EZNEC Modeling of Alpha-Delta DX-EE, Multi-Band Dipole Antenna

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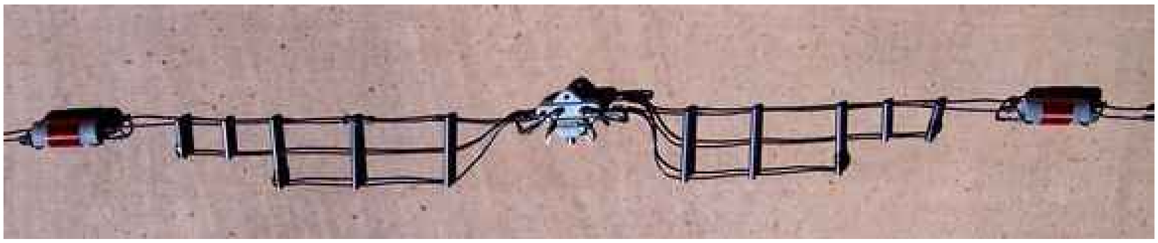


Fig. 1 Alpha-Delta, multi-band, dipole antenna

The antenna is an Alpha-Delta, model DX-EE [1]. (www.alphadeltacom.com) It is a multi-wire dipole for operation on 40m, 20m, 15m and 10m bands (7, 14, 21 & 28 MHz). It's overall length is about 40 ft. It is made of #14, uninsulated, solid copper wire. There are three separate dipoles for 20m, 15m and 10m with 2" vertical spacing between the wires. There are 40 m loading coils at the ends of the 20 meter dipole which are parallel resonant at 20m. The 20m dipole, plus the loading coils and short lengths of wire beyond the coils comprise a shortened 40m dipole.

Measured from the center of the coax feed insulator, the overall length of each of the bottom wires (10m) is 102" (2.59m). The middle wires (15m) are 131" (3.33m). The top wires (20m) are 191" (4.85m). The 40m tuning wires extending beyond the loading coils are 20" (0.51m). The loading coils are 49 turns of close wound, enameled wire on a 1 5/8" plastic coil form. The overall length of the actual coil windings is 2". Based upon these dimensions, the coil wire is #18 wire.

Calculations were made for the resistance and inductance of the 40m loading coils. The dc resistance was calculated to be 0.13 Ω.
per the ARRL 2002 Handbook [2], page 6.22, coil inductance =

$$L(\mathrm{uH}) = (d^2 * N^2) / (18*d + 40*l) = 20.7\ \mu\mathrm{H}$$

where d = diameter of coil in inches
l = coil length in inches
N = number of turns

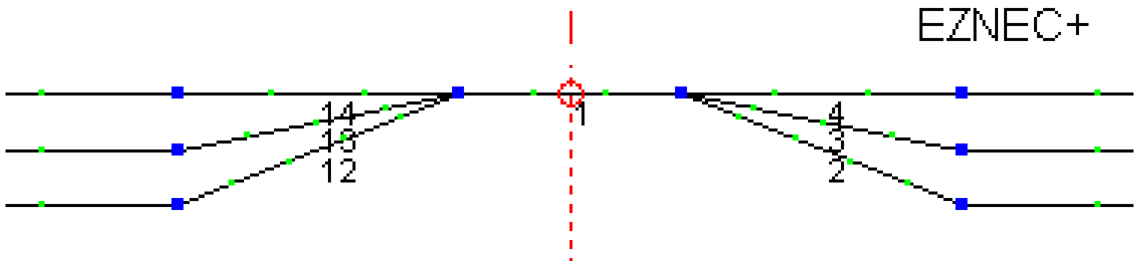


Fig. 2 Wire model for center feed-point of multi-band, dipole antenna.

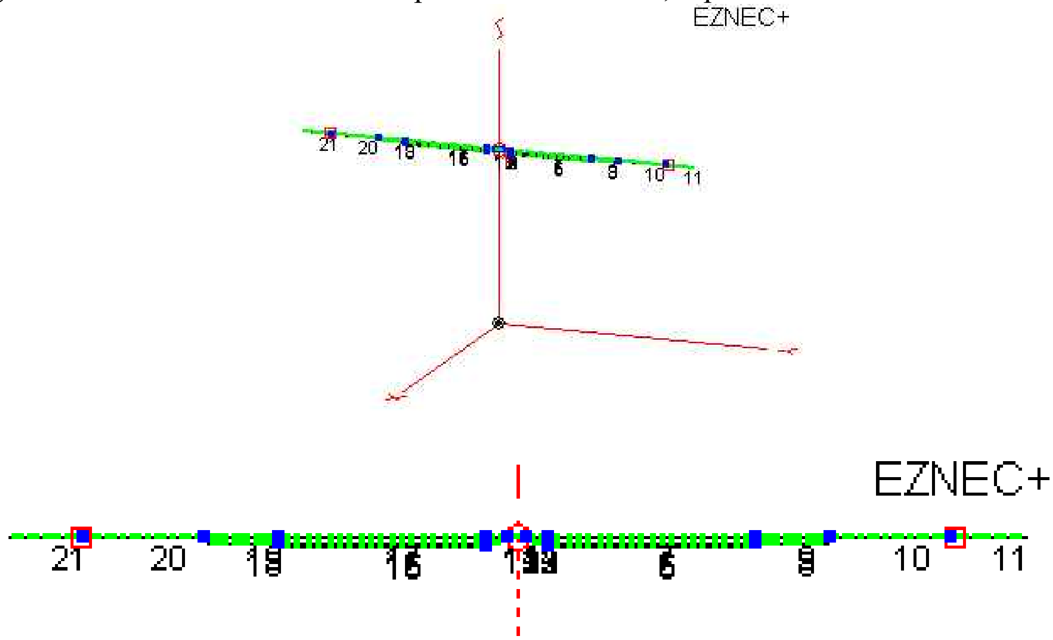


Fig. 3 Complete wire model of multi-band, dipole antenna.

The antenna modeling program EZNEC [3, 4] was used to analyze this antenna. A wire model was created using a total of 21 wires. The 40m loading coils were inserted into the junction between wires W10-11 and W20-21. See Figures 2 & 3. The X axis is broadside to the dipole. The Y axis is looking into the ends of the dipole. The Z axis is the height above earth.

The antenna was installed at the KH6HTV station at a height of 5 meters (approx. 16 ft). For the real world simulations, the ground was assumed in the EZNEC program to be real earth. The earth in Hawaii is not what EZNEC considers "normal". Based upon research at the University of Hawaii [5], for the rich, red volcanic soil found in agricultural lands in Hawaii, I assumed a value of 0.2 siemens/m conductivity and a dielectric constant of 25 for moist earth.

The first EZNEC models were for a perfectly horizontal multi-band dipole at 5 meters over real earth. It was necessary to make minor adjustments in the wire lengths and also the 40m loading coil parameters to make the model work. The antenna would not work using the calculated coil inductance of 20 μH. Instead a "trap" coil of 47 μH with 2.65 pF of shunt capacitance and 1 Ω resistance was used in the model. This coil had a parallel resonance at 20 meters. Swept frequency calculations of VSWR are done in

EZNEC. Fig. 4 shows the result from 5 to 35 MHz. It is obvious that the antenna is resonant on the 40m, 20m, 15m and 10m bands (i.e. 7, 14, 21 and 28MHz)

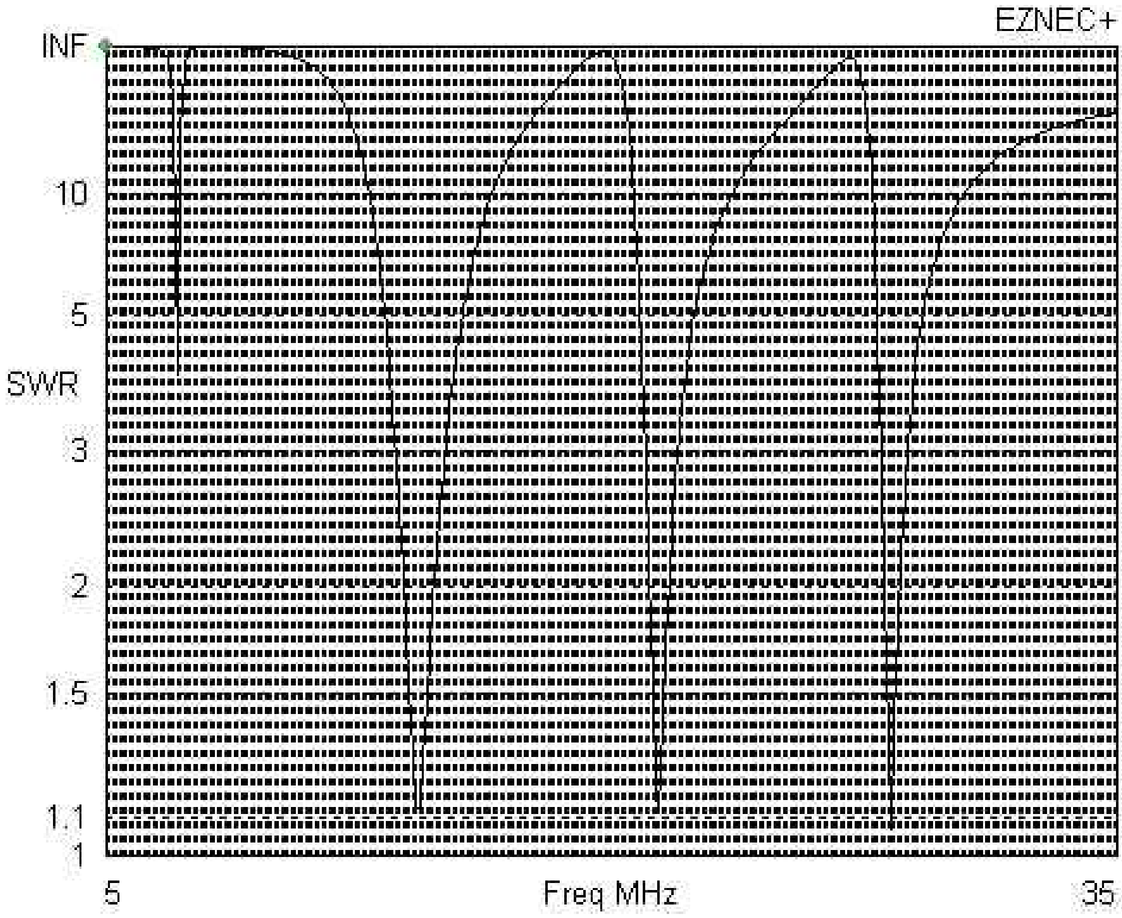


Fig. 4 Swept frequency calculation of antenna's VSWR.

40 METER NVIS PERFORMANCE:

For the 40 meter band (7.0-7.3MHz), a horizontal dipole antenna at 5 meter height abouve ground is basically a Near Vertical Incidence Skywave (NVIS) antenna with most of the radiation going straight upward at 90 degrees. The low angle radiation at 30 degrees is down 5 to 6dB, or 1 S unit. At 20 degrees elevation, the gain is down almost 2 S units. The azimuth antenna patterns show very little directionality with 5 to 6 dB front to side ratio.

A set of 40m simulation runs were made at increasing heights of 5, 10, 20 and 30 meters for the Alpha-Delta antenna without the 15m and 10m dipole wires. See Figs. 5-8 below. The max. gains were: 7.8dBi (90deg), 7.0dBi (90deg), 7.4dBi (30deg) and 7.8dBi (20deg). The VSWRs were: 2.6, 1.1, 1.2 and 1.3 respectively. The conclusions are: (1) doubling the height to from 5 to 10 meters, i.e. to 1/4 λ, makes little change, except for improved VSWR. (2) 20m, or 1/2 λ height makes a significant change from a NVIS antenna to the low angle (30deg) over the horizon radiation pattern. (3) At 30 meters, 3/4 λ, one has both a NVIS and very low angle (20deg) radiation pattern of equal gains.

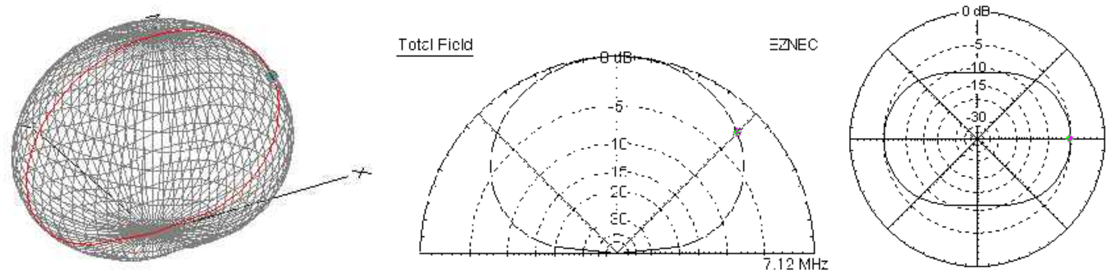


Fig. 5 **40m dipole antenna at 5 meter height**. 3D, elevation plot and azimuth plot (left to right). Max gain = 7.8dBi at 90 deg. Azimuth plot at 30 deg elevation.

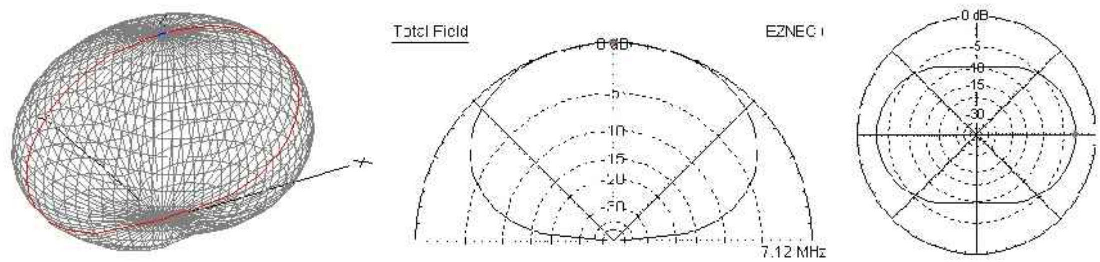


Fig. 6 **40m dipole antenna at 10 meter height**. 3D, elevation plot and azimuth plot (left to right). Max gain = 7.0dBi at 90 deg. Azimuth plot at 30 deg elevation.

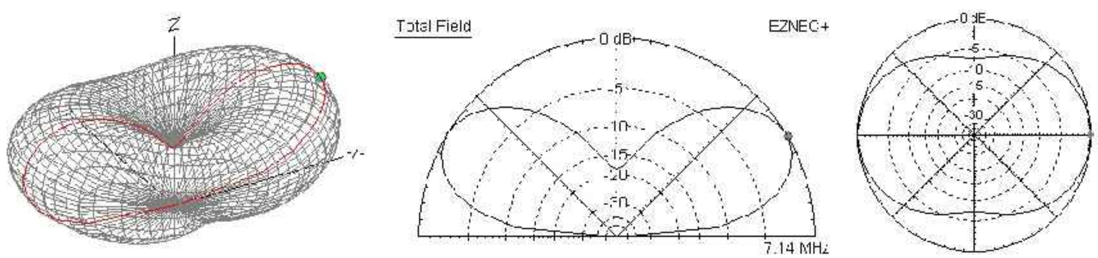


Fig. 7 **40m dipole antenna at 20 meter height**. 3D, elevation plot and azimuth plot (left to right). Max gain = 7.4dBi at 30 deg. Azimuth plot at 30 deg elevation.

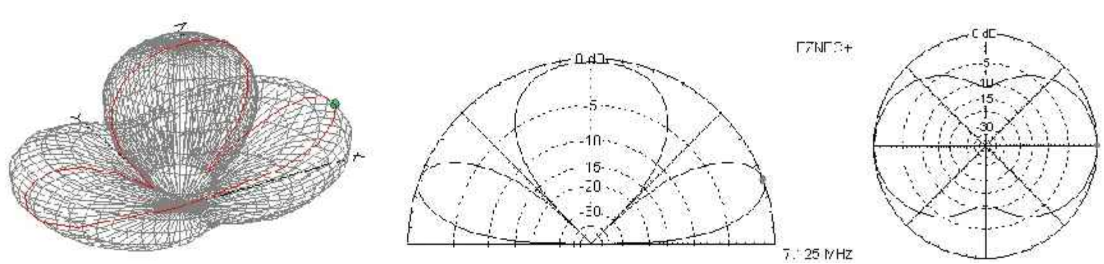
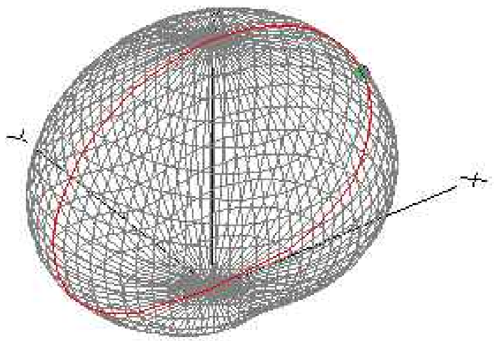
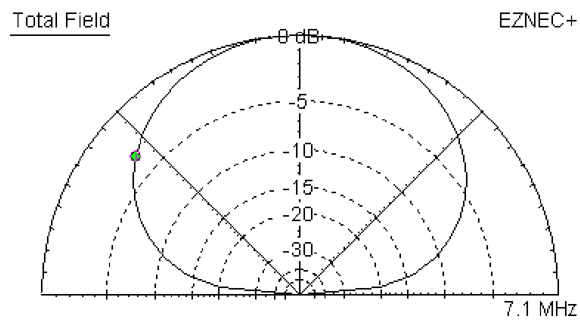


Fig. 8 **40m dipole antenna at 30 meter height**. 3D, elevation plot and azimuth plot (left to right). Max gain = 7.8dBi at 20 deg. Azimuth plot at 20 deg elevation.

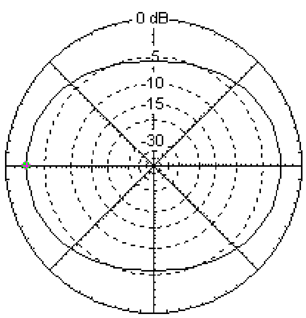
Figs 9-12 below show the computed radiation patterns for the Alpha-Delta DX-EE, horizontal multi-band dipole on the 40m, 20m, 15, and 10m bands at a height of 5 meters. For 20 meters, the antenna is still basically an NVIS antenna. For 15 meters, the antenna now has it's max. gain at 45 degrees, but is still a good NVIS antenna. For 10 meters, the antenna shows the classical dipole radiation pattern for an antenna at a height of λ/2 with a max. gain of 8 dBi at an angle of 30 degrees.



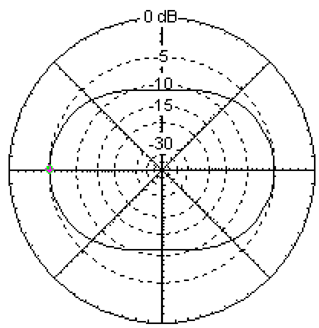
3D Plot



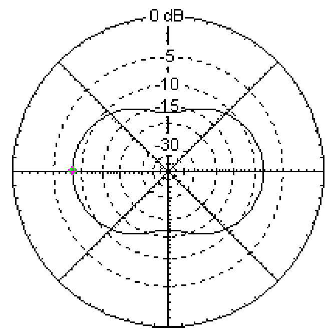
Elevation Plot



45 deg

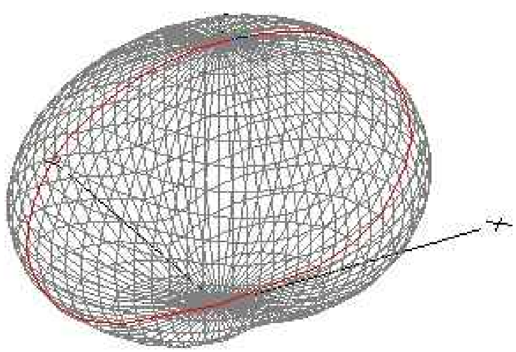


30 deg

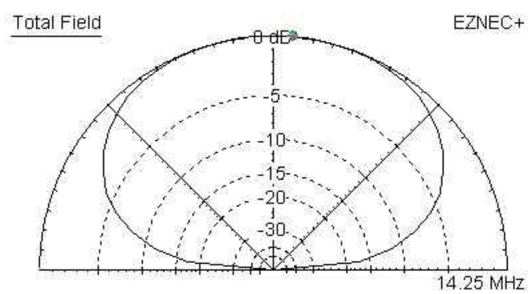


20 deg

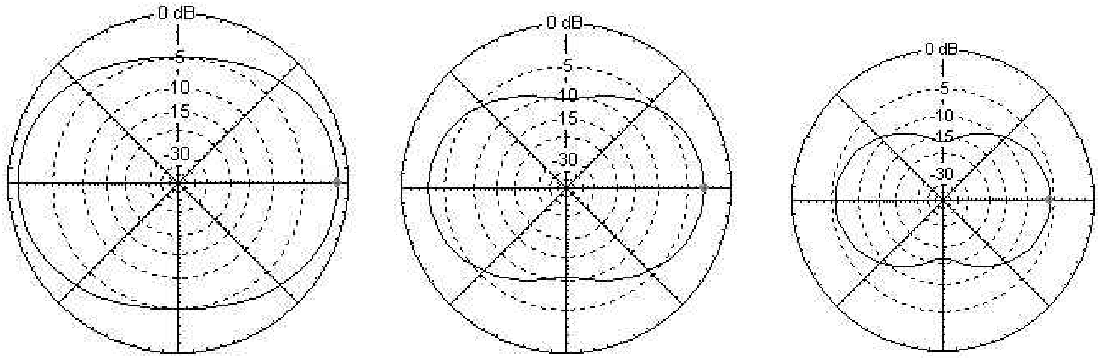
Fig. 9 **40 meter**, 3D & 2D radiation patterns for multi-wire, horizontal dipole at 5 meters. vswr = 3.6:1 Max. Gain = 9.2dBi at 90 deg. Gain = 6.7dBi (45 deg), 4.0dBi (30deg) & 0.9dBi (20deg)



3D Plot

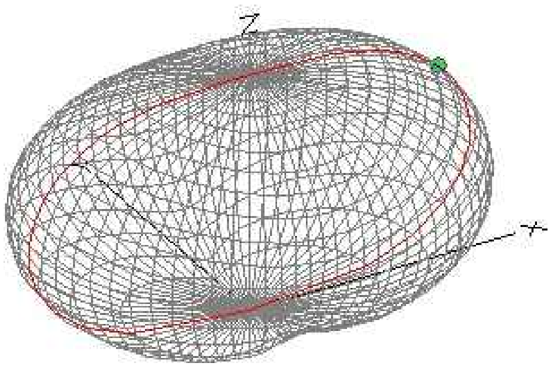


Elevation Plot

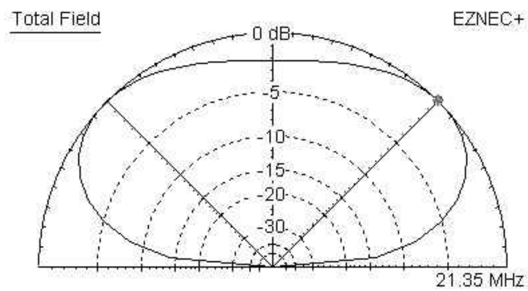


45 deg 30 deg 20 deg

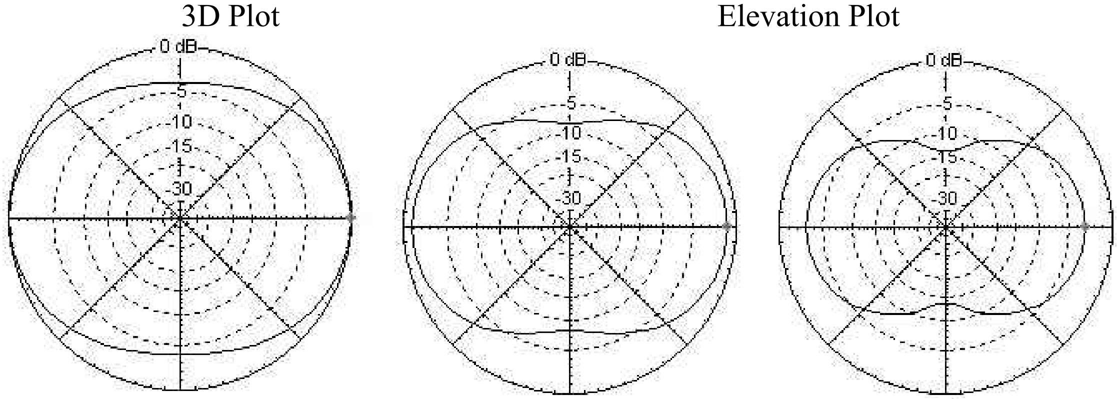
Fig.10 **20 meter**, 3D & 2D radiation patterns for multi-wire, horizontal dipole at 5 meters. vswr = 1.05:1 Max. Gain = 8.7dBi at 90 deg. Gain = 7.8dBi (45 deg), 5.7dBi (30deg) & 3.0dBi (20deg)



3D Plot

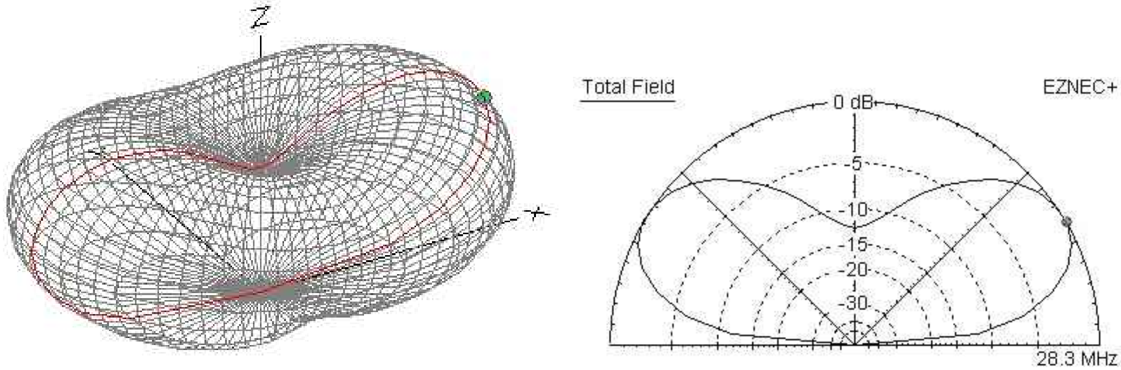


Elevation Plot

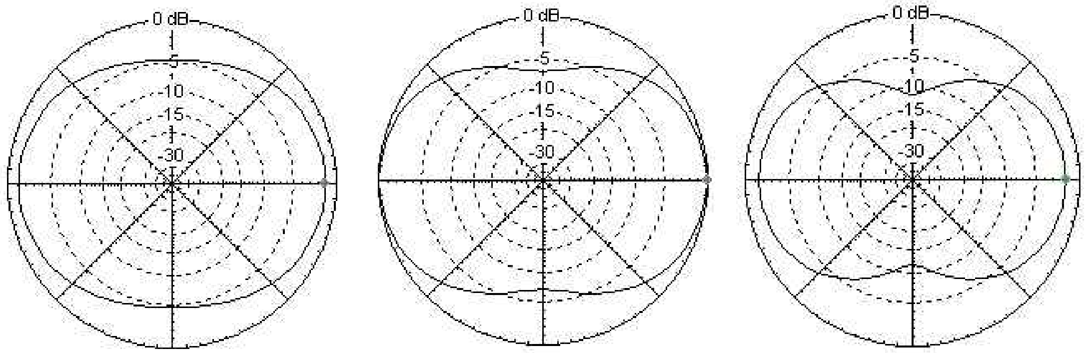


45 deg 30 deg 20 deg

Fig.11 **15 meter**, 3D & 2D radiation patterns for multi-wire, horizontal dipole at 5 meters. vswr = 1.0461 Max. Gain = 8.2dBi at 45 deg. Gain = 6.0dBi (90deg), 7.4dBi (30deg) & 5.2dBi (20deg)



3D Plot Elevation Plot



45 deg 30 deg 20 deg

Fig.12 **10 meter**, 3D & 2D radiation patterns for multi-wire, horizontal dipole at 5 meters. vswr = 1.12:1 Max. Gain = 8.1dBi at 30 deg. Gain = -4.2dBi (90deg), 7.0dBi (45deg) & 6.7dBi (20deg)

KH6HTV Skewd - Inverted V - Multi-Band Dipole

Fig. 13 Actual installation of Alpha-Delta DX-EE, 40-10m Dipole Antenna at the KH6HTV Maui, Hawaii QTH. Note 15 ft. green mast attached to side of house. S-W leg of dipole antenna is tied off to the large palm tree on the right.

The actual installation of the Alpha-Delta DX-EE 40m-10m dipole antenna is shown in the photos in Figs. 13-16. To prevent radiation from the coaxial cable, a 1:1 current BALUN is attached directly to the center feed insulator of the antenna, Fig. 14. The BALUN is a W2AU type made by Unadilla www.unadilla.com The antenna is supported only in the center by a 15 ft. antenna mast sitting in an antenna tripod mount which is sitting on the ground. The antenna mast is also secured with a metal bracket to the eaves of the house under the rain gutter. The center feed point of the antenna is at a height of 5 meters. The antenna end insulators are attached to long 3/16" dacron ropes. The antenna is oriented to run along the back gutter of the house. The house faces in a southerly direction of 197 degrees. The eastern leg of the antenna is tied off to a vent pipe on the roof and runs in a 105 degree direction which is defined as the negative Y axis.. The north-western leg of the antenna is tied off to a tall palm tree on the north-west corner of the lot. This leg of the antenna runs in a "skewed" direction of 325 degrees. Thus there is a "skew" angle of 35 degrees for this leg relative to the EZNEC modeling Y axis. Due to the inverted V construction, the insulated ends of the antenna are estimated to be about 4 ft, or 1.2 meters lower than the center insulator located at the coordinates X = 0m, Y = 0m, & Z = 5m.

Fig.14 Close up detail of the center feed point for the Alpha-Delta DX-EE antenna. Immediately below the center insulator is an Unadilla W2AU, 1:1 BALUN.

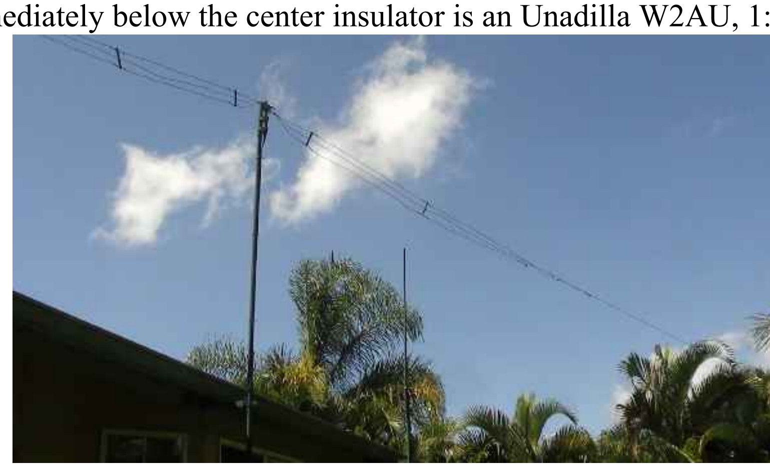


Fig. 15 15ft. mast on left is the center support for the Alpha-Delta DX-EE antenna. Vertical antenna and mast on the right is 2m/70cm Diamond X-50NA antenna.

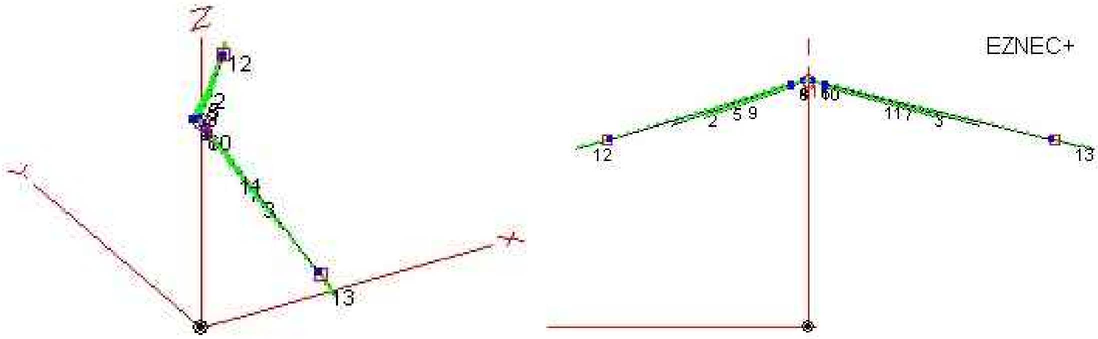


Fig. 16 Two views of the EZNEC wire model for the skewed, inverted V antenna.

EZNEC simulations were also run on this modified multi-band dipole antenna. Fig. 16 shows the wire model used in EZNEC. The wire model coordinates were adjusted to introduce the inverted V droop and also the skewing due to the available locations to tie off the guy ropes. No significant changes were noted in the radiation patterns, nor the gains, over the "ideal" horizontal antenna. The "skewing" of the north-west leg of the antenna caused a slight rotation in the azimuth angle of max. radiation. Fig. 17 shows the 10 meter result. Only minor changes in the resonant frequencies, gains and VSWRs resulted.

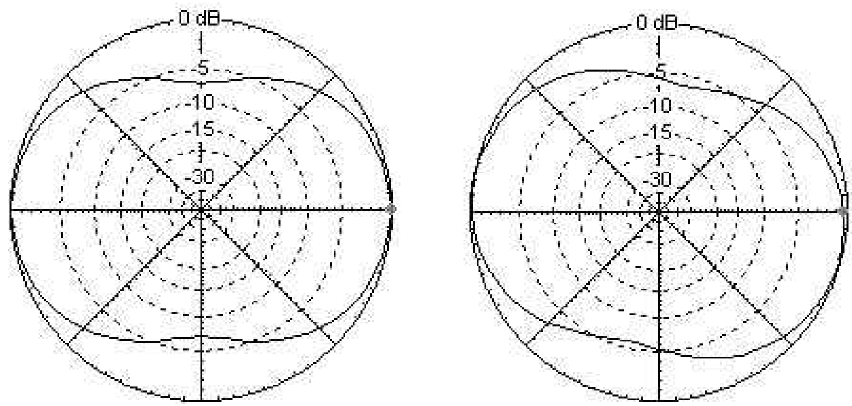


Fig. 17 Azimuth plots for 10 meters at max. gain elevation angle of 30 degrees. Plot on left is the "ideal" horizontal antenna. On the right is the "skewed", inverted V.

REFERENCES:

1. Steve Ford, "Alpha Delta DX-EE Four Band Dipole Antenna", QST, Jan. 2013, p. 62
2. "The ARRL Handbook for Radio Amateurs - 2002", ARRL, Newington, CT, 2002
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