Low Profile 2m Mobile Antenna

This horizontal slot antenna performs like a vertical whip, but is low in profile – ideal for tall vehicles.

By John Portune W6NBC

When it comes to carwashes, garage doors and parking structures, rooftop 2m antennas can be inconvenient. Yet mounted lower down, performance can be compromised. This high-efficiency rooftop antenna is vertically polarized yet only 3 in. high, Figure 1.

Slot antennas are not widely known in the ham fraternity, but have long been fixtures in VHF TV, aeronautical applications, mobile stealth and now more recently in cell phones. For ham use, their big asset is that a horizontal slot is vertically polarized, while gain, radiation pattern and efficiency remain much the same as a vertical. We'll see how this happens in a moment.

In its simplest form, a slot antenna is a narrow opening in a flat metal surface or plane. This 2m version is a little different. It's a short cylinder at right angles to a square. The slot is the ½ in. air gap between the two – 19 in. long, closed at one end and open at the other. See Figure 1. Technically it's a ¼λ slot monopole.

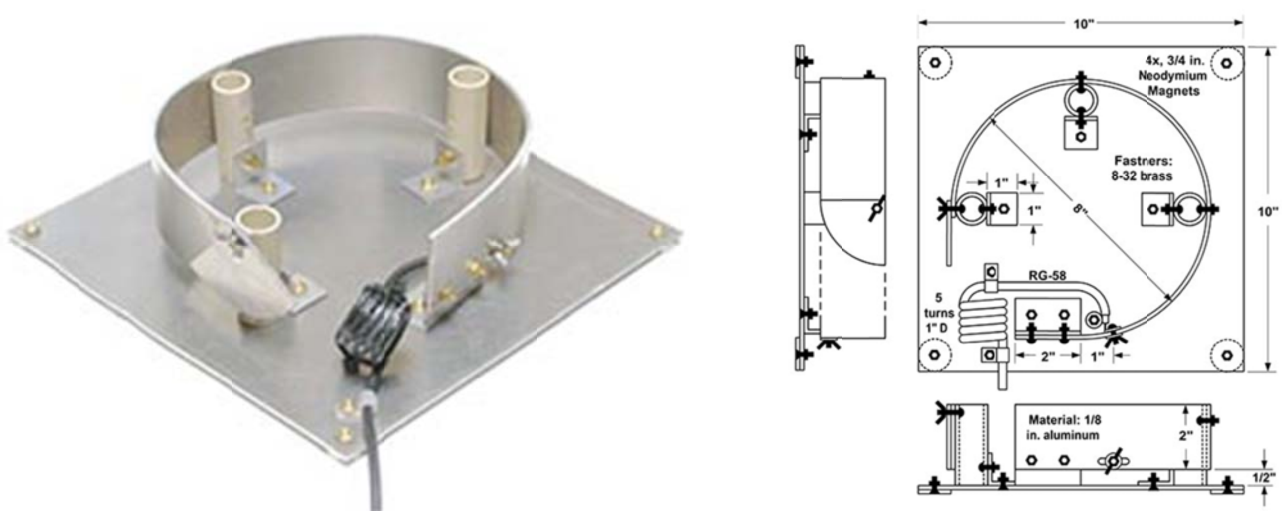

Figure 1: Details of 3 in. high vertically-polarized horizontal 2m slot antenna, ideal for tall vehicles

Why This Configuration?

To see why a horizontal slot makes a good mobile antenna, consider how a hole in a metal sheet can be an antenna. It may be difficult to visualize for hams who have only ever thought in terms of a conventional dipole. As we know, when RF current flows in the conductors of a resonant ½λ dipole or ¼λ monopole, radio waves appear in the space to the side. In a slot antenna, when RF current flows in the metal plane around the resonant slot, radio waves also appear. The net result is the same.

One big difference, however, important to us here, is polarization. It arise from how a slot is fed compared to a dipole. Think about this. One can't open a gap in a slot to connect a feed line, as we do in a conventional dipole. Therefore, RF voltage has to be applied across the slot. A slot, therefore, is shunt fed while a dipole is series fed. See Figure 2. It shows a ½λ slot and dipole, but the principle's identical for ¼λ.

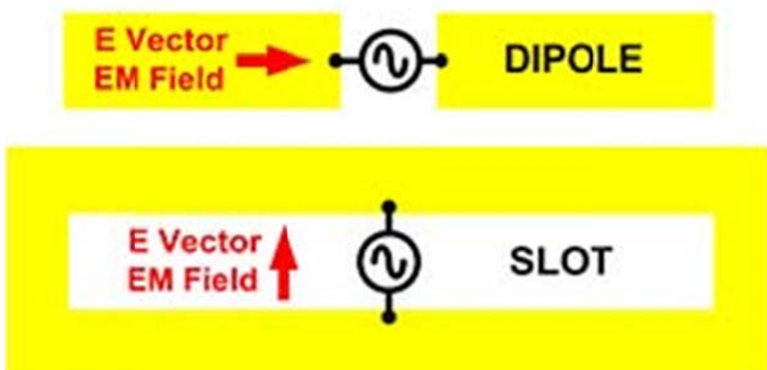

Figure 2: Feed and Polarization differences between a slot and a dipole. Note the 90 degree rotation of the e-vector

But now with the RF voltage across a slot, the e-vector (polarization) of the wave is also transverse to the slot. In contrast, the e-vector in a dipole is normal to it (lengthwise). This means that wave polarization is rotated 90 degrees in slot compared to a conventional dipole. A low-profile horizontal slot antenna has vertical polarization.

Radiation Pattern

Next, why bend the slot into a cylinder? It's necessary in that the radiation pattern of a slot isn't rotated 90 degrees. It's the same as a horizontal dipole – sideways gain, nulls off the ends – unsuitable for a mobile. But as a cylinder, this slot has much the same azimuth and elevation pattern as a 19 in. vertical whip.

Figure 3 shows two comparative EZNEC elevation patterns, both 6 ft. above average soil. The azimuth pattern is essentially omni-directional. The red pattern typifies this antenna atop a fiberglass-bodied motorhome. The blue simulates it on top of a SUV, car or van.

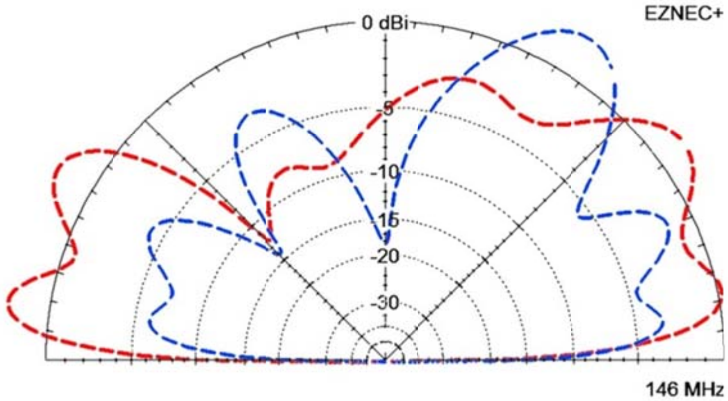

Figure 3: Comparative elevation radiation patterns – (blue) on top of a car, van or SUV, (red) on top of a fiberglass-bodies motorhome. Both 6ft. above average soil

As you can see, the groundplane does not augment the performance as it would for a whip. Proximity of the plane to the horizontal slot turns the energy upward. This happens for all horizontal antennas, slot or dipole. Basically, horizontal antennas lower than ½λ are NVIS.

But in a different way, there is a benefit here compared to a vertical whip. With one plane vertical and the other horizontal, this antenna has significant horizontal polarization as well as vertical. A whip does not. Dual polarization is a phenomenon of all antennas in which part is vertical and part horizontal, such as an inverted V or a Marconi.

Bandwidth

Bending the slot into a cylinder does, however, introduce one small compromise. For when any antenna is made small, bandwidth decreases. The reduction is caused by a smaller capture area (aperture). Loaded HF whips are a familiar example.

Figure 3 shows this antenna's working bandwidth measured with an SDR Kits VNWA 3E network analyzer. As you can see it is 1.8 MHz at the 3:1 VSWR –1 MHz at 2:1 VSWR – entirely adequate for many applications, especially fixed frequency operation. Case in point: this slot serves on my roof on an Echolink node.

Just for interest, slot width has only minor effect on bandwidth. Hence the ½ in. gap in this case is arbitrary. Bandwidth is much more determined by the width of the metal surfaces adjacent to the slot. Two inches of plane for 2m is my practical working minimum. Add more to both sides for increased.

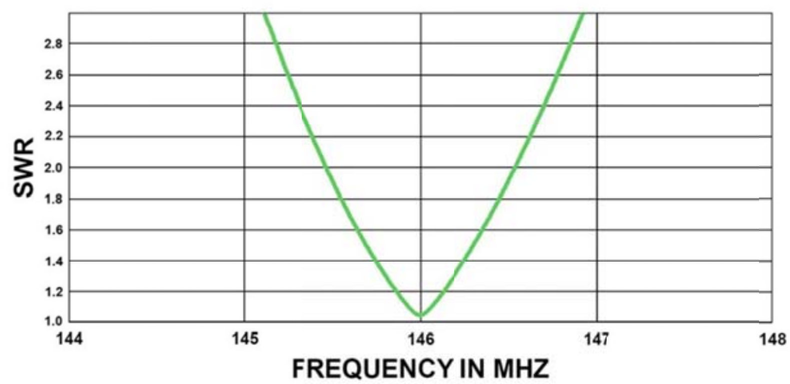

Figure 4: Free-space 3:1 SWR bandwidth measured with an SDA Kits VNWA 3e vector network analyzer

Practical 6m and 10m versions are feasible in this design. Just scale the plane widths in proportion to wavelength. For example, on 6m use 6 in. planes. On 10m use 10 in. planes. The surfaces needn't be solid metal, but wire grid of 1/10λ or less spacing. The closer the spacing and the heavier wire, the better, to minimize skin effect losses, a fundamental source of loss in all small antennas. I used 2 in. spacing (1/40λ) and 1/8 in. diameter wire for the EZNEC models above.

Construction Materials

I chose heavy-weight materials here to permit exposed outdoor use: (1/8 in. aluminum) and 8-32 brass fasteners throughout. Under a plastic cover, thin galvanized steel and common fasteners are satisfactory. Rain gutter materials and roof flashings are available at most large hardware outlets. I have a lighter-weight covered version on my RV under an upside-down Rubbermaid #2951-AR 14x12x6 in. plastic dish pan. Slots are very versatile, admitting to many variants. I have built them from aluminum tape on glass, on mirrors and out of hardware cloth.

Tuning and matching

Because of the bandwidth, this design includes wide-range tuning and matching fixtures. See Figures 4 and Figure 1. For operating frequency, there's a rotatable 90-degree ¼ "pie slice" slot-stretcher. It affords a 4 MHz tuning range. For SWR adjustment, the feed point screw hole is slotted. Wing nuts assist at both. Use crimp-on ring terminals for the coax connections, weather-proofed with silicone sealant.

To tune up the antenna, use an antenna analyzer, or a transceiver and an SWR bridge. Set the operating frequency first. Pay no attention to SWR at first. Then adjust the SWR (the match) by moving the feed point in small increments. As with all antennas, tuning and matching do interact, so you will need to make more than one pass. Tuning is the most critical; the match changes little once it is close. Due also to the tight bandwidth, this antenna needs to be re-adjusted at least in frequency for each different operating situation.

Figure 5: (a) Frequency adjustment vane, (b) Slotted feedpoint (SWR) adjustment

Note also the balun (Figure 1). It is necessary. Wind 5 turns of vinyl-jacketed RG-58 around a short length of ¾ in. PVC pipe, securing the turns with tie-wraps. Then apply vinyl repair cement (available at most hardware stores) to the outside of the coil turns. When the cement is dry, remove the PVC pipe. Alternately, VHF-mix ferrite beads are suitable. Secure the coax and balun to the base plate with cable tie-downs.

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