Double Cross — A NOAA Satellite Downlink Antenna

An easy to build antenna for ground reception of NOAA weather or amateur satellite signals.

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US National Oceanographic and Atmospheric Administration (NOAA) polar orbiting weather satellites (POES) transmit data for production of gray scale images of the ground below them.[1] These automatic picture transmissions (APT) signals are sent at 137 MHz and are available twice a day to anyone on the earth. There are many free programs available that can decode the satellite signals and then produce color images on a personal computer. I prefer *APTDecoder* by Patrik Tast, available on the Internet.[2]

Antennas for POES Satellite Reception

The NOAA weather satellites are polar orbiting, so they can and do appear at all azimuth and elevation directions from any ground location. An ideal ground-based antenna for reception of NOAA satellite signals would be right-hand circularly polarized (RHCP) and have no deep pattern minimums within the hemisphere. Figure 1 shows the ideal pattern shape of a ground-based antenna for APT reception. It would have a 12 dB minimum toward zenith since the satellites will be approximately 12 dB stronger when overhead as compared to their strength when at the horizon due to path loss.

This ideal pattern cannot quite be obtained for a ground-based receiving antenna for VHF. But it is a useful guide to remind the antenna designer that the ground-based antenna pattern should have a minimum of nulls within the hemisphere, with a maximum toward the horizon.

Four dipoles can be mounted as shown in Figure 2 to produce a radiation pattern with excellent RHCP at 0° elevation in the free space radiation pattern as shown in Figure 3. The design concept for this four dipole array with hemispheric coverage with RHCP is derived from the fundamental concept that two dipoles, crossed, spaced a quarter wave apart, and fed in phase as shown in Figure 4 can be polarized to produce a pattern as shown in Figure 5.

The pattern null along the X axis can be filled in by including a second pair of crossed dipoles as shown in Figure 6. If the second pair is fed 90° later than the first pair, the four dipole array has the excellent radiation pattern shown in Figure 7.

Double Cross as an Amateur Satellite Antenna

The Double Cross can also be built as

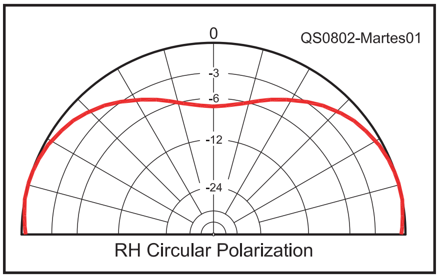

Figure 1 — Ideal radiation pattern for a ground-based antenna for reception of NOAA weather satellite images.

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Figure 2 — The four dipoles that make up the Double Cross antenna prototype.

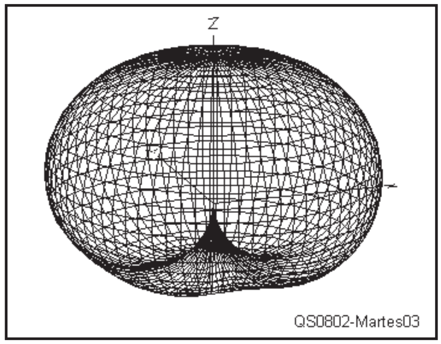

Figure 3 — The free space three dimensional pattern of the Double Cross closely matches our design goal.

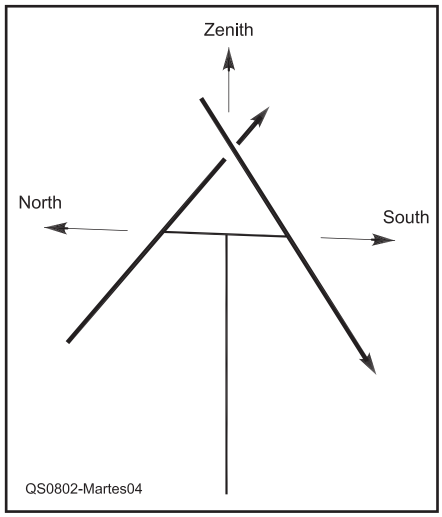

Figure 4 — One pair of crossed dipoles makes half a Double Cross.

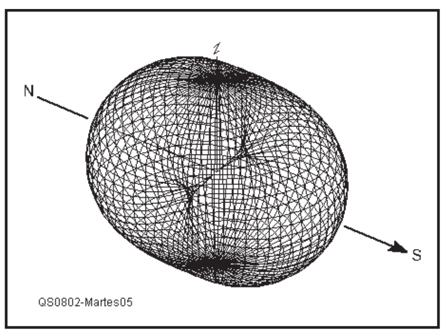

Figure 5 — Free space radiation pattern of crossed dipoles.

[1]**www.oso.noaa.gov/poesstatus/index.asp**.
[2]**www.poes-weather.com/**.

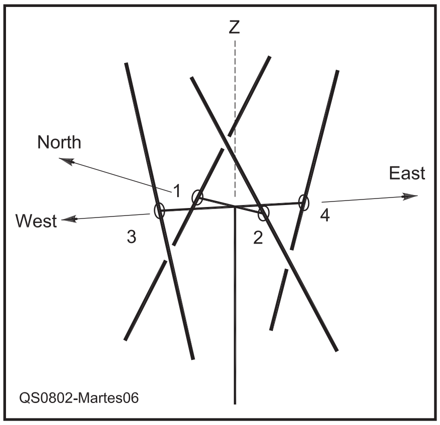

Figure 6 — Two pairs of crossed dipoles become the Double Cross.

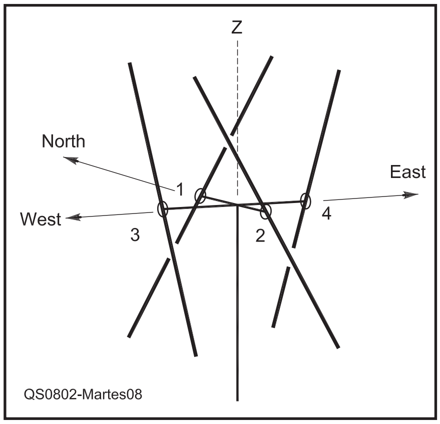

Figure 8 — Dielectric support for the dipoles and harness.

Table 1

Dimensions of Double Cross Array (Inches)

Operating Frequency (MHz)	*137*	*145*	*435*
Dipole length	38.25	37.125	12.125
Dipole diameter	0.375	0.375	0.25
Dipole spacing	21.5	20.5	6.75
Poly coax λ/4 phasing section	14.25	13.5	4.5

an antenna for amateur frequencies. Table 1 shows the dimensions for both NOAA and amateur satellite bands. Note that circular polarization toward the horizon is also useful for terrestrial communication, since it responds equally well to both vertical (for FM) and horizontal (for SSB and CW) polarization.

Making it Happen

One beneficial aspect of this Double Cross antenna is that it is quite tolerant of construction variations. That is, an antenna in this configuration will almost always work well even when the dimensions are only close to the optimum design. The only thing critical is the proper connection of the harness to the dipoles.

Field testing with this antenna indicates that it produces very little radiation pattern nulling within the hemisphere. Pattern nulls would be expected to produce dark horizontal lines across the image. The images, recorded with the Double Cross thus far constructed and tested, have indicated that very little image quality degradation is seen as a result from elevation plane nulls from ground reflection.

A Double Cross APT antenna can be built by constructing a dielectric support as shown in Figure 8 and attaching the dipoles and harness, as described later, to the dielectric support.

Build four dipoles from a convenient conductor, each about 38 inches long, and attach them to the supports. The dipole supports numbers 1 and 2 are separated by about 20 inches. The dipoles number 3 and 4 are also separated by 20 inches. Each of the four dipole supports is tilted 30° from vertical.

Dipoles 1 and 2 are fed in phase and with the proper polarity, so the upward pointing end of dipole #1 has the same polarity as the downward pointing end of dipole 2. The upward pointing end of dipole 3 has the same polarity as the downward pointing end of dipole 4.

The input impedance of each of the λ/2 dipoles when configured as shown will be very close to 50 Ω. Each pair is wired in series to have an impedance of 100 Ω. After connecting the two pairs in parallel, as shown in the harness diagram of Figure 9, we end up with the desired 50 Ω for the run to the radio.

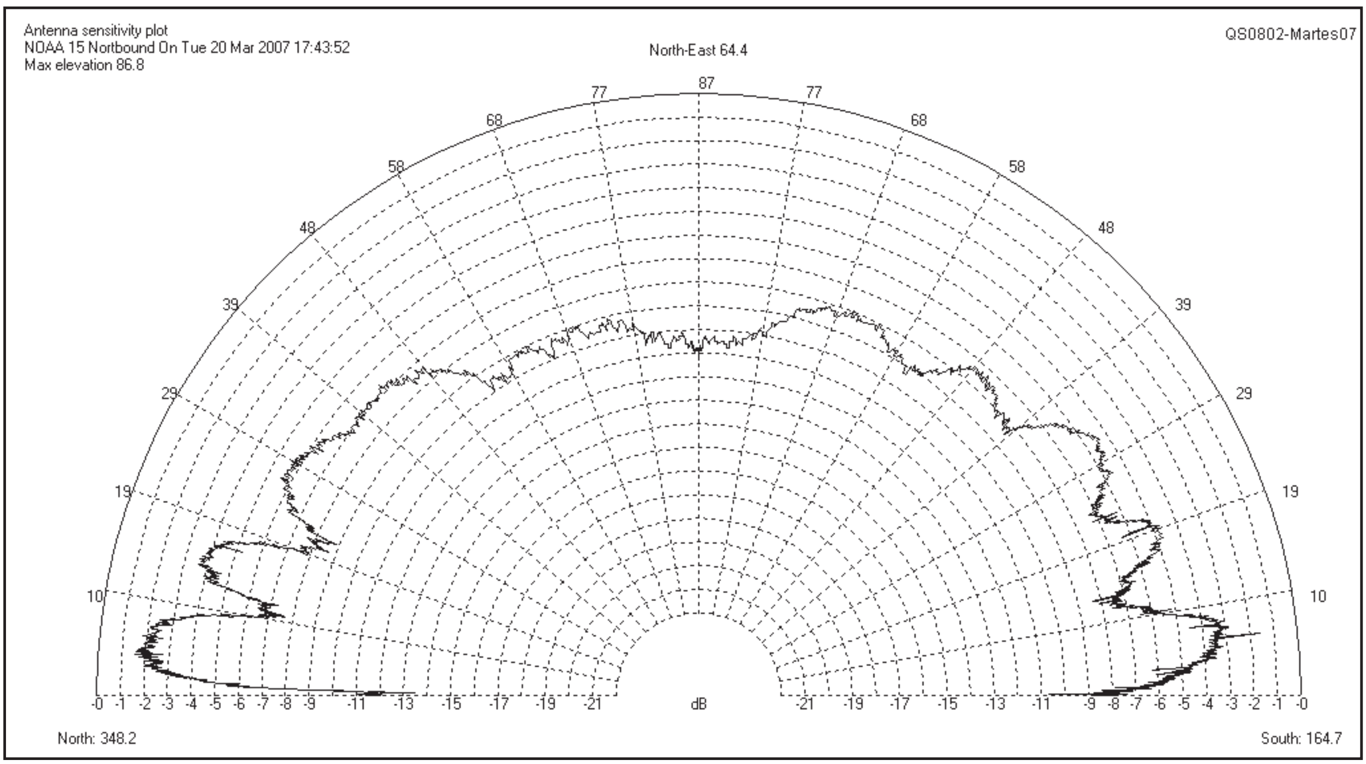

Figure 7 — The measured pattern of the Double Cross antenna closely matches the ideal of Figure 1.

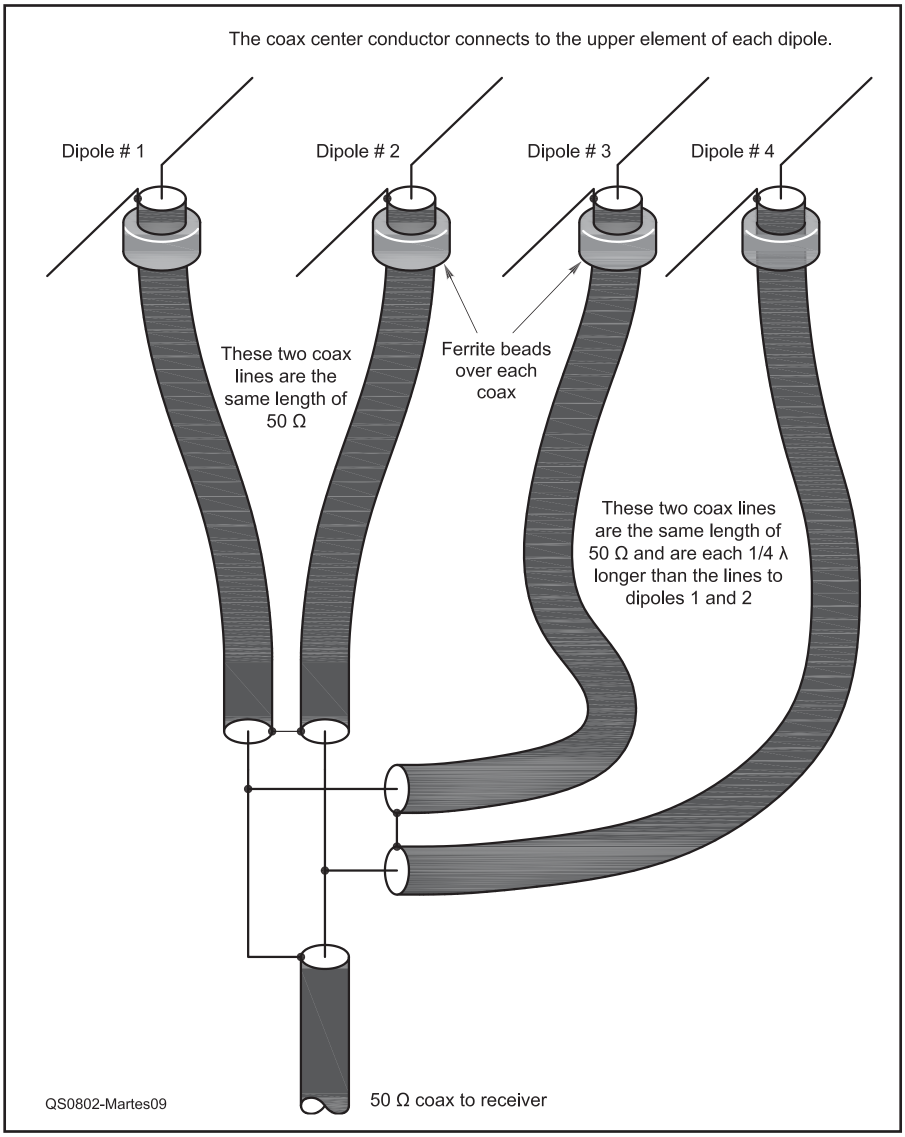

Figure 9 — Harness for Double Cross using 50 Ω coax.

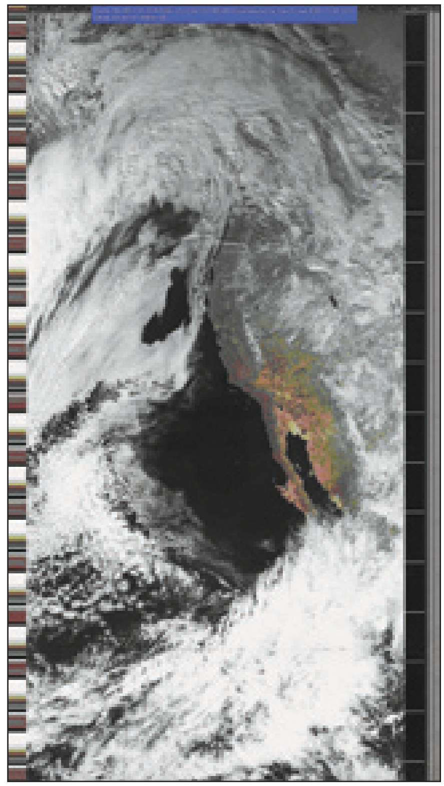

Figure 11 — NOAA satellite image from Double Cross at 2 λ height.

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Figure 10 — Photograph of the Double Cross antenna mounted 2 λ above ground, at the beach in Southern California.

It Works!

The antenna works very well, either from my home station or on the road, as shown in Figure 10. A sample of the received signal is shown in Figure 11.

Gerald Martes, KD6JDJ, has been licensed, on and off since 1949. He received his first license, and call KL7LL while in the USAF in Alaska. He took the test again in the 1950s and had the call K6LZC. Several years ago, he took the General class exam and barely passed it but is now KD6JDJ and promises not to let this one lapse. He also held commercial First Class Radiotelephone and Radiotelegraph licenses, including CW at 20 WPM.

Gerald earned a BSEE from Pacific States University and was employed as an antenna design engineer from 1955 through 1970. He then started his own electrical business and never went back to engineering.

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