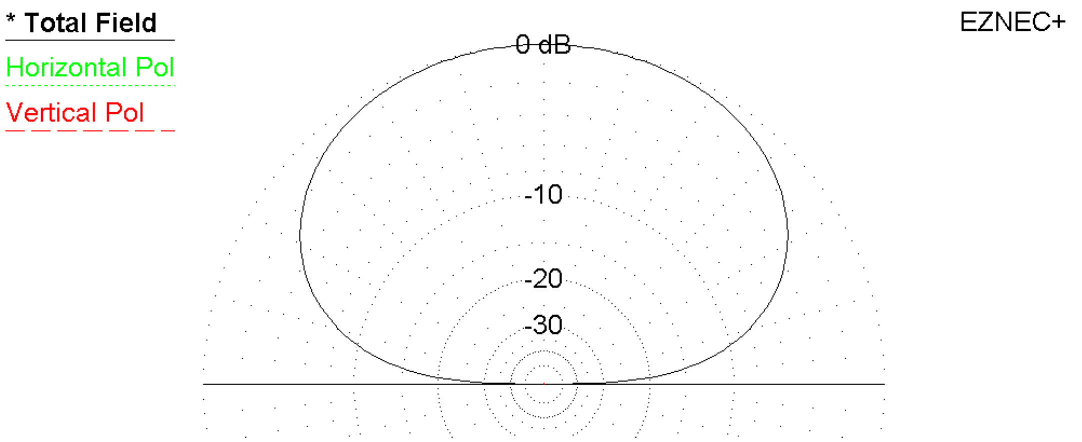

Figure 3: Elevation Pattern of a Low Horizontal Dipole

The maximum gain of the dipole is 6.0 dBi, which is considerably better than the magnetic slot's 1.8 dBi – but this maximum gain is at 90 degrees elevation, straight up! Gain at 10 degrees elevation is –5.3 dBi, some 4.7 dB worse than the Magnetic Slot. The dipole will perform well as a near vertical incidence skywave (NVIS) antenna for local communications, but the Magnetic Slot is a better choice at the low takeoff angles required for effective DX communication.

Feeding the Magnetic Slot

Since the magnetic slot is a balanced antenna, a 1:1 balun should be used if it is fed with coaxial cable, to avoid the possibility of feed-line radiation. As with other antennas with low-impedance feedpoints, such as dipoles, you *may* get away without using a balun, depending on the common-mode impedance of the coax run you use to feed the antenna with. Unfortunately it is difficult to predict beforehand whether you need a balun or not. One simple test is to measure the SWR *using very low power* while a helper touches the coax at various points between the rig and the antenna. If the SWR changes at all, that is an indication that there is RF on the outside of the coax, and you should be using a balun. If the SWR remains constant, then you are probably all right without a balun.

Fortunately there are several simple ways to construct homemade baluns, especially for antennas like this one that only operate on a single band. If there's enough interest then perhaps I'll make this the subject for a future column.

Construction

All you need to build this antenna is 45m of suitable antenna wire, a centre insulator, cable ties, a couple of supports at least 16.5m apart and 8m high, and some nylon cord to attach the antenna to the supports. I used 1.5mm^2 insulated stranded "panel" wire, which is available at most electrical wholesalers. I chose green wire, which blends in nicely with the foliage.

Form the wire into a rectangle, with the short vertical sides 5m high. Attach the ends of the wire to the centre insulator, placed so the antenna is fed in the middle of one of the vertical sides (see Figure 1). Make one of these attachments temporary, so you can trim the antenna for best SWR (you can use a terminal block for the temporary connection, or simply twist the bare wires together). Tie nylon cord to the four corners of the rectangle; suspend it between the supports with the base at least 3 metres above ground; and connect the coax to the two ends of the antenna wire (with or without a balun). The coax should be led off at right angles to the antenna wires for at least 10m so it does not interact with them. Use cable ties to provide strain relief for the antenna wires and coaxial cable (see Figure 4).

Check the SWR at the bottom and top of the 40m band (I suggest using 7.001 MHz and 7.099 MHz as the test points to ensure you stay within the band limits). Hopefully the SWR at the bottom of the band will be lower than the SWR at the top of the band, indicating that the resonant frequency is too low and the wire too long. (If not, you may need to start over with a longer piece of wire!) Gradually shorten the wire, each time readjusting the corner points to maintain symmetry and keeping the two vertical sides 5m long and the horizontal sides equal lengths. Continue until the SWR at the top and bottom of the band is the same – you should be able to manage 1.5:1 or better across the whole band. (Of course the process is even easier if you have access to a low-power SWR Analyser and can find the frequency of lowest SWR even if it falls outside the amateur band.)

In my case, I tuned the antenna for the CW portion of the band, with SWR 1.1 from 7.000 to 7.040 MHz, rising to 1.4 at 7.100 MHz. The 1.5:1 SWR bandwidth is 200 KHz, about 3% of the centre frequency. This included the effects of the balun and a

40m run of RG58 coax. The total length of wire in the loop after trimming was 42.25m.

Remember to adjust the length of the antenna in *small* increments as you approach the desired resonant frequency – it's very frustrating to accidentally cut too much off the antenna and end up with an antenna that is resonant at 7.3 MHz, for instance! I cut in 10 or 20cm lengths as I approached the desired centre frequency – it takes a little longer, but avoids embarrassment.

When the SWR is acceptable across the whole of the 40m band, make the connections to the centre insulator and nylon cords permanent, ensuring that you have sufficient strain relief at the centre insulator for both the antenna wire and the coaxial cable. Waterproof the join between the coax and the antenna wire using self-vulcanizing rubber tape (Scotch number 23 or equivalent, available at hardware shops). Figure 2 shows detail of the feedpoint. Note the use of cable ties for strain relief. The second piece of coax is part of the homemade narrowband balun that I used with the antenna.

Figure 4: Detail of the Feedpoint

Construction, erection and trimming this antenna took me about five hours in total, so it makes a good weekend antenna project.