By Chuck Morrison,
Chief Engineer, Grove Enterprises

A Helical Antenna for FLTSATCOM Reception

Reception of the FLTSATCOM transmissions in the 240-270 MHz range using an omnidirectional antenna will normally yield signals barely above the noise level on an Icom R-7100 VHF/UHF communications receiver - just barely enough to move the S meter. With the recent international tensions around the world, I wondered how many interesting signals I was missing under the noise level. A gain-type antenna would bring the signals up and let me hear what I was missing. I considered many different types of antennas, but based on the characteristcis of the downlink signal, one design stood out - the Helical Antenna.

FLTSATCOM Characteristics

The minimum effective isotropic radiated power of the FLTSATCOM satellite is 26 dBW. The average downlink frequency is 255 MHz, giving a wavelength (λ) of 300/255, or 1.18 meters. The satellites are in geosynchronous orbit at an altitude (d) of 35680 kilometers. Path loss is given by

$$L\ (dB) = 10\log_{10}(4\pi \times d/\lambda),$$

or 171.6 dB. For an EIRP of 26 dBW, the power at a perfectly omnidirectional 0 dBi antenna would be 26 - 171.6 = -145.6 dBW, or -115.6 dBm. This is .37 microvolts into 50 ohms - a quite weak signal. A receiving antenna with 10 dB gain would increase the received signal to -105.6 dBm, or 1.2 microvolts - a signal that should be readable on most receivers.

Helical Antenna Design

A helical antenna provides a high gain over a wide bandwidth. It is also naturally circularly polarized, which is necessary since FLTSATCOM transmissions are right-hand circularly polarized. It is relatively easy to build and forgiving of mechanical inaccuracies. The following design information is adapted from Chapter 19 of the 16th edition of The ARRL Antenna Book.

The helical antenna is a large coil with one end fed against a ground plane. The diameter of the coil should be λ/π, the spacing between turns should be $\lambda/4$, and the ground plane diameter or side length should be λ. Antenna gain is proportional to the number of turns (n) on the helix. Gain over an isotropic antenna is given by

$$G\ (dBi) = 11.8 + 10\log_{10}(n/4).$$

A four turn helix should yield a gain of 11.8 dBi, which would be adequate.

The input impedance of a helical antenna is 140 ohms. There are several ways to match this to the typical receiver input impedance of 50 ohms. I used one extra turn on the helix, with the first half turn spaced closely to the ground plane. This in effect formed a parallel line transmission line matching section with its characteristic impedance determined by the spacing. I would adjust the spacing experimentally to obtain minimum antenna VSWR.

Construction

I had been looking for the ideal structural material to support VHF wire antennas for a long time. Several years ago, I tried to make a 6-meter quad frame out of PVC pipe. This seemed to be the ideal material, since it is so easy to work with, and so many fittings are available. I would just cut the pipes and put the antenna together like a tinkertoy. But after I had purchased all of the materials and brought them home I made a shocking discovery - that small diameter PVC pipe was not rigid enough to support even its own weight over any distance at all.

Not long ago, I was in a home supply store thinking about a way to build this antenna. I needed to build a form to support a 15-inch diameter coil, but I wanted it to be cheap. PVC pipe was on my mind again. Then I passed the dowel rods. They were rigid enough, and cheap. But they were only 3 feet long, which was too short. If I could connect them together like PVC pipe, they would work great. I got a few 1/2 inch PVC fittings and went back to the dowel rods. It turns out that 5/8 inch dowel rods make a great fit in 1/2 inch PVC fittings. This would work well for this antenna.

I first built a 4-foot square frame out of 2" by 2" lumber. Four feet is close enough to the wavelength of 46 1/2 inches. I put a 2 by 4 from the midpoint of one side of the frame to the midpoint of the other side. I drilled two 5/8" diameter holes in the 2 by 4 with their outside edges the required coil diameter apart, being very careful to keep the drill bit perpendicular to the frame. Then I covered the frame with chicken wire, and stapled it to the wood. The ground plane frame is shown in Figure 1.

Insert the dowel rod coil form into the holes drilled into the 2 by 4. They should be a snug fit. If they are square to the ground plane, glue them into place. I did not get my holes exactly square, so I reamed out the holes a little bit to allow adjustment of the dowels. When I got them square, I used some automotive body putty to hold them in place. The 3 foot long dowel rods were not long enough, so I spliced 2 more feet onto the form with 1/2-inch PVC unions. At the end of the coil form I put a dowel rod cross piece using 1/2-inch PVC elbows.

When the form was completed, I placed marks on the dowel rods at the places where the wire would touch them per the dimensions shown in Figure 2. These dimensions are for a turn spacing of $\lambda/4$ at 255 MHz, with numbers rounded to the nearest 1/8-inch. I filed a small notch in the dowels at these places to help locate the wire.