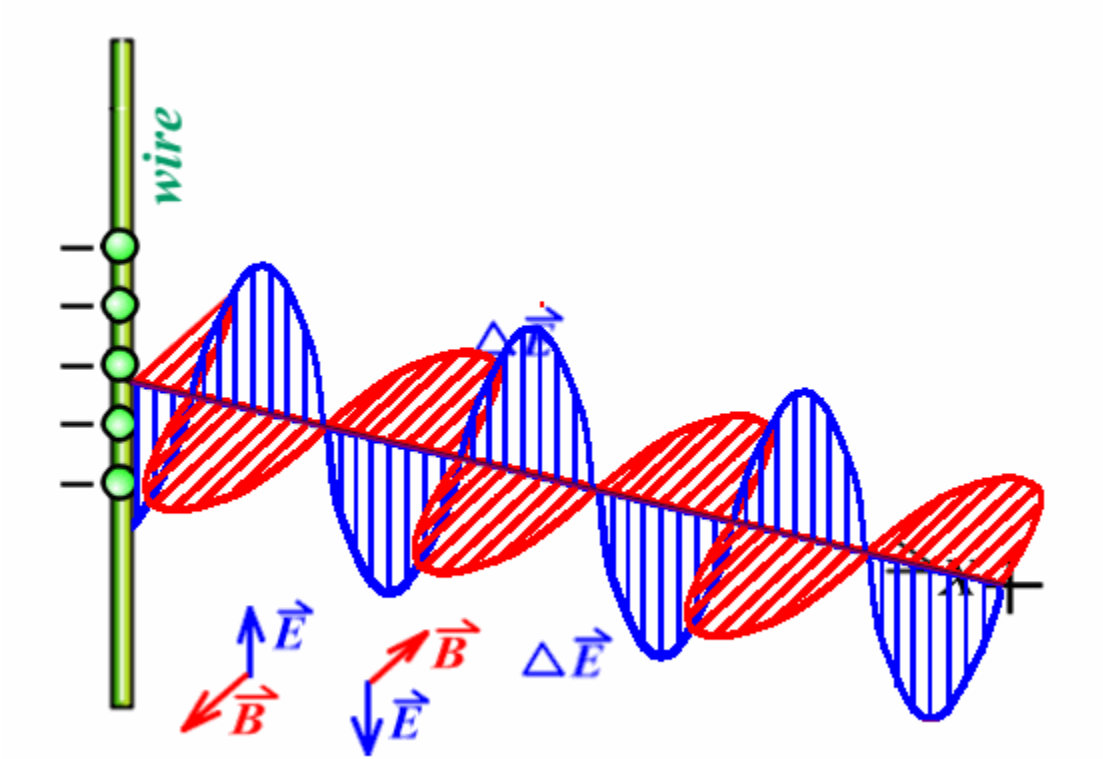
Effects of Cross Polarization with Direct Wave Propagation

Electromagnetic Waves

- Radio waves are electromagnetic waves
  - Electric and magnetic fields at right angles to each other, oscillating at the wave's frequency
  - Spread out into space from the antenna
  - Created by ac current
  - Wave and current have the same frequency



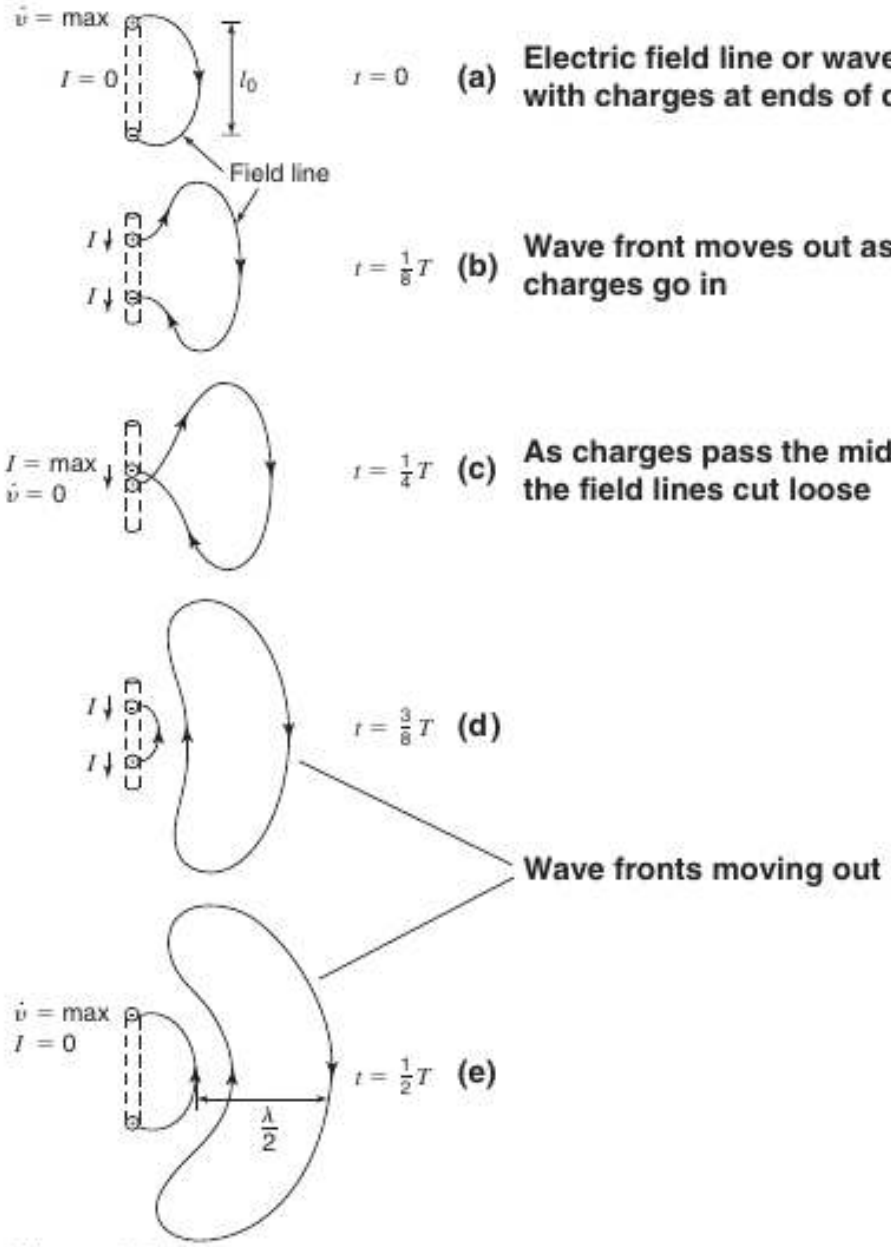
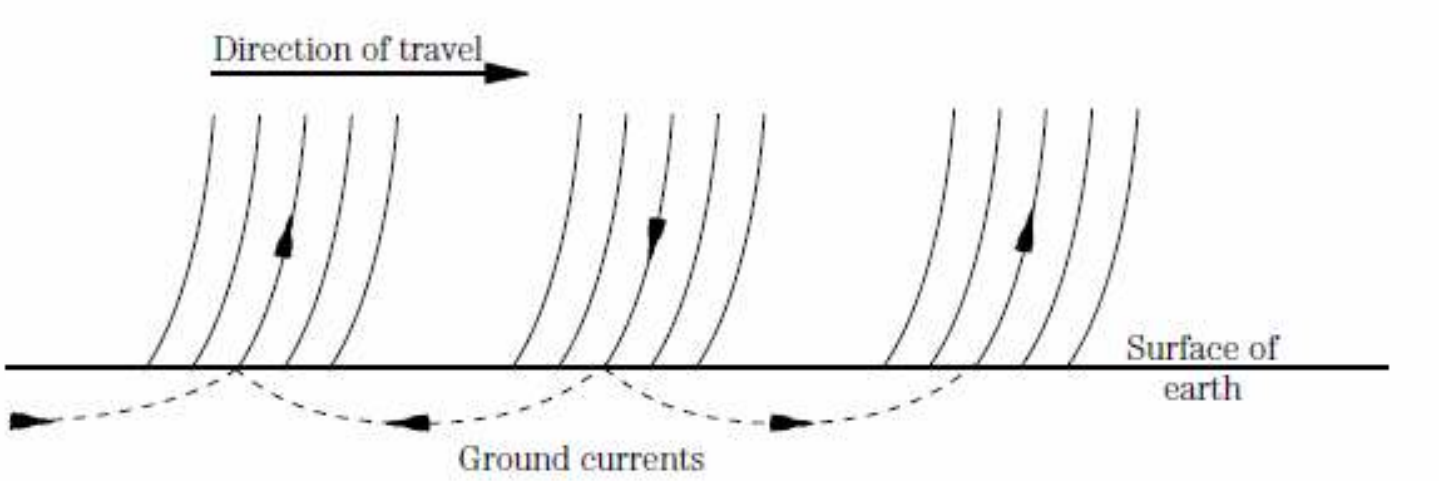


Figure 2–15
Oscillating electric dipole consisting of two electric charges in simple harmonic motion, showing propagation of an electric field line and its detachment (radiation) from the dipole. Arrows next to the dipole indicate current (I) direction.

Ground Wave

- At lower HF frequencies radio waves can follow the Earth's surface as they travel.
- These waves will travel beyond the range of line-of-sight.
- Range of a few hundred miles on bands used by amateurs.



2-16 Distortion of vertically polarized electric field by lossy ground resistance.

Space Wave/Direct Wave

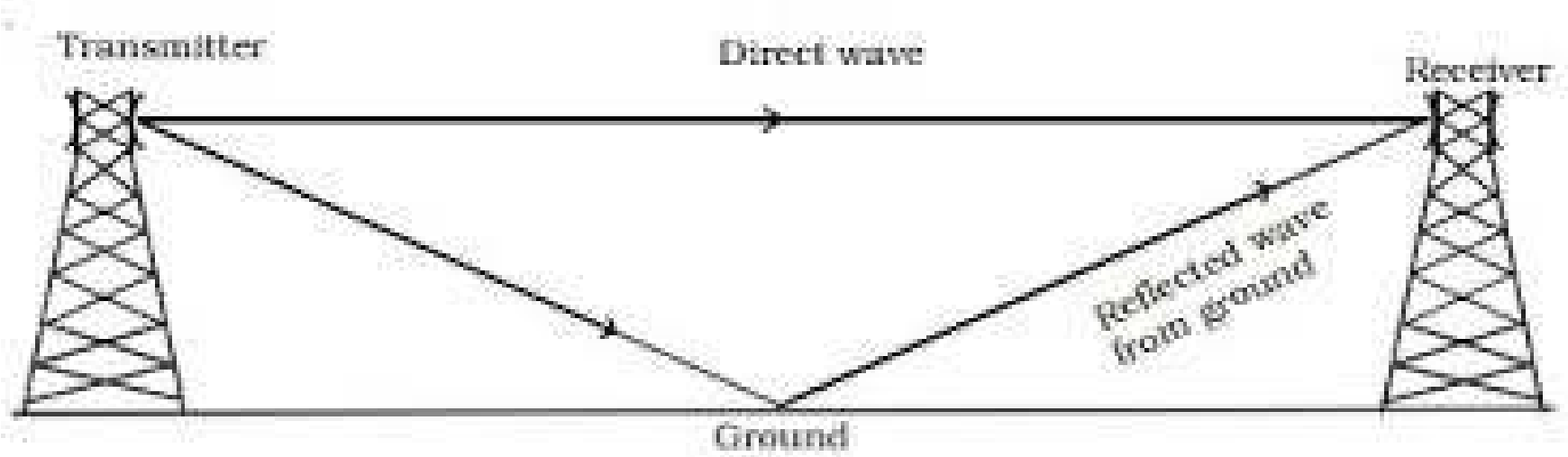
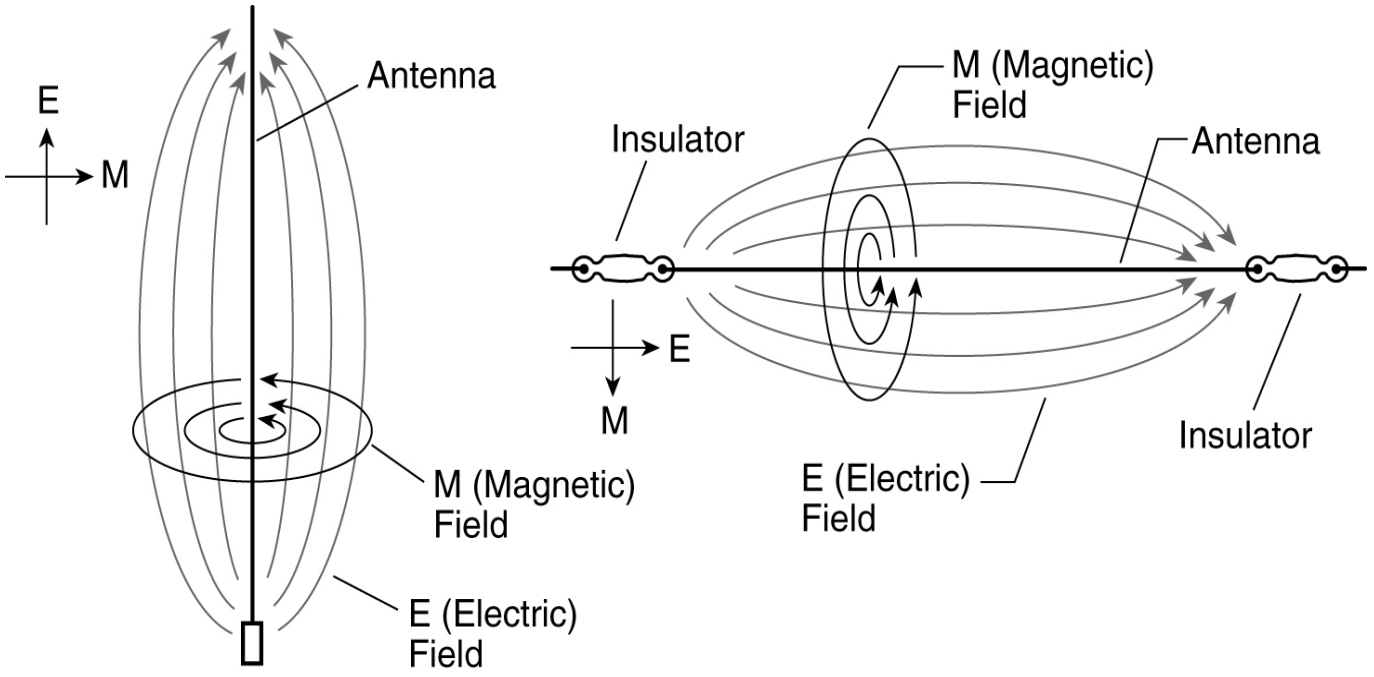


Fig Space wave propagation

Wave Polarization

- Orientation of the wave's electric field component with respect to the surface of the Earth
  - *Vertical* or *horizontal* – determined by orientation of the electric field
  - Can be *circular* if the orientation twists as the wave spreads through space
  - Combinations of polarization are called *elliptical* polarization



a. Vertically-Polarized Antenna

b. Horizontally-Polarized Antenna

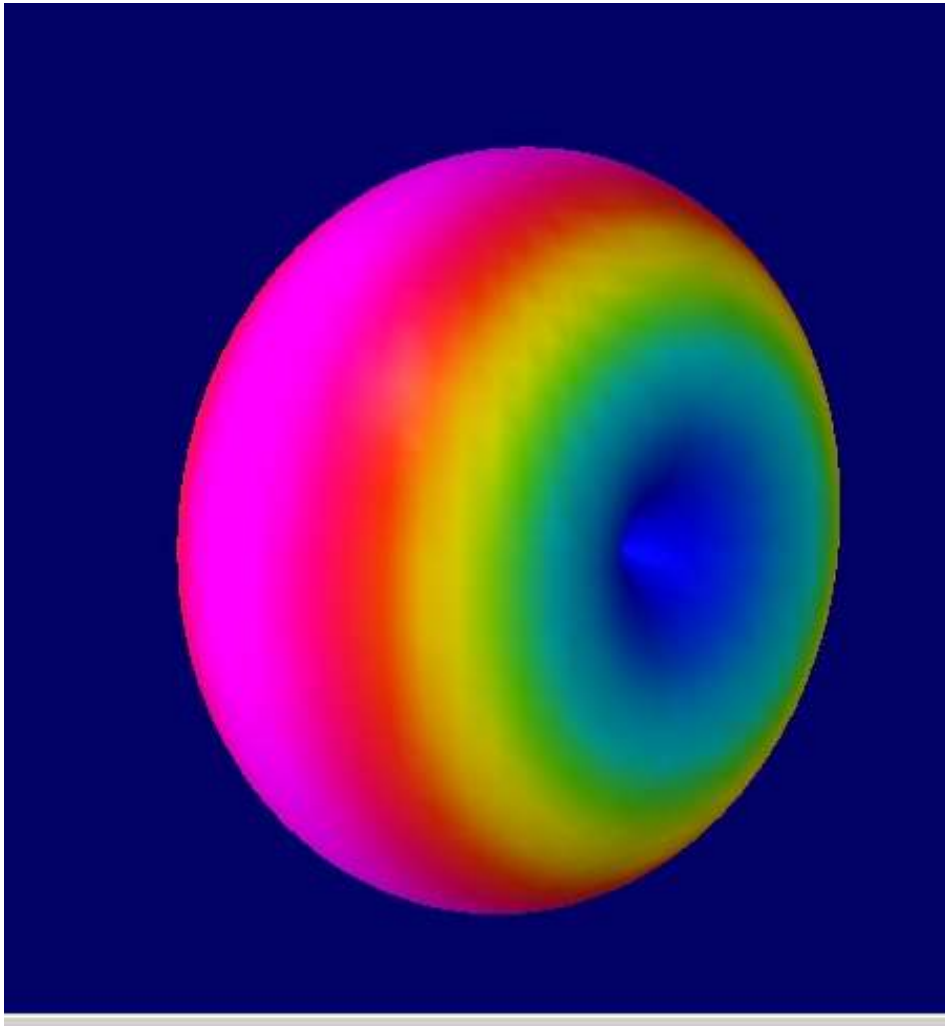
Cross-Polarization

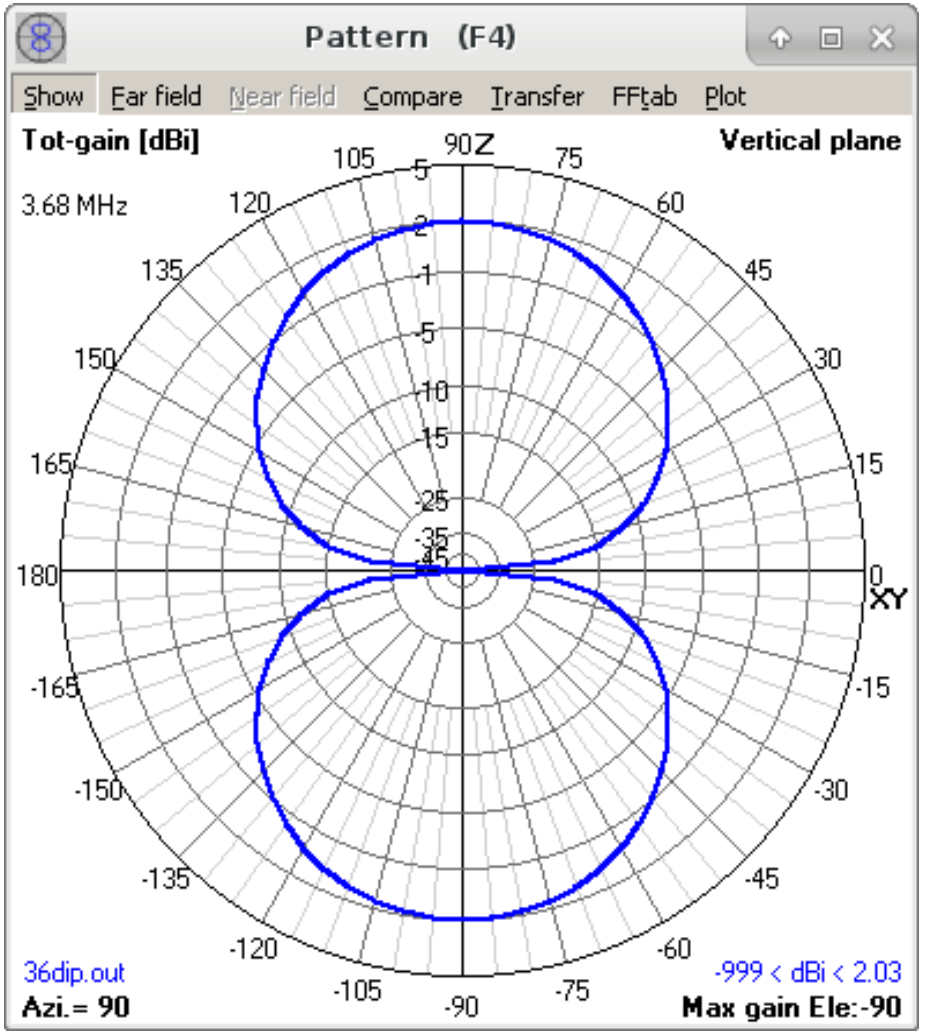
- Antenna and wave polarization must match for maximum reception.
  - **Cross-polarized**: antenna elements and the wave's electric field at right angles
  - Can reduce reception by a factor of 100
- For elliptically polarized waves (such as HF sky-wave) any antenna will respond at least partially.

Polarization Mismatch Between Two Linearly Polarized Waves as a Function of Angular Orientation

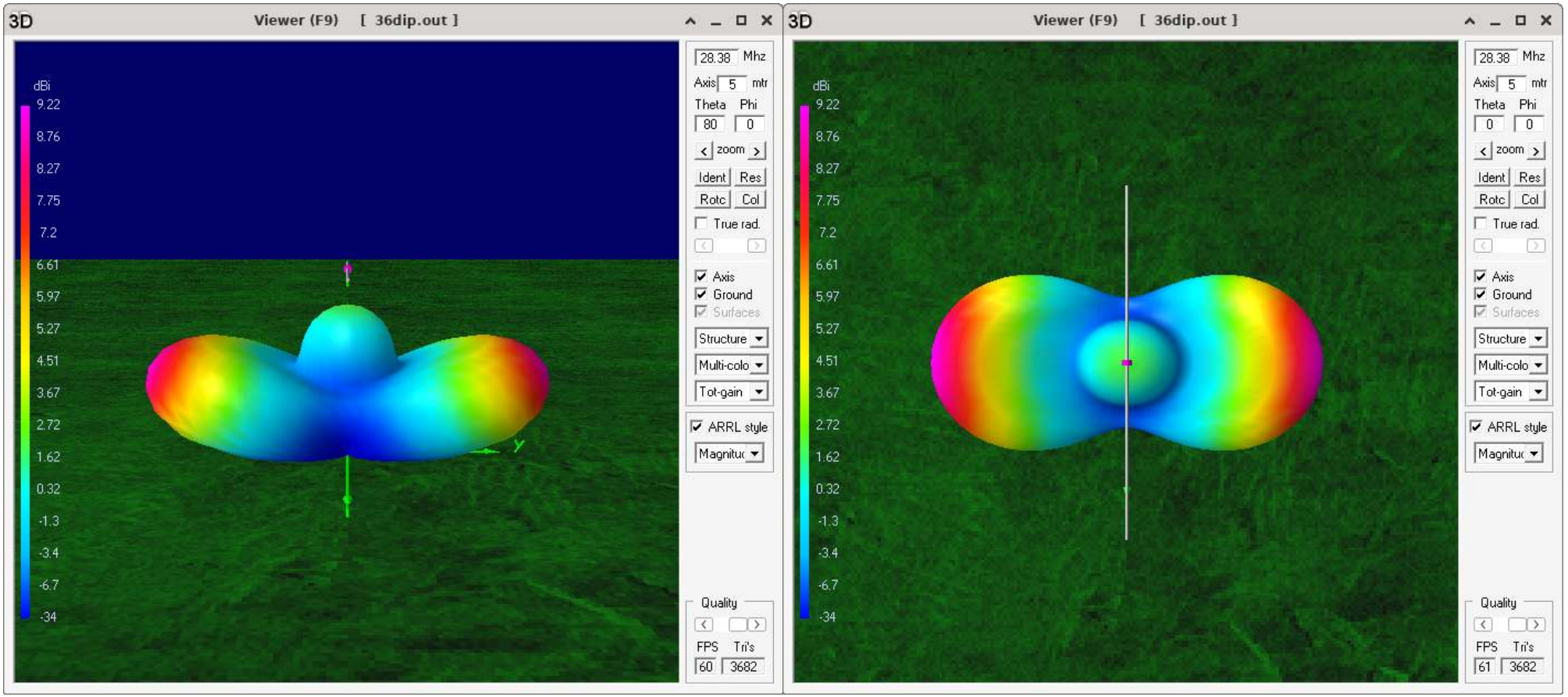
Orientation Angle	Polarization Mismatch (dB)
0.0 (aligned)	0.0
15.0	0.3
30.0	1.3
45.0	3.0
60.0	6.0
75.0	12.0
90.0 (orthogonal)	infinite (real world varies 20-35 dB)

Dipoles

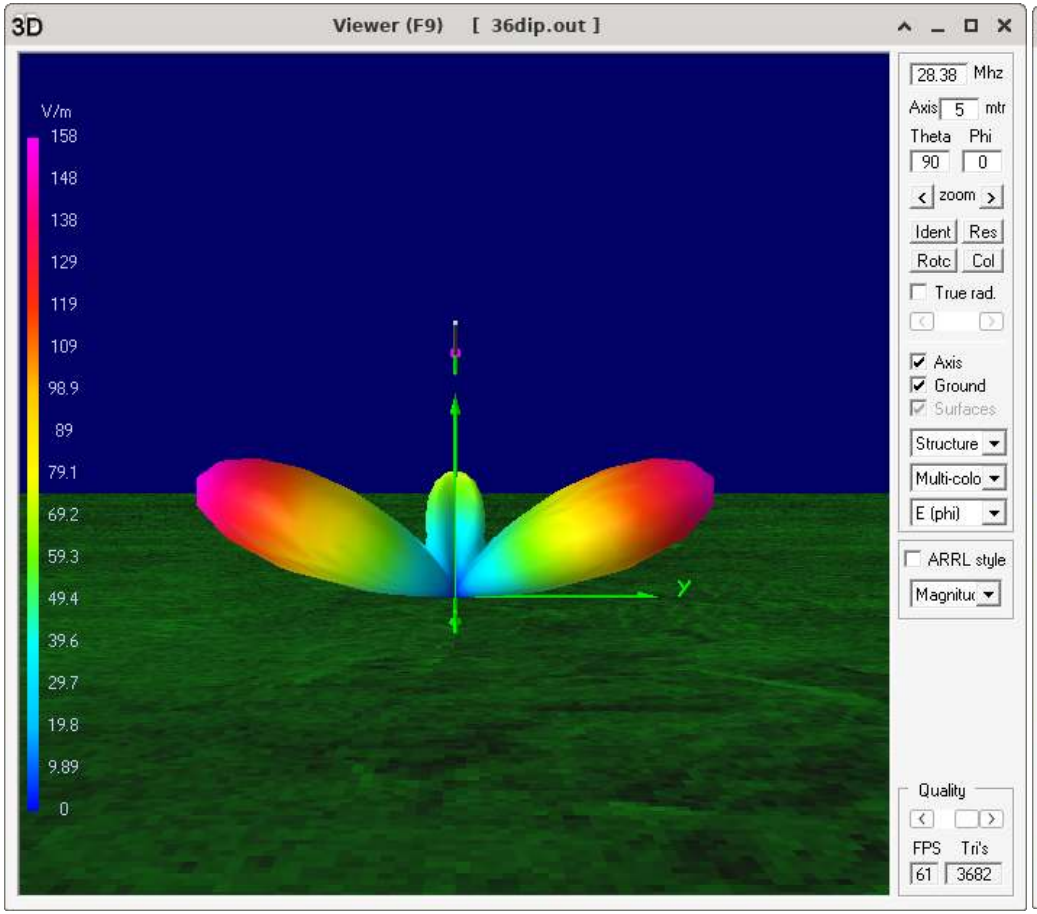


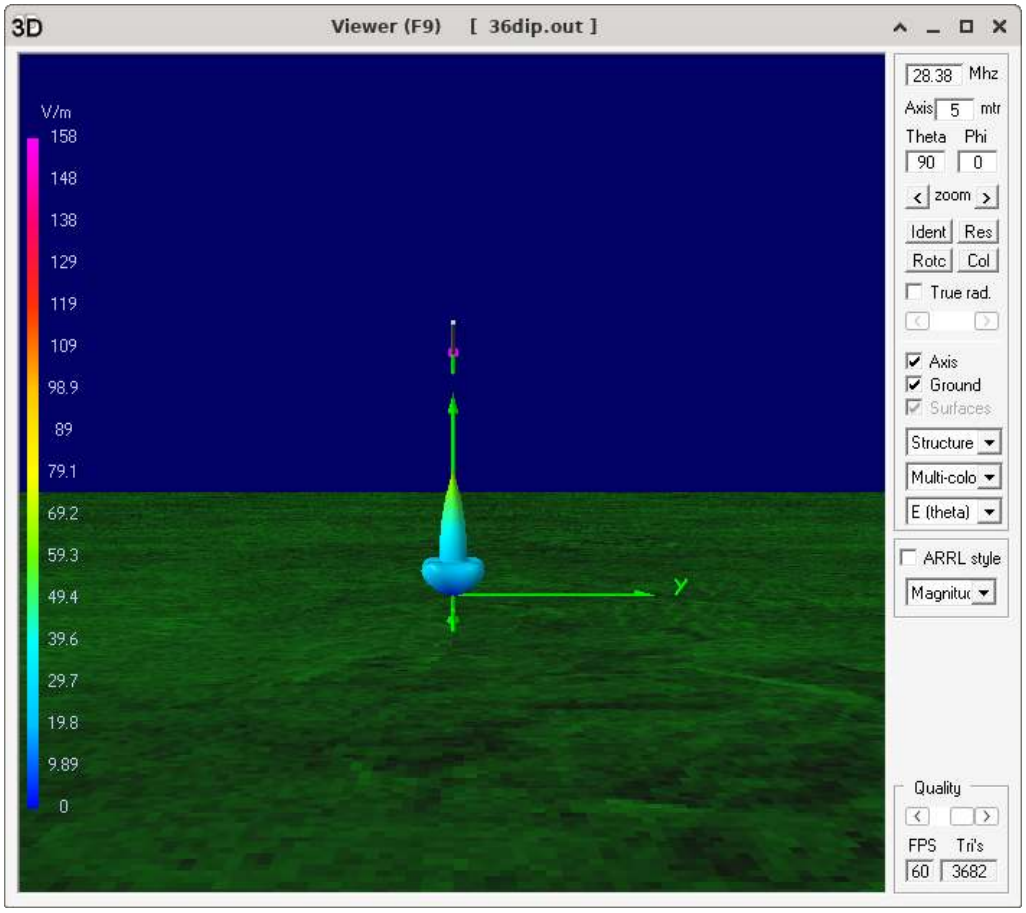

Pattern (F4)
Show
Far field
Near field
Compare
Transfer
FFtab
Plot
Tot-gain [dBi]
Vertical plane
3.68 MHz
90Z
105
75
120
60
135
45
150
30
165
15
180
0
XY
-165
-15
-150
-30
-135
-45
-120
-60
-105
-90
-75
5
2
1
-5
-10
-15
-25
-35
-45
36dip.out
-999 < dBi < 2.03
Azi.= 90
Max gain Ele:-90

10 meter dipole 20 feet above ground at 28.38 MHz



10 meter dipole 20 feet above ground at 28.38 MHz

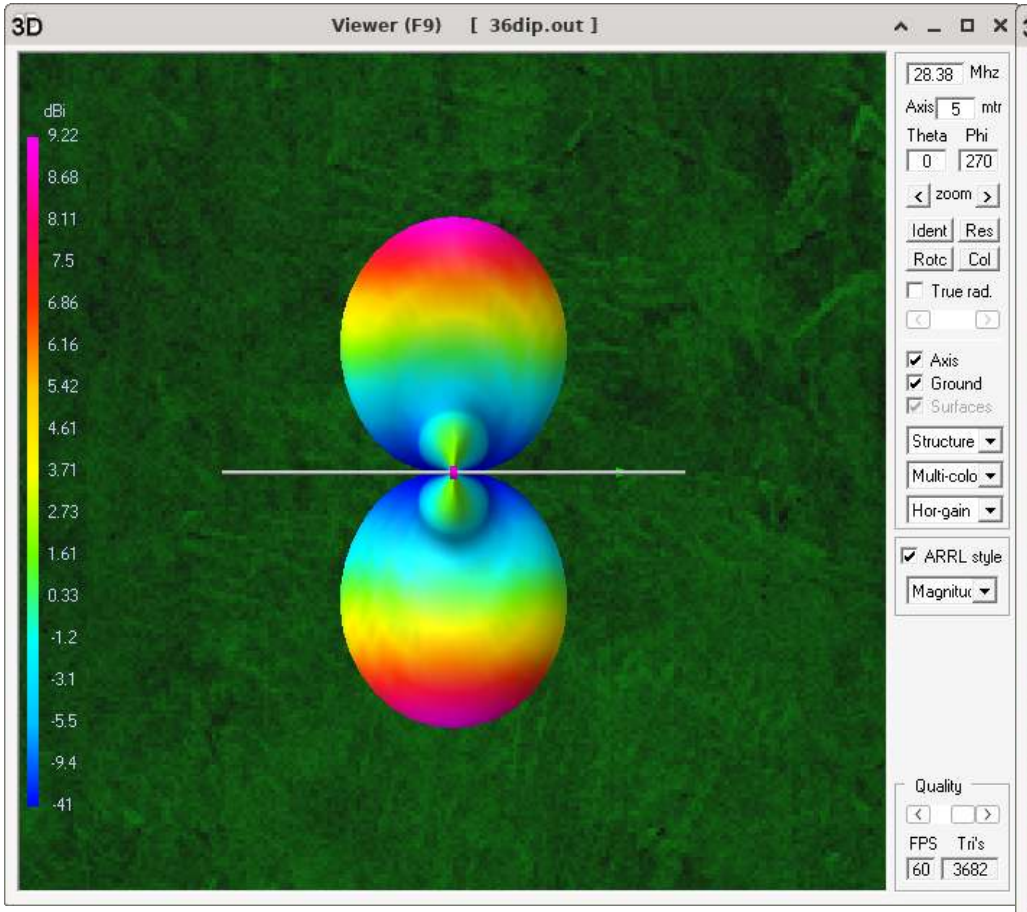




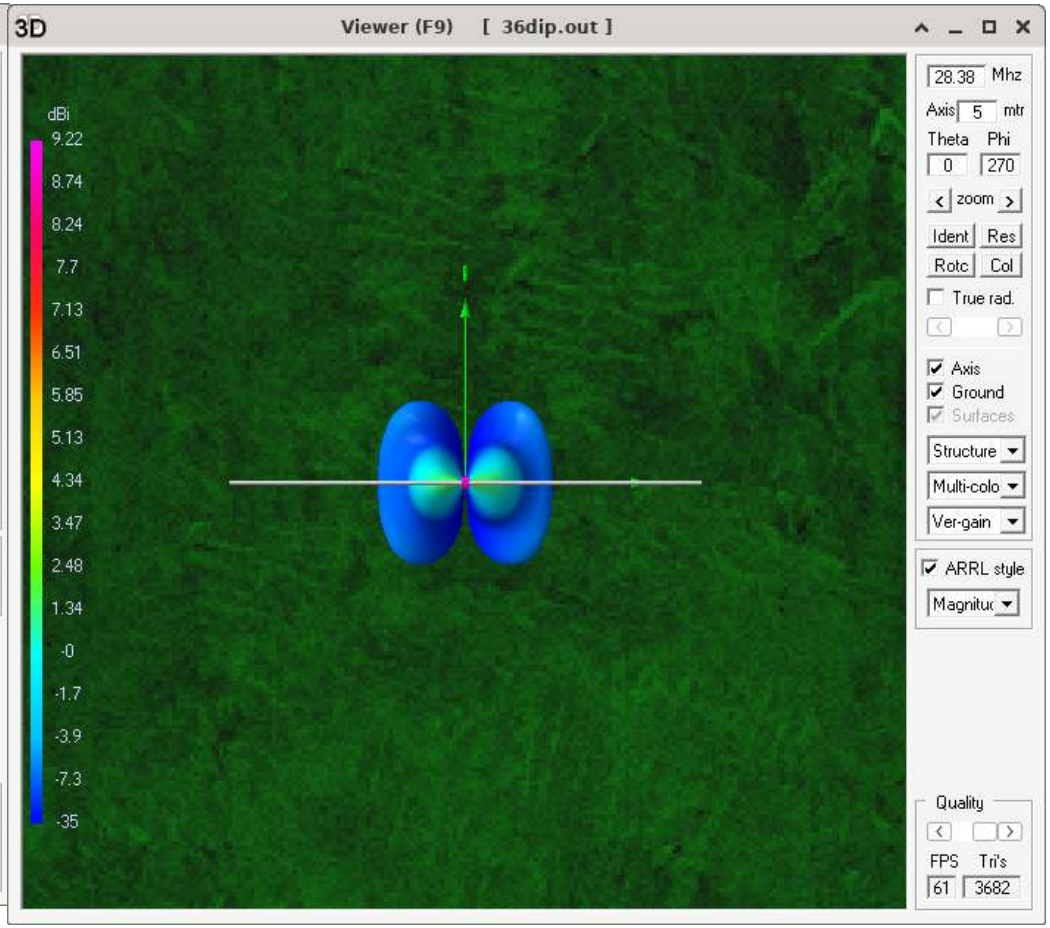
Horizontally Polarized Electric Field (Phi)

Vertically Polarized Electric Field (Theta)

10 meter dipole 20 feet above ground at 28.38 MHz

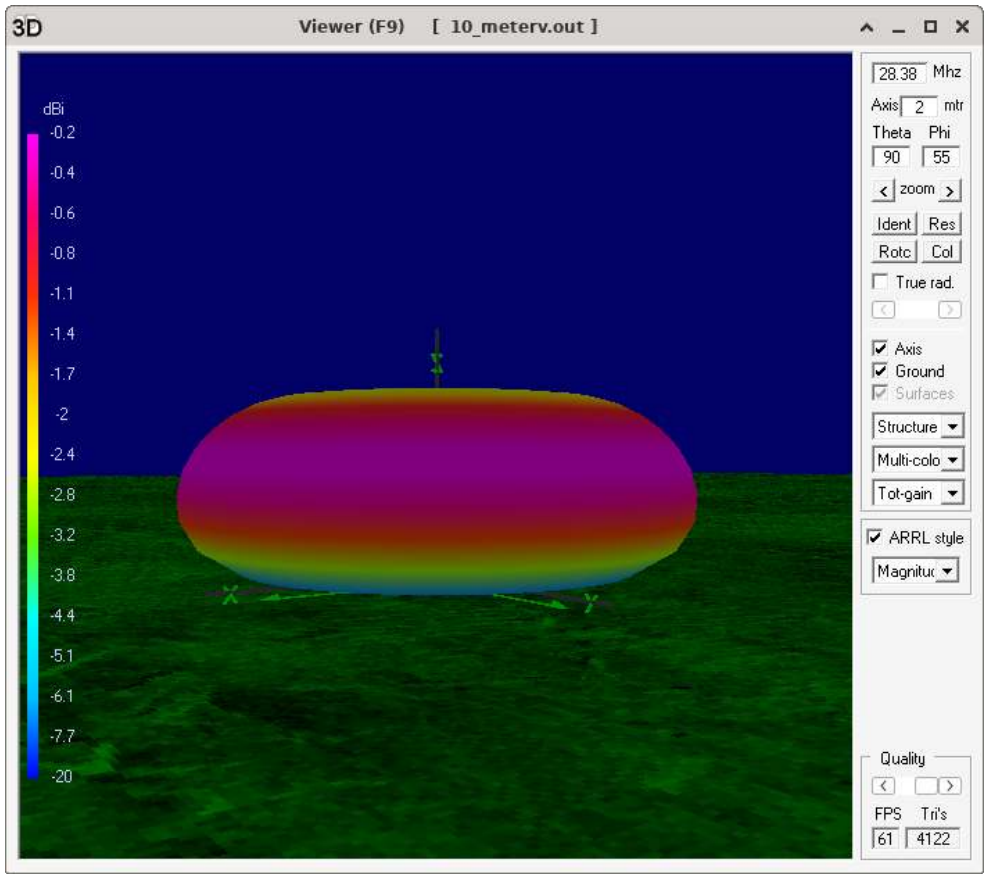


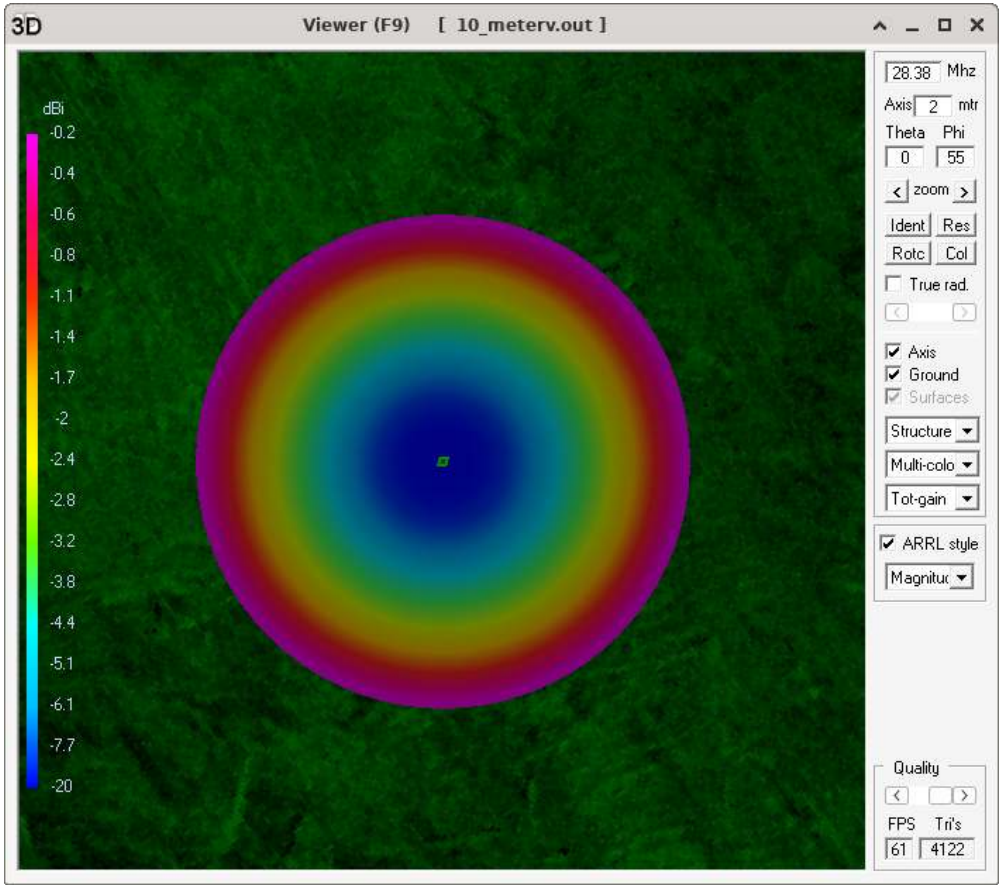
Horizontal Gain



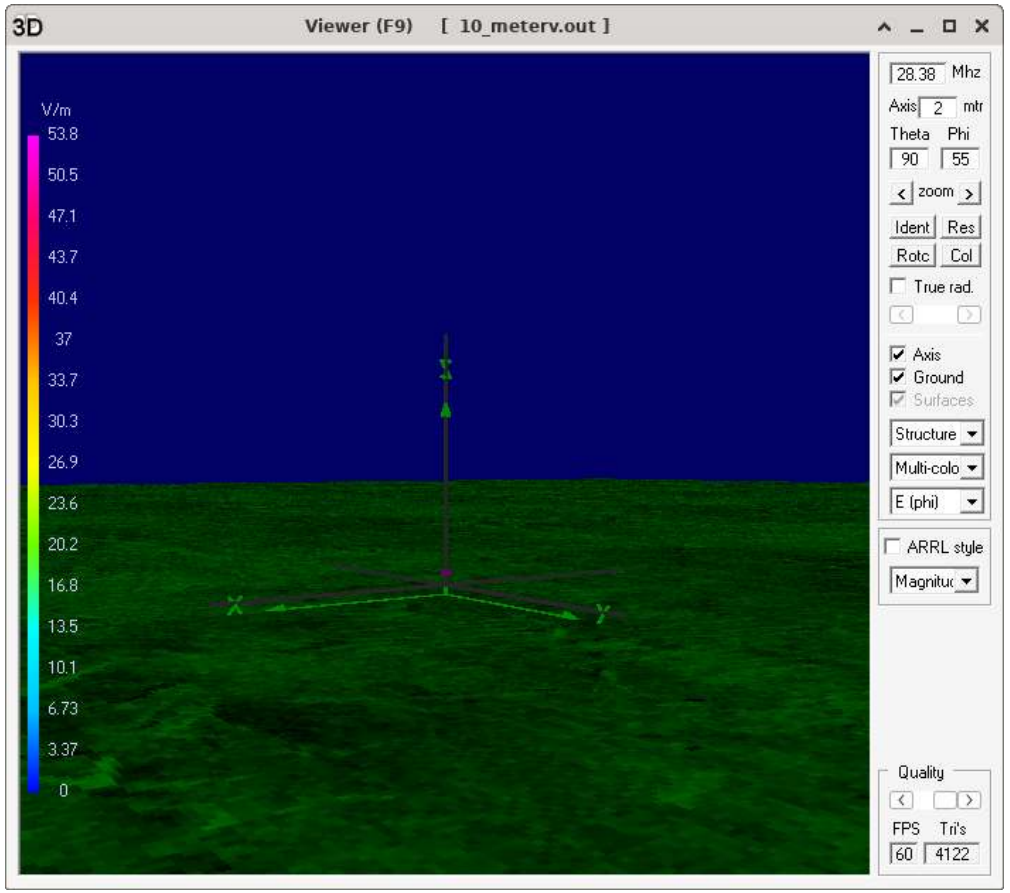
Vertical Gain

10 meter vertical at ground level at 28.38 MHz

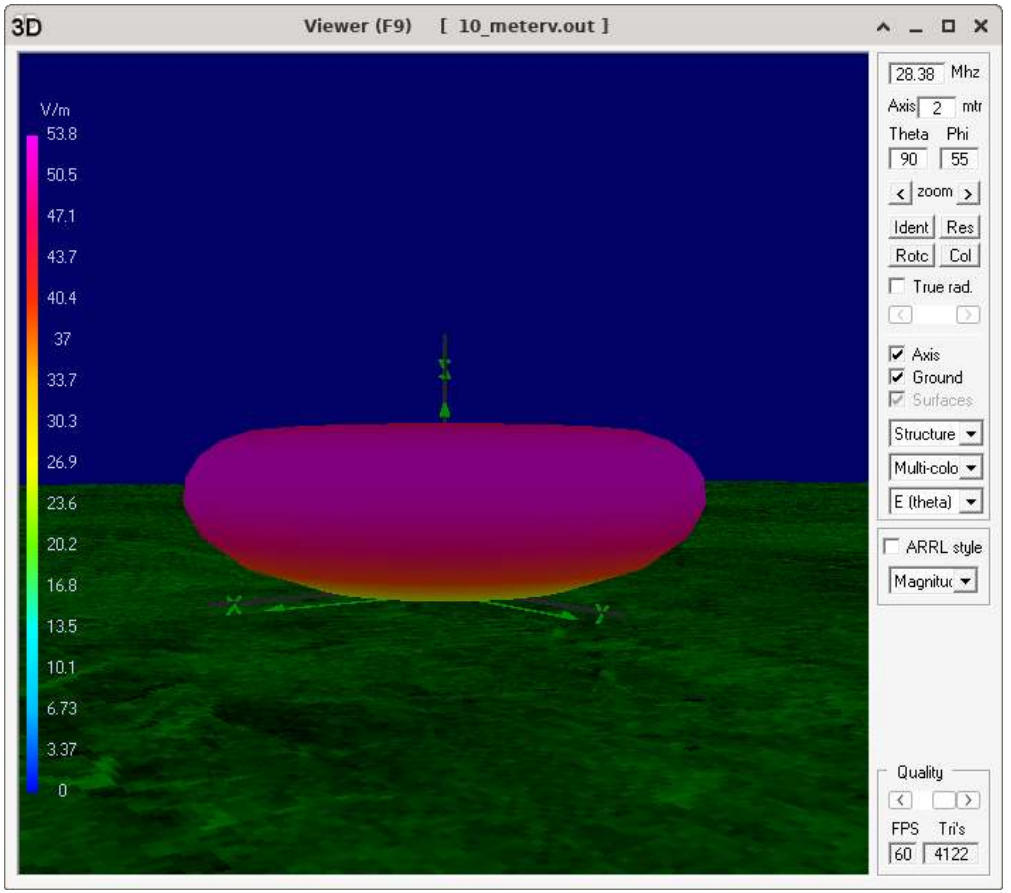




10 meter vertical at ground level at 28.38 MHz

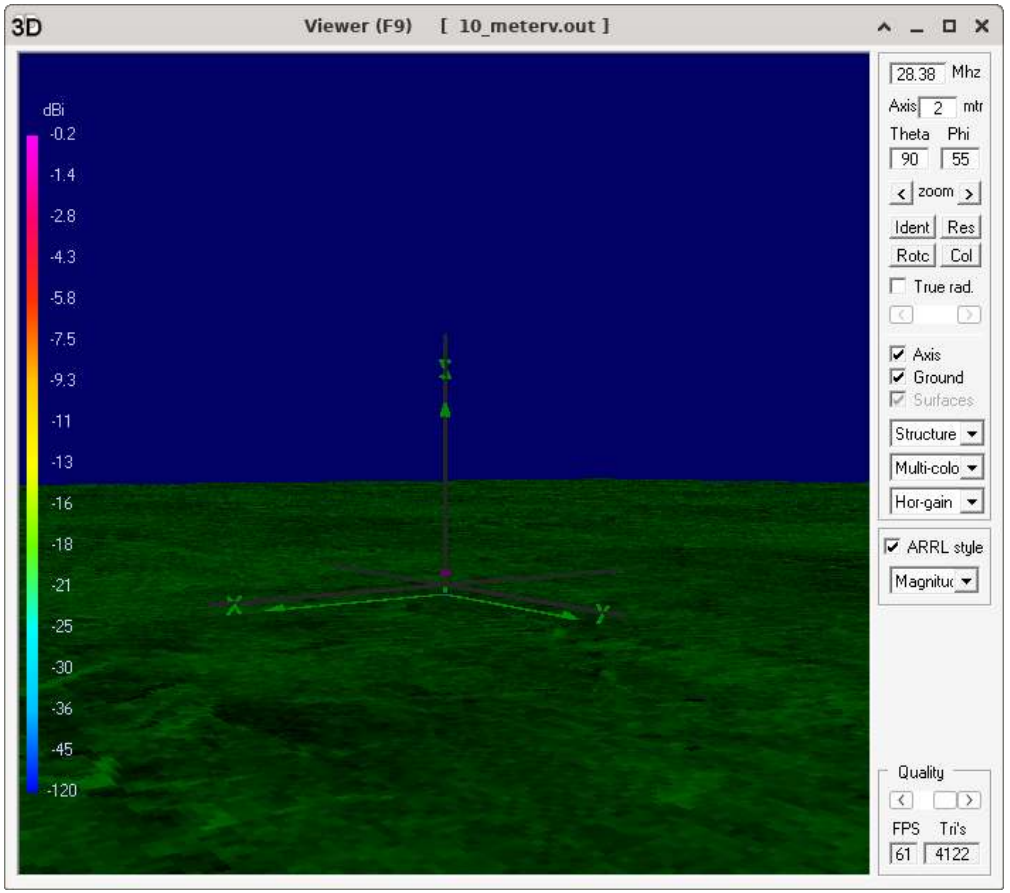


Horizontally Polarized Electric Field (Phi)

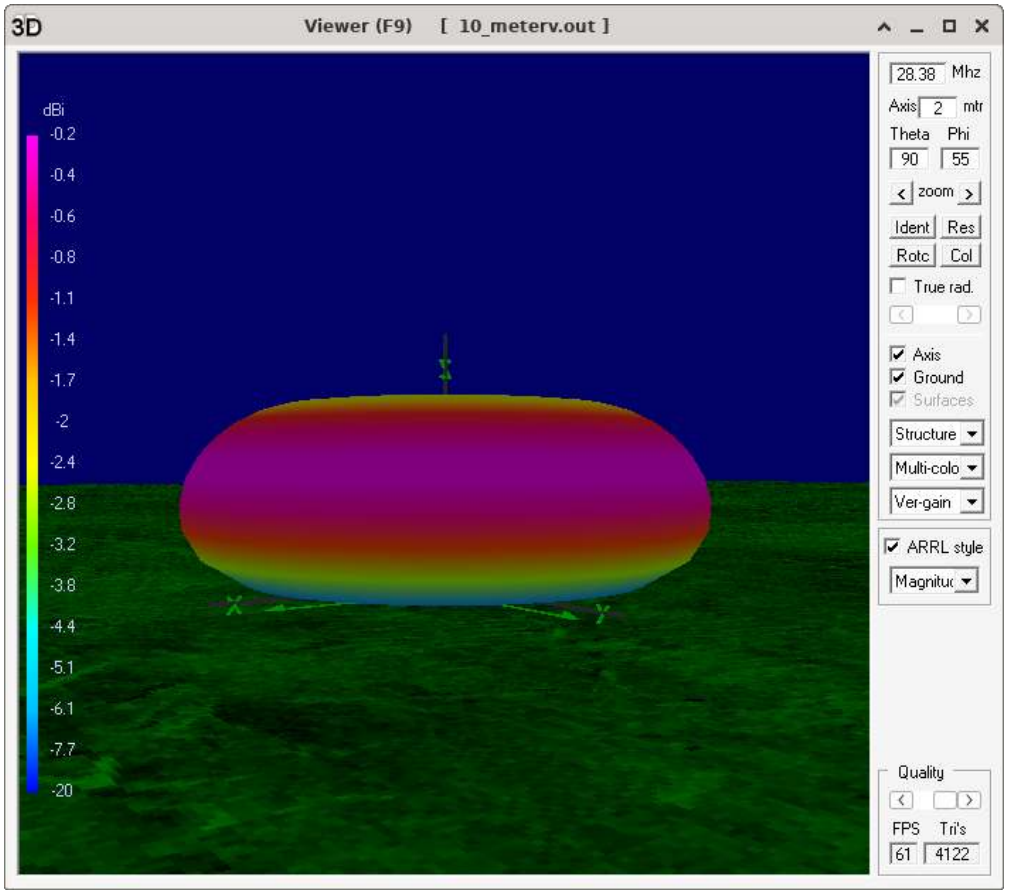


Vertically Polarized Electric Field (Theta)

10 meter vertical at ground level at 28.38 MHz

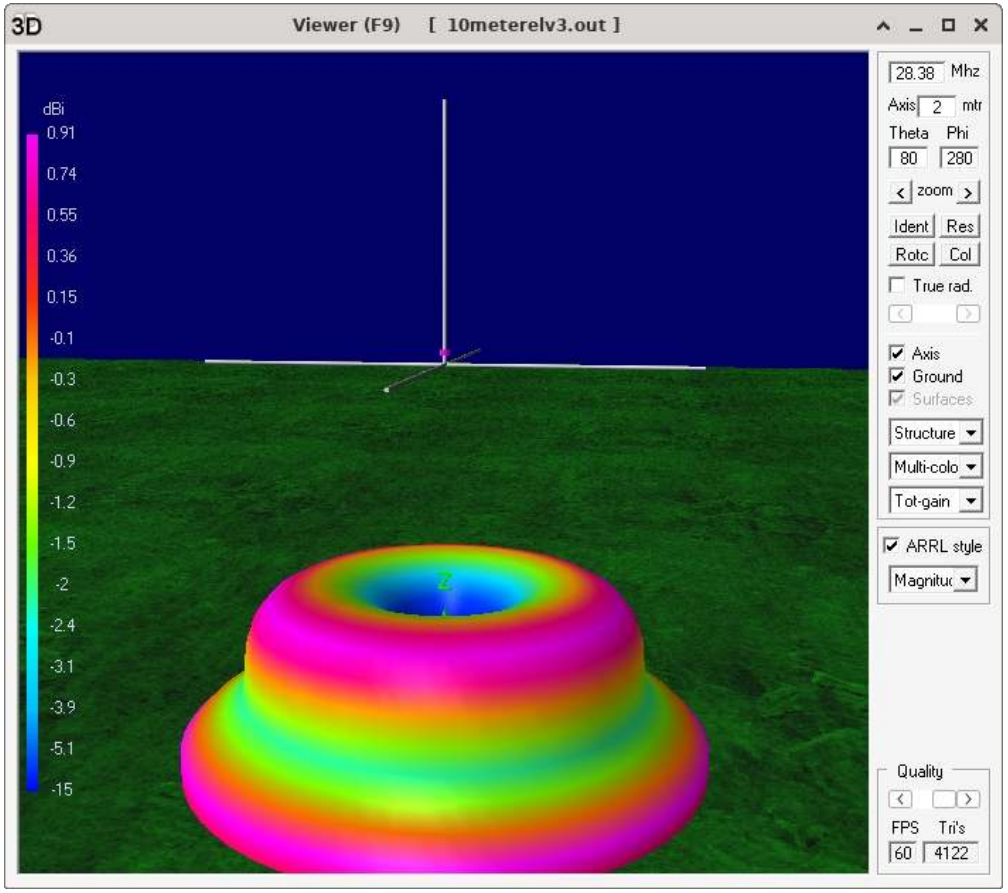


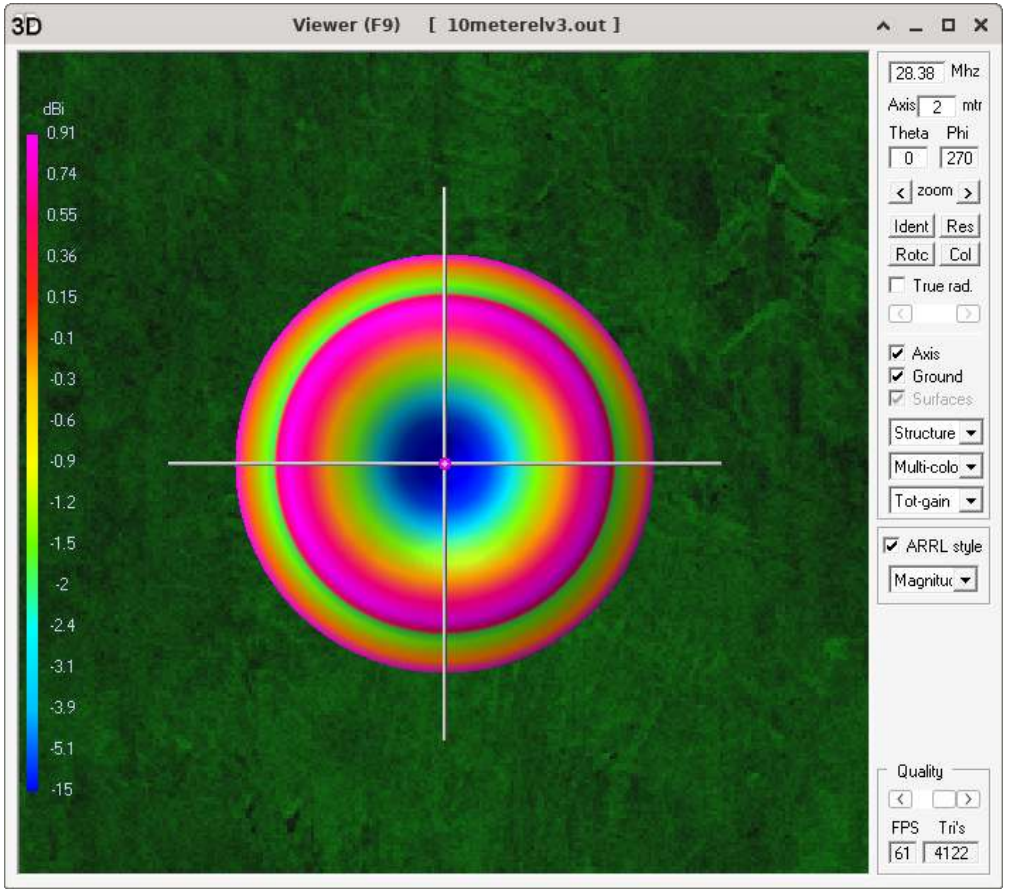
Horizontal Gain



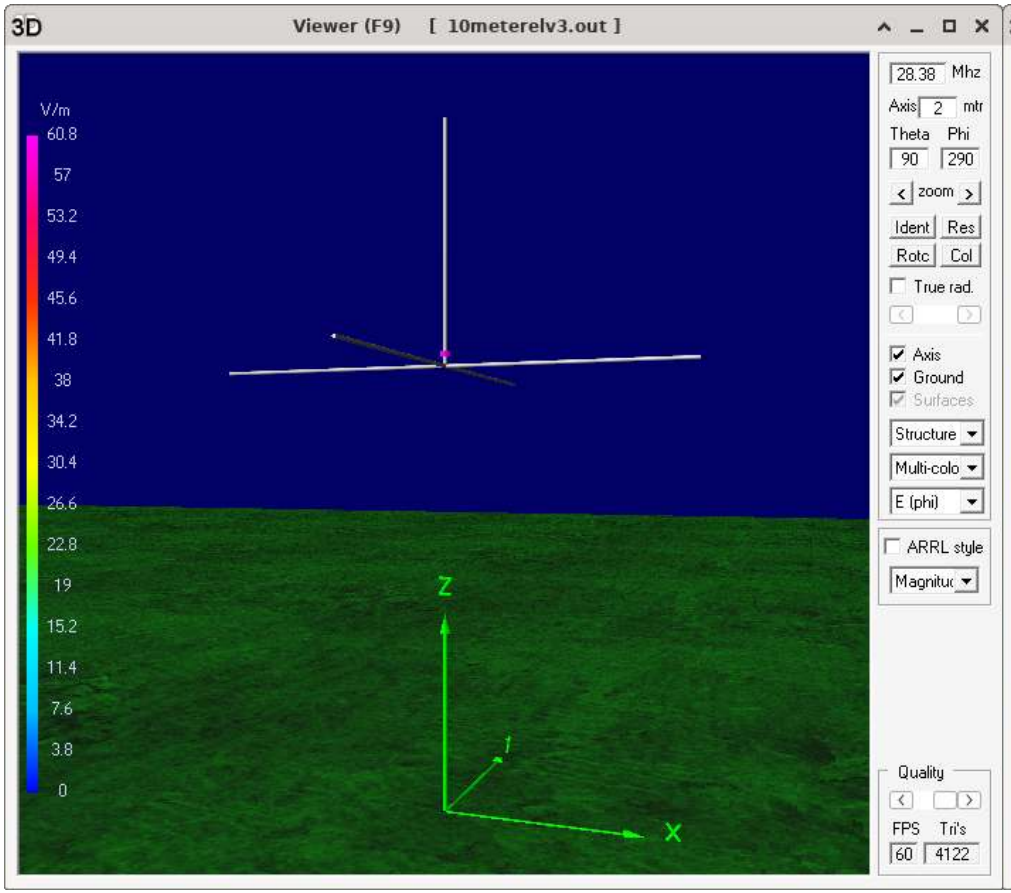
Vertical Gain

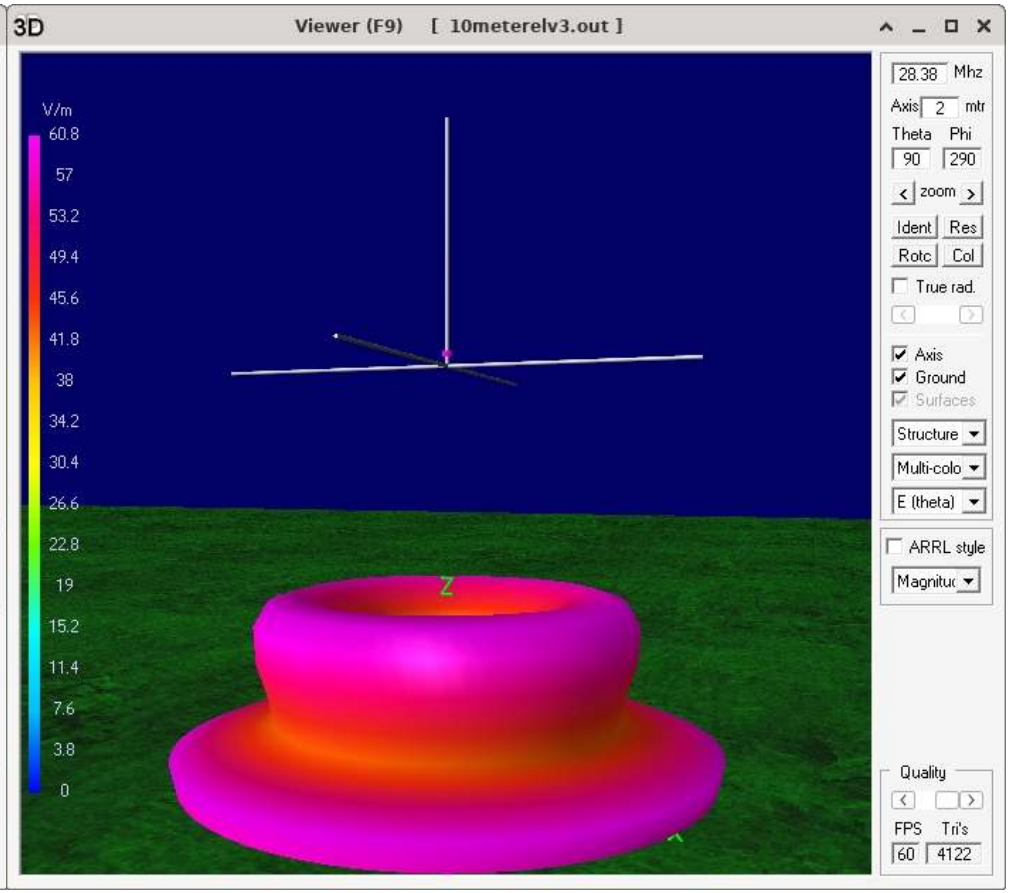
10 Meter Elevated Vertical at ~15 Feet at 28.38 MHz





10 Meter Elevated Vertical at ~15 Feet at 28.38 MHz

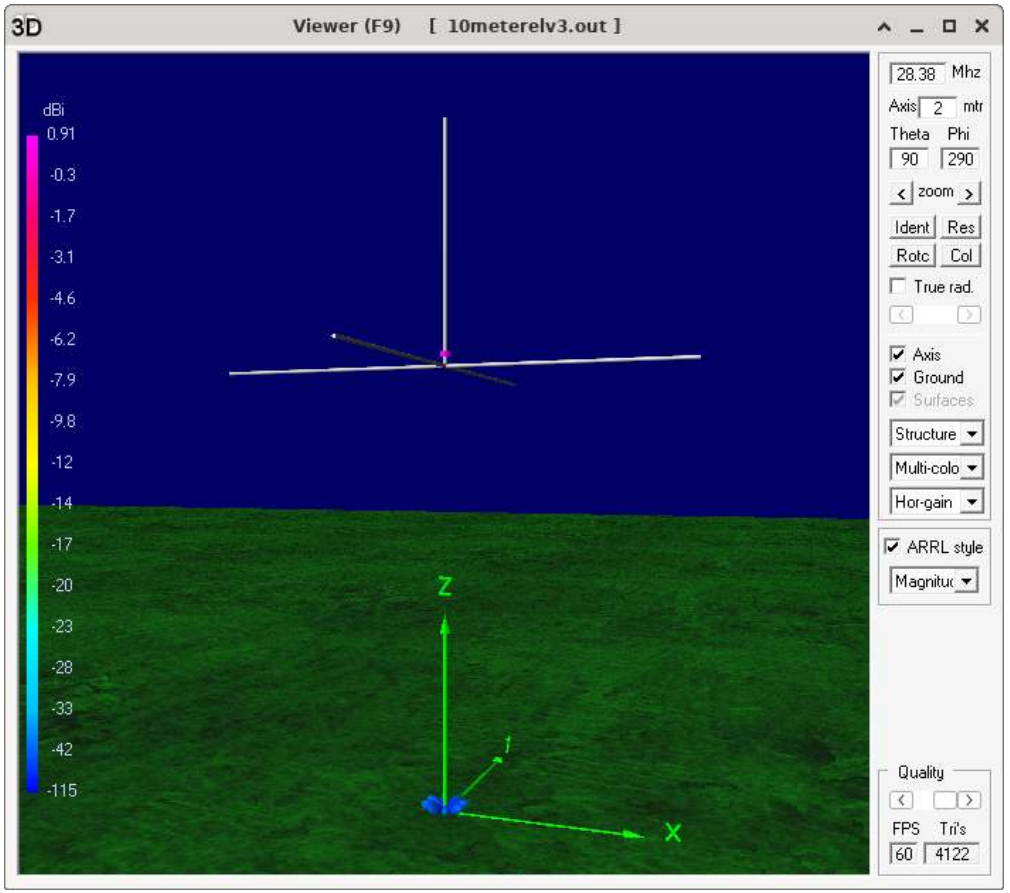




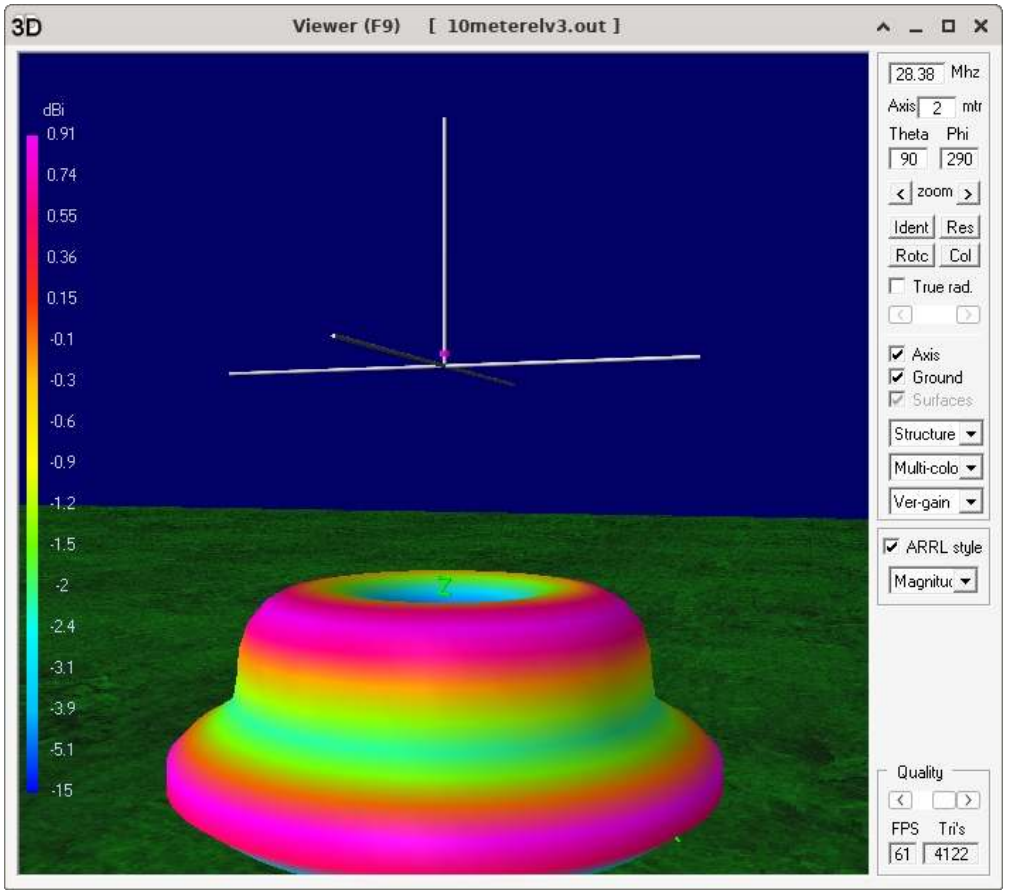
Horizontally Polarized Electric Field (Phi)

Vertically Polarized Electric Field (Theta)

10 Meter Elevated Vertical at ~15 Feet at 28.38 MHz

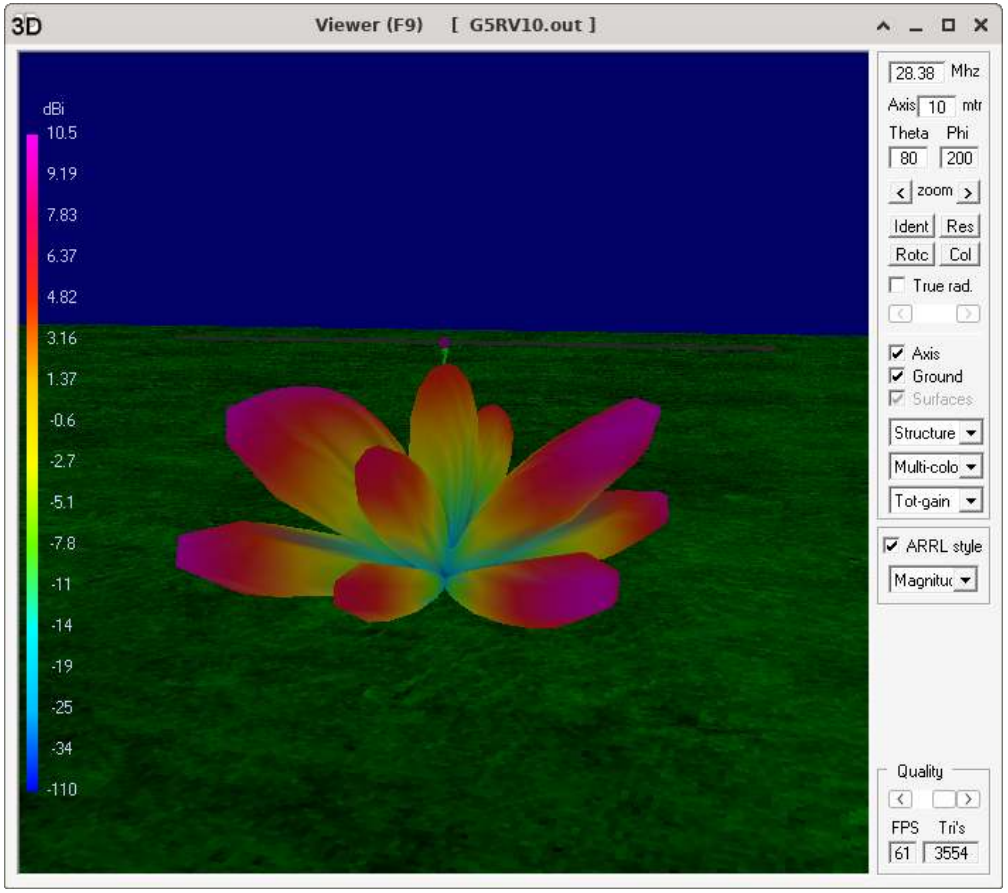


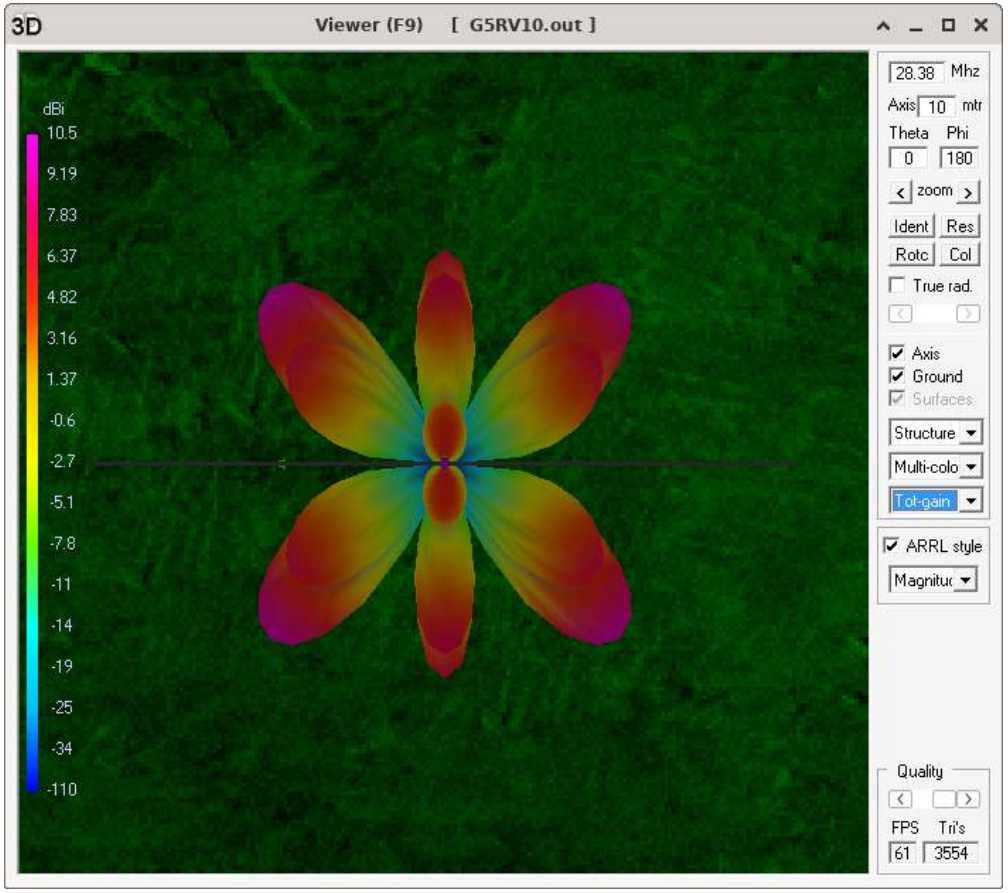
Horizontal Gain



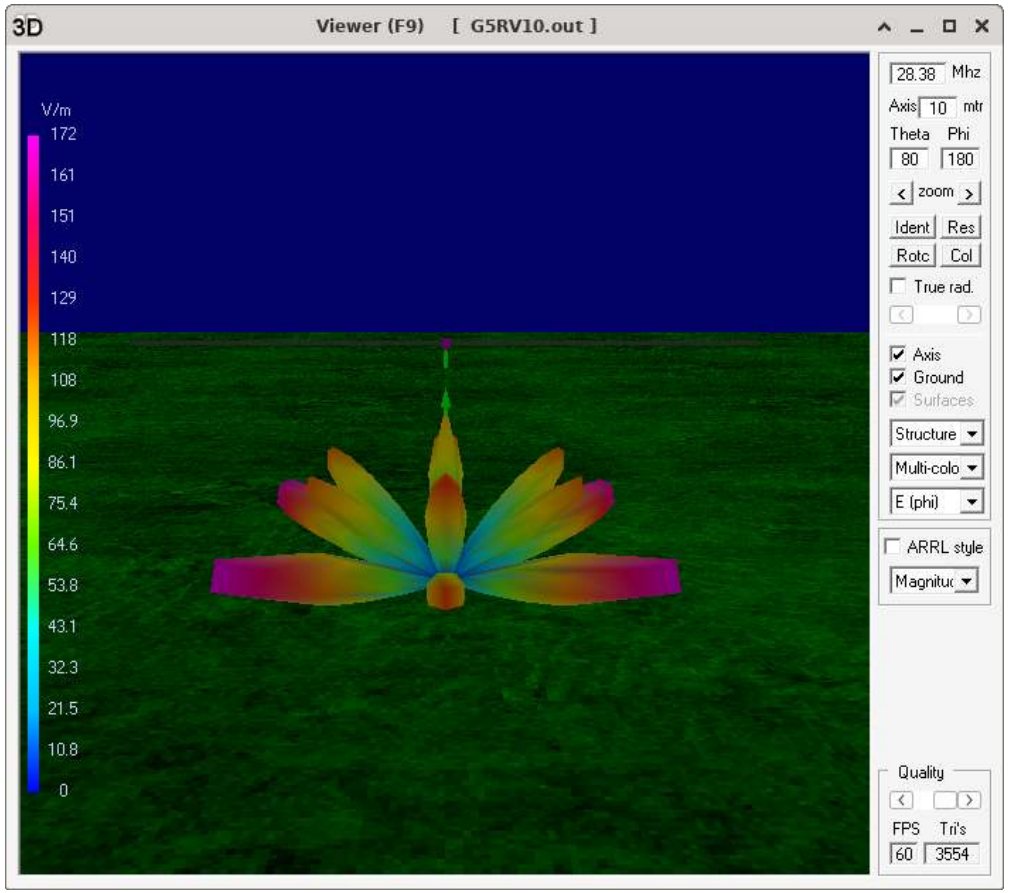
Vertical Gain

G5RV Multiband Antenna at 40 Feet on 10 Meters at 28.38 MHz

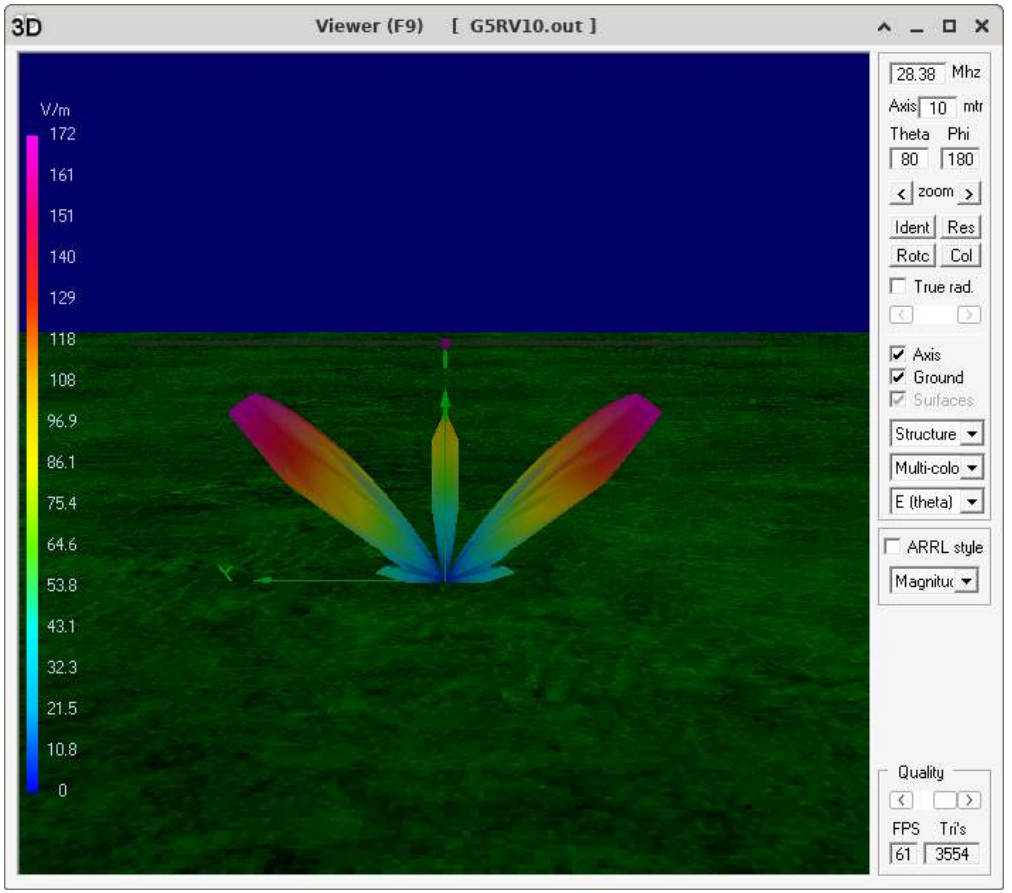




G5RV Multiband Antenna at 40 Feet on 10 Meters at 28.38 MHz

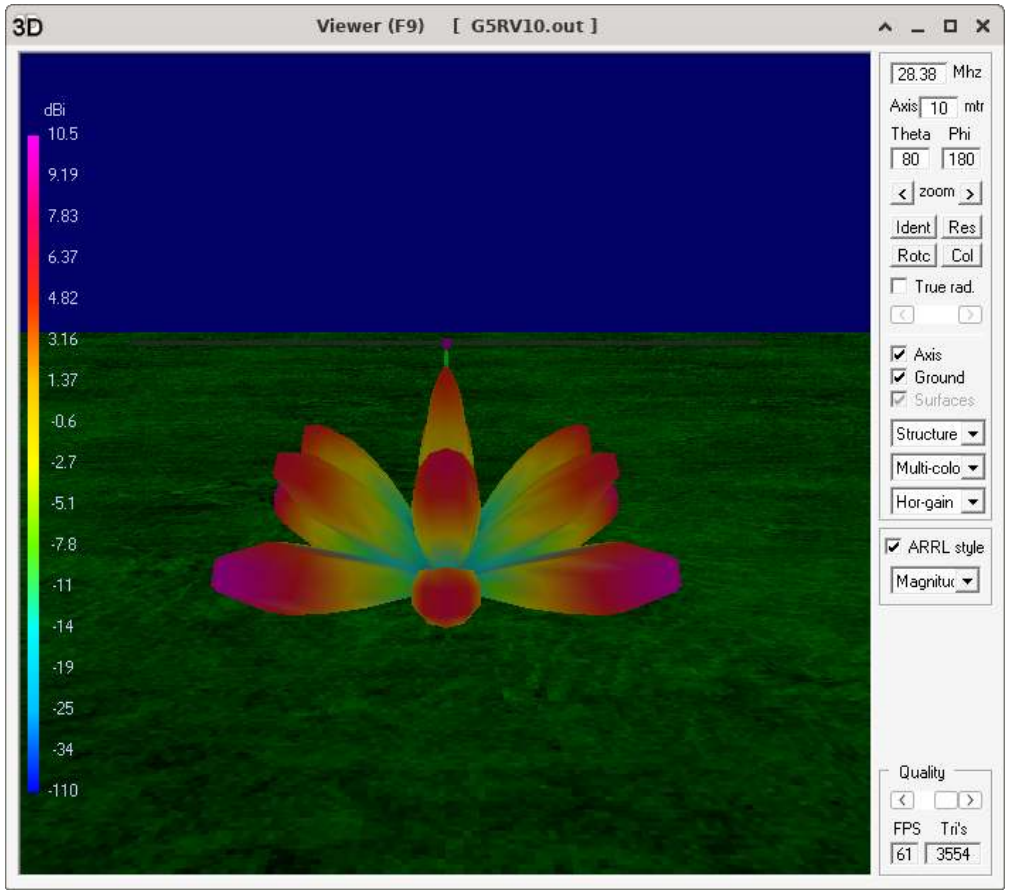


Horizontally Polarized Electric Field (Phi)

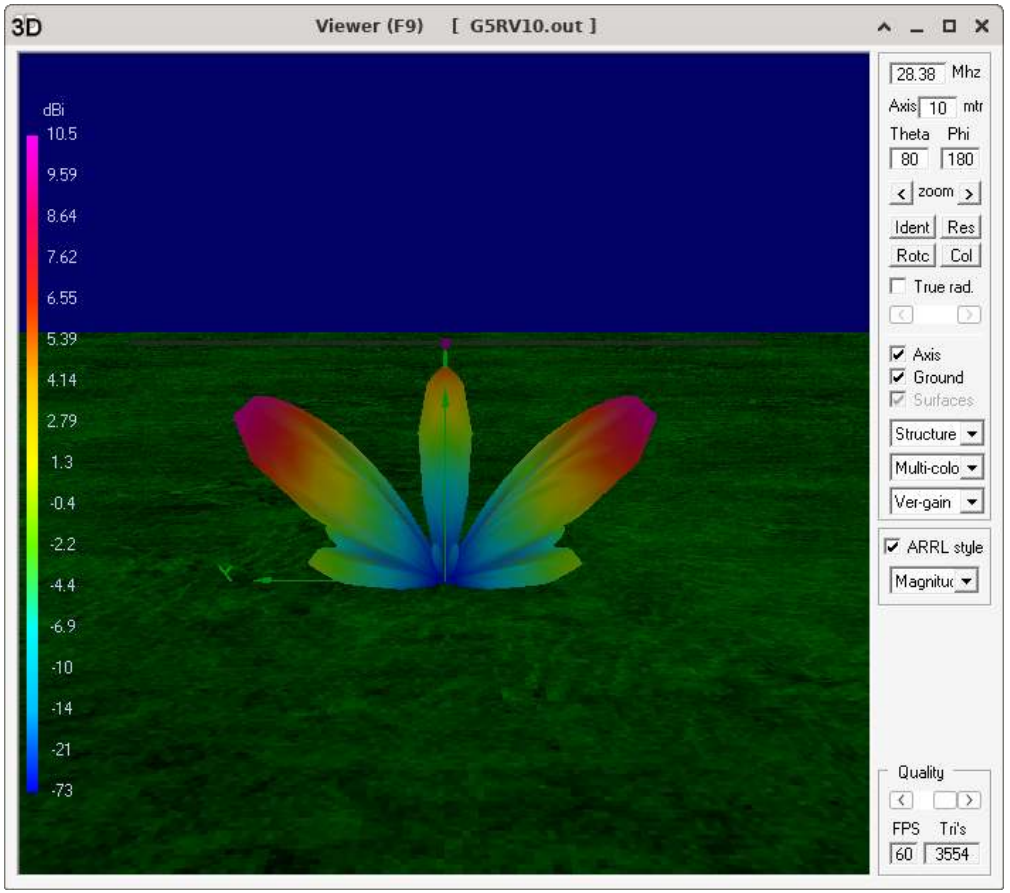


Vertically Polarized Electric Field (Theta)

G5RV Multiband Antenna at 40 Feet on 10 Meters at 28.38 MHz



Horizontal Gain



Vertical Gain