MIT Haystack Observatory

FEKO Simulations for the MWA

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1] Introduction

The results from FEKO simulations of the MWA are presented. Specifically, one of the tiles of the array, consisting of 16 of the "short-wide" bow tie antennas, is modeled over an infinite ground plane and the finite wire grid currently in place. The radiation patterns, represented by the directivity of the total electric field, are compared at 100, 200, and 300 MHz to observe the effects of the wire grid and obtain an estimate for the front-to-back ratio. With this, we can calculate an estimate for the noise contribution from the ground below the tile.

2] Description of the Model

An individual "short-wide" element was modeled in FEKO. The model was then copied 16 times in the 4 x 4 square configuration (Figure 2). The goal of this first version is to obtain a rough estimate of the front-to-back ratio for a tile. As a result, certain properties have been omitted. The arms of the elements are modeled in the u-channel shape of the actual antenna. However, the material is approximated as perfect electrical conductor rather than aluminum and thus resistive losses in the antenna are ignored. This can be modeled at a later date when a more accurate approximation of the loss in the antenna is necessary. A voltage source drives one of the polarization axes by means of connecting a wire between the plates at the end of each arm. We have not modeled the LNA connecting wires. The other axis is not excited but has a 150Ω load across the plates. The wire grid is 5 m x 5 m and consists of perfectly conducting wires, 3.15 mm in diameter, spaced 5 cm apart. Figure 1 shows a single element over the wire grid as it appears in FEKO. Ignored are the dielectric feet supporting the antenna and the PVC cylinder housing the LNA. Again, these can be included in later versions of the simulation. Also ignored is the fact that the actual wire grid is constructed of 3 separate panels that are overlapped to create the 5x5m grid. However, it has been determined through additional simulations that the effect is minimal with the overlap of 50 cm currently being used.

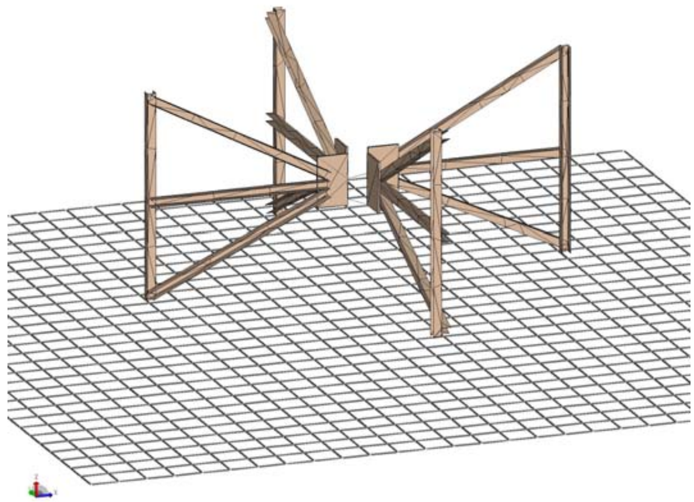


Figure 1: A view of a single bowtie over the wire grid.

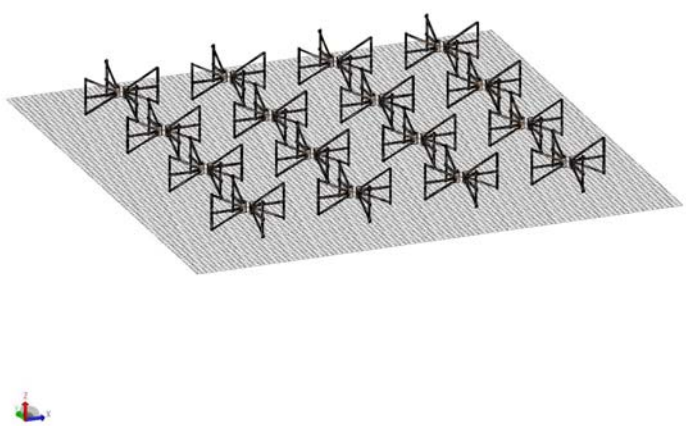
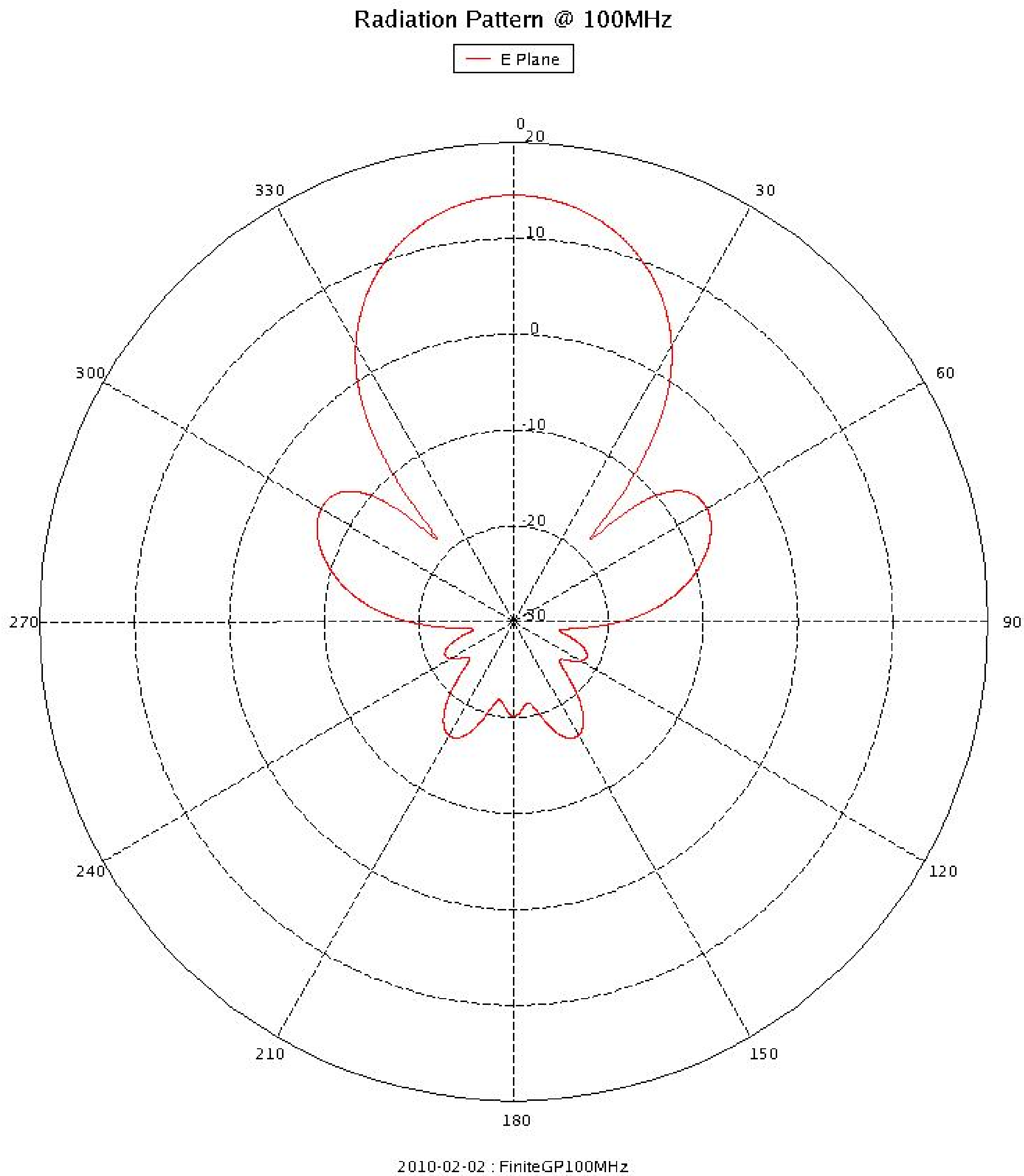


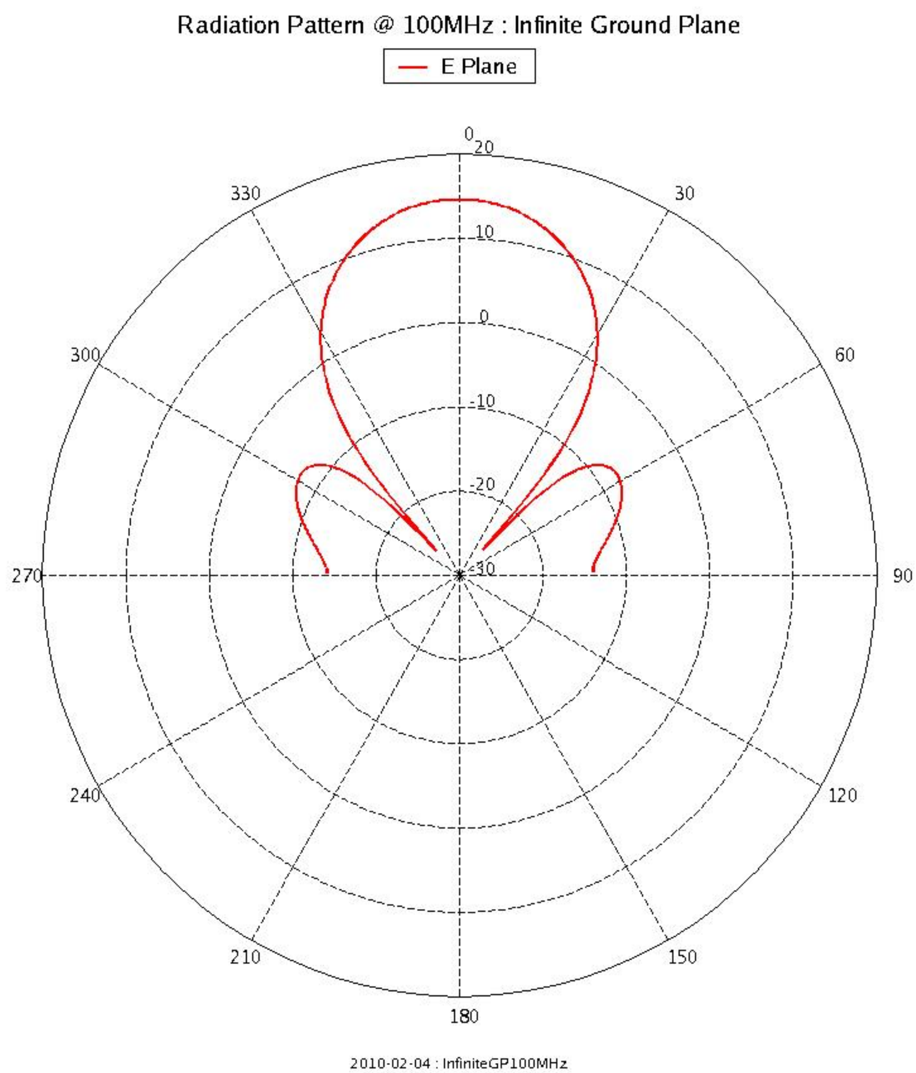
Figure 2: A view of the tile as modeled in FEKO.

3] Results

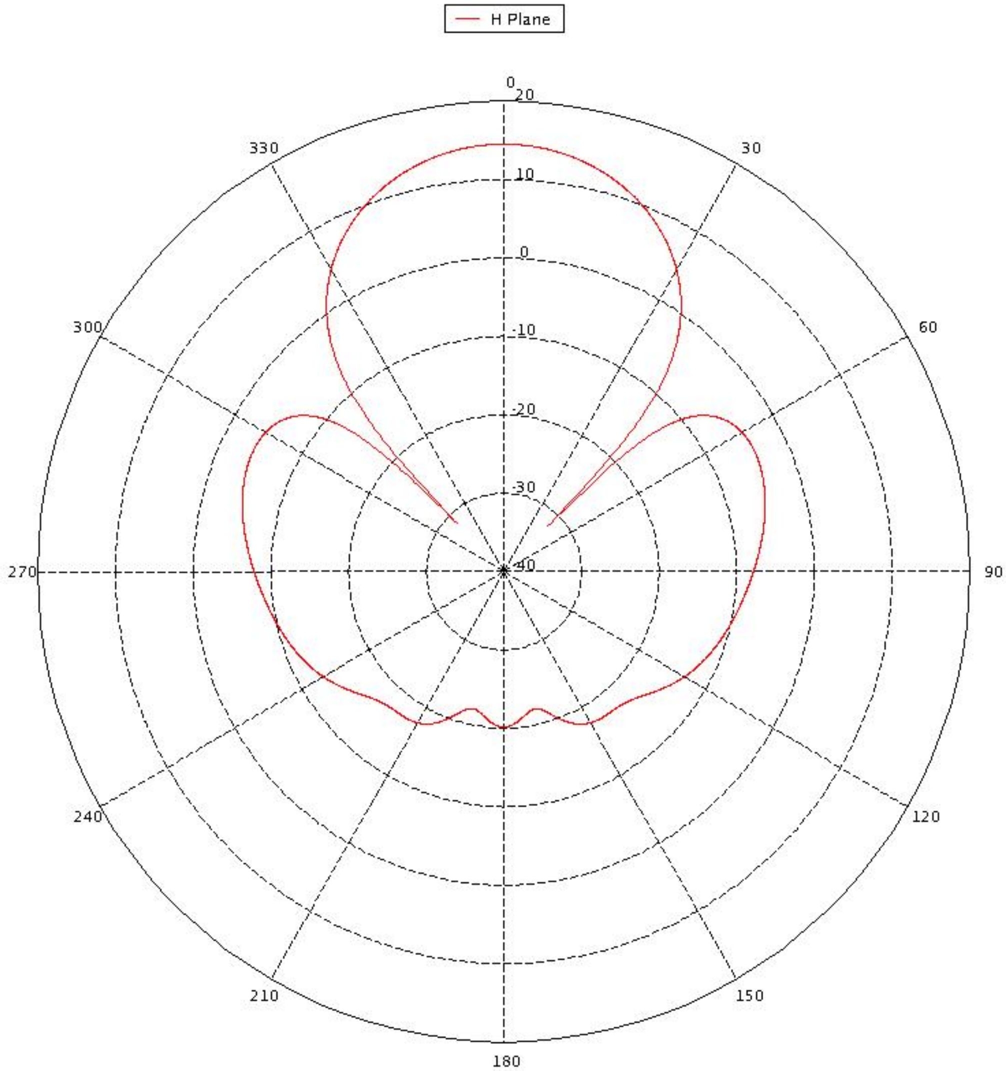
The following are graphs of the E-plane and H-plane cuts of the radiation pattern of a tile at 100, 200, and 300 MHz over the finite ground plane and the infinite ground plane.

i) 100 MHz

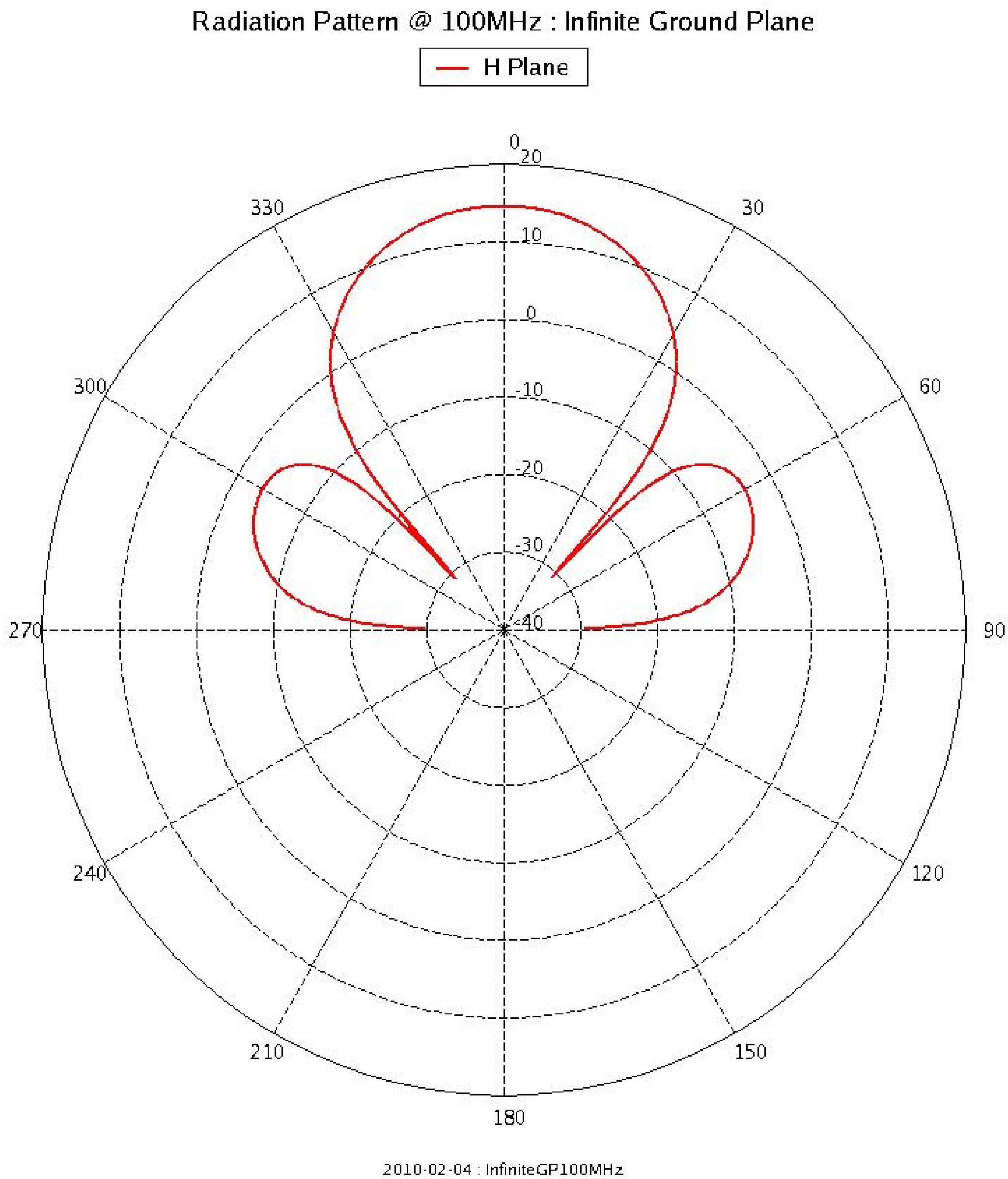



Radiation Pattern @ 100MHz : Infinite Ground Plane
E Plane
0
30
60
90
120
150
180
210
240
270
300
330
20
10
0
-10
-20
-30
2010-02-04 : InfiniteGP100MHz

Radiation Pattern @ 100MHz

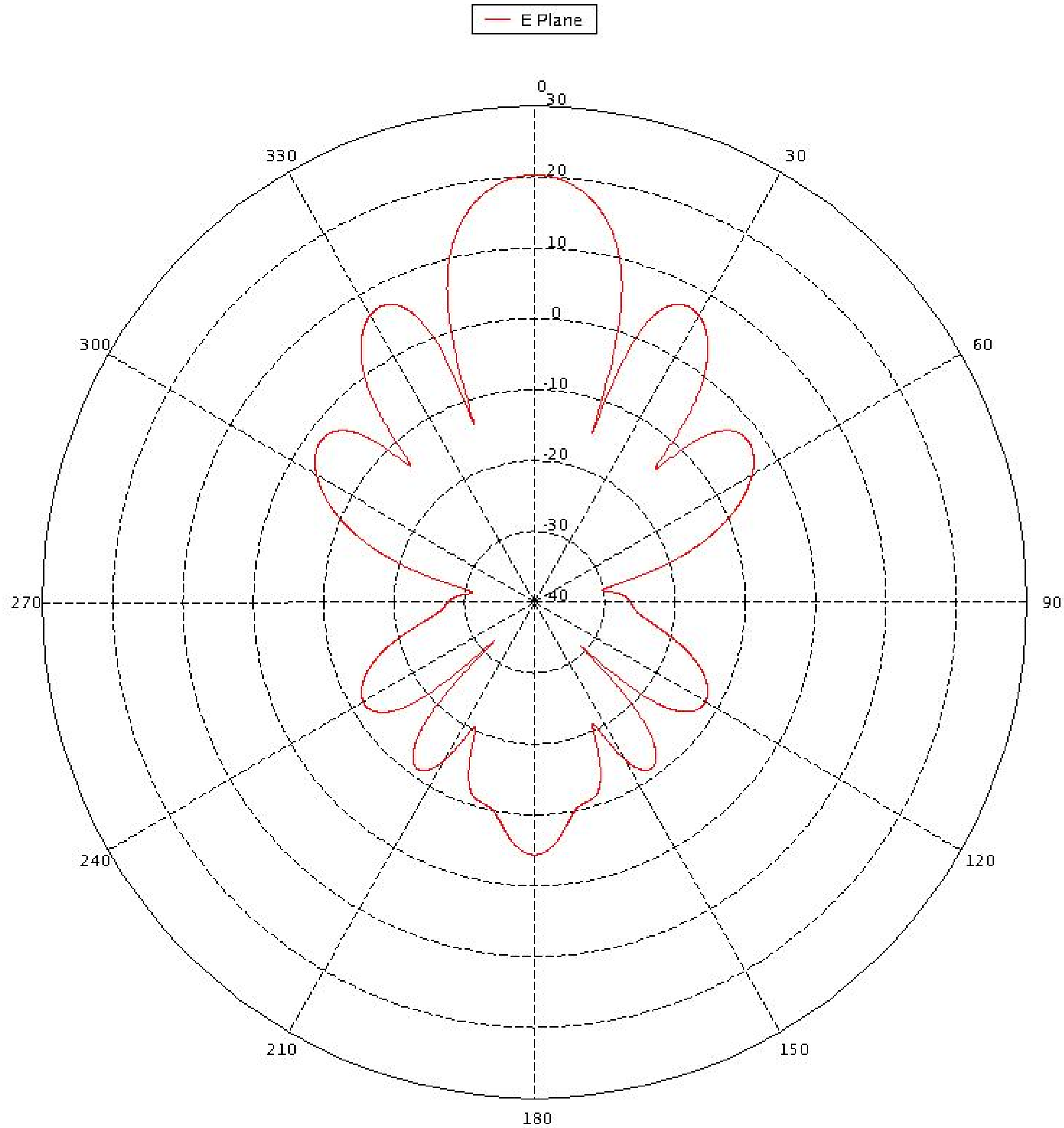


2010-02-02 : FiniteGP100MHz


Radiation Pattern @ 100MHz : Infinite Ground Plane
H Plane
0
30
60
90
120
150
180
210
240
270
300
330
20
10
0
-10
-20
-30
-40
2010-02-04 : InfiniteGP100MHz

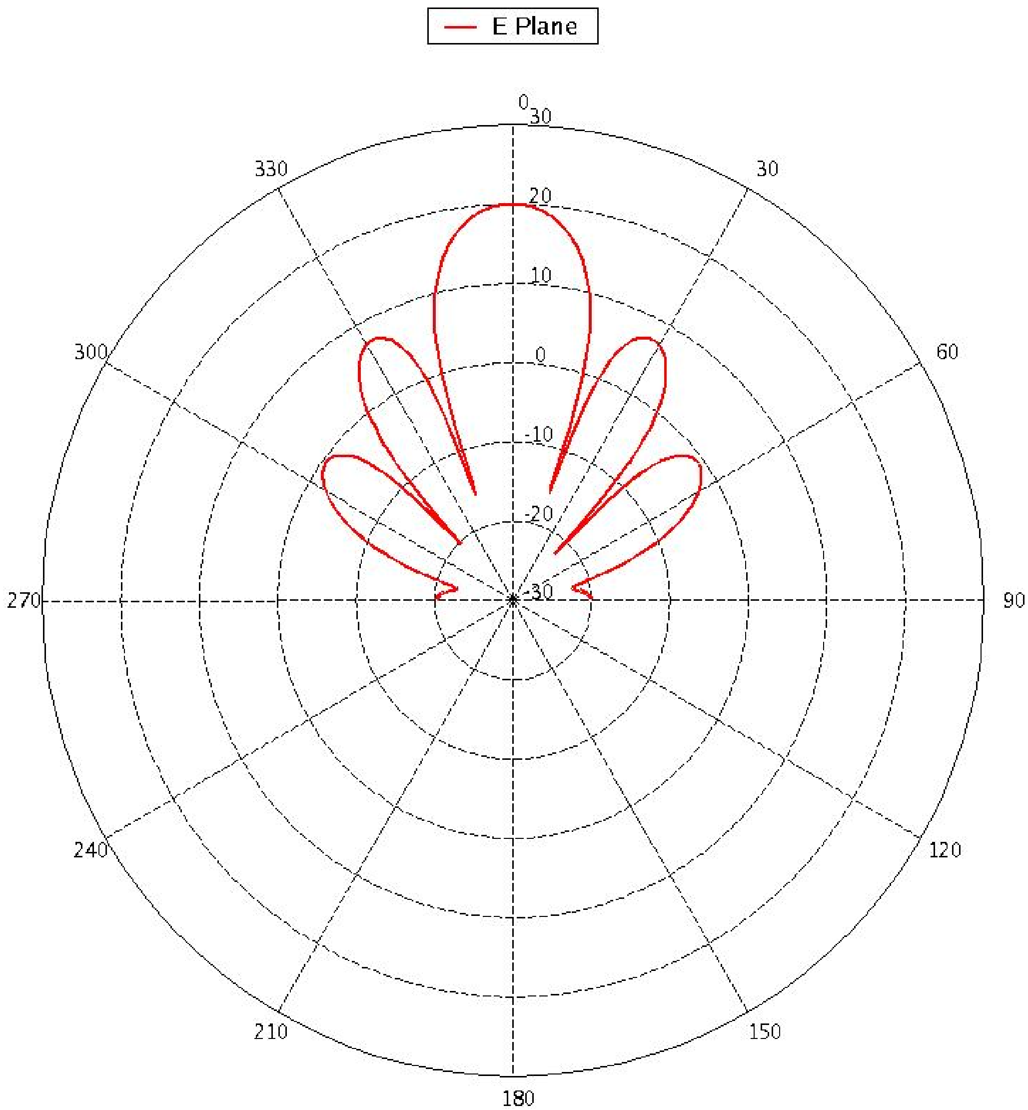
ii) 200 MHz

Radiation Pattern @ 200MHz



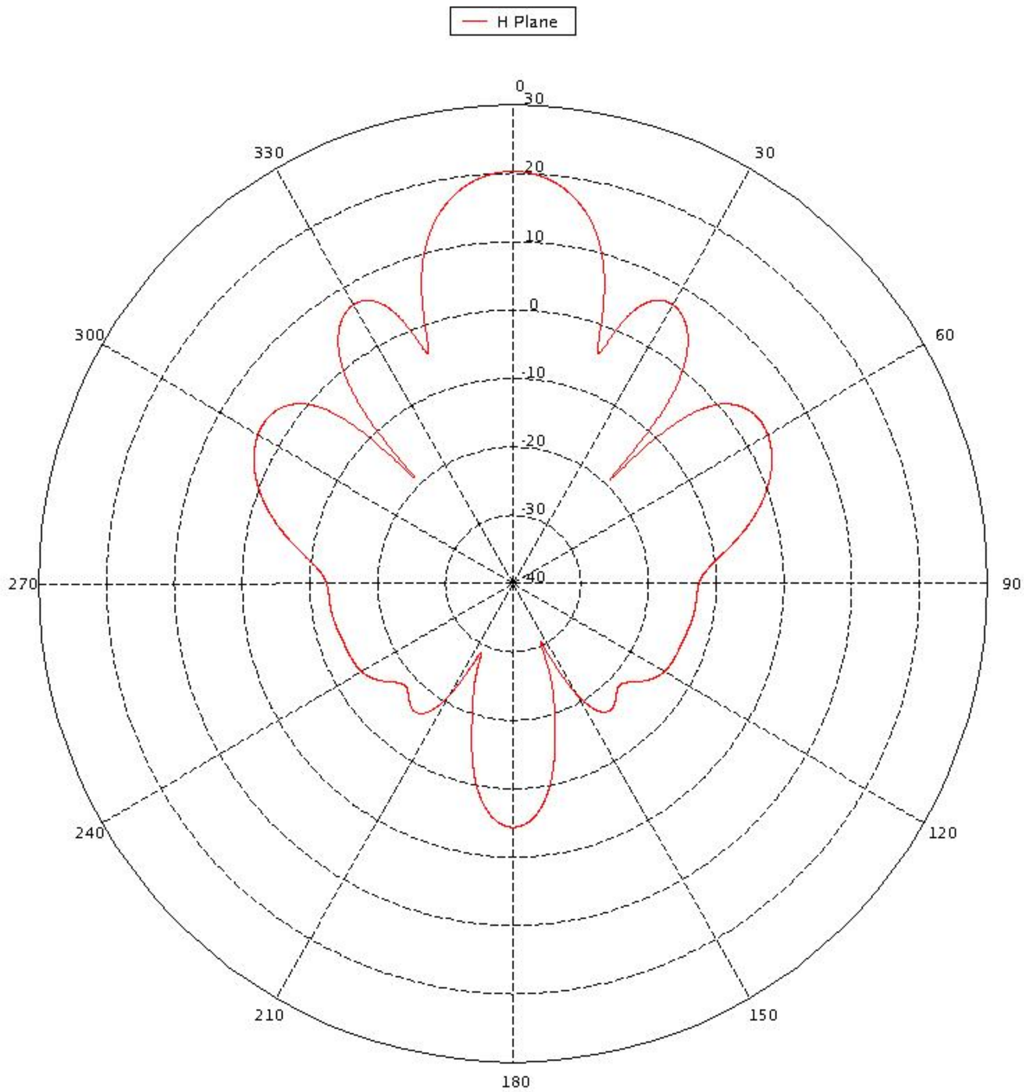
2010-02-02 : FiniteGP200MHz

Radiation Pattern @ 200 MHz: Infinite Ground Plane



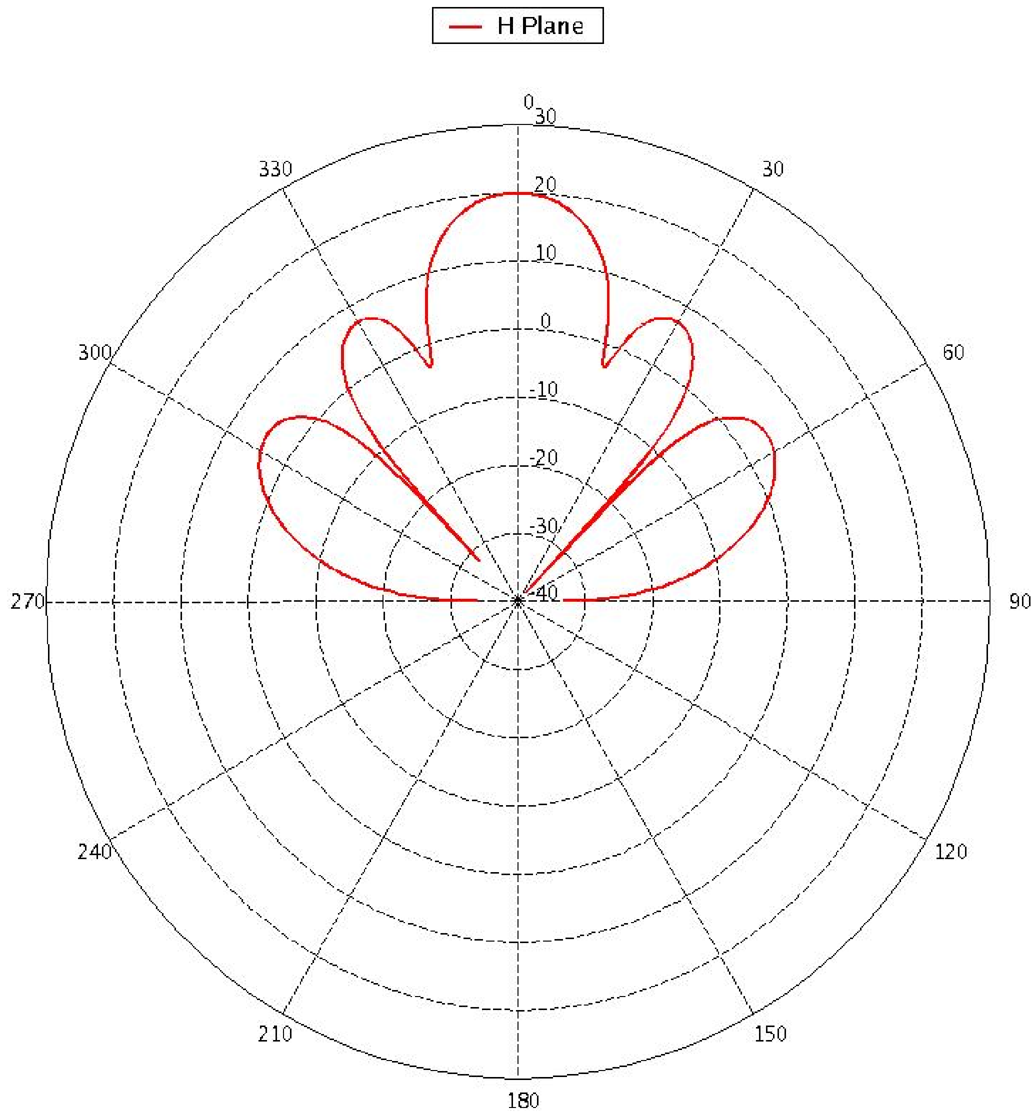
2010-02-04 : InfiniteGP200MHz

Radiation Pattern @ 200MHz



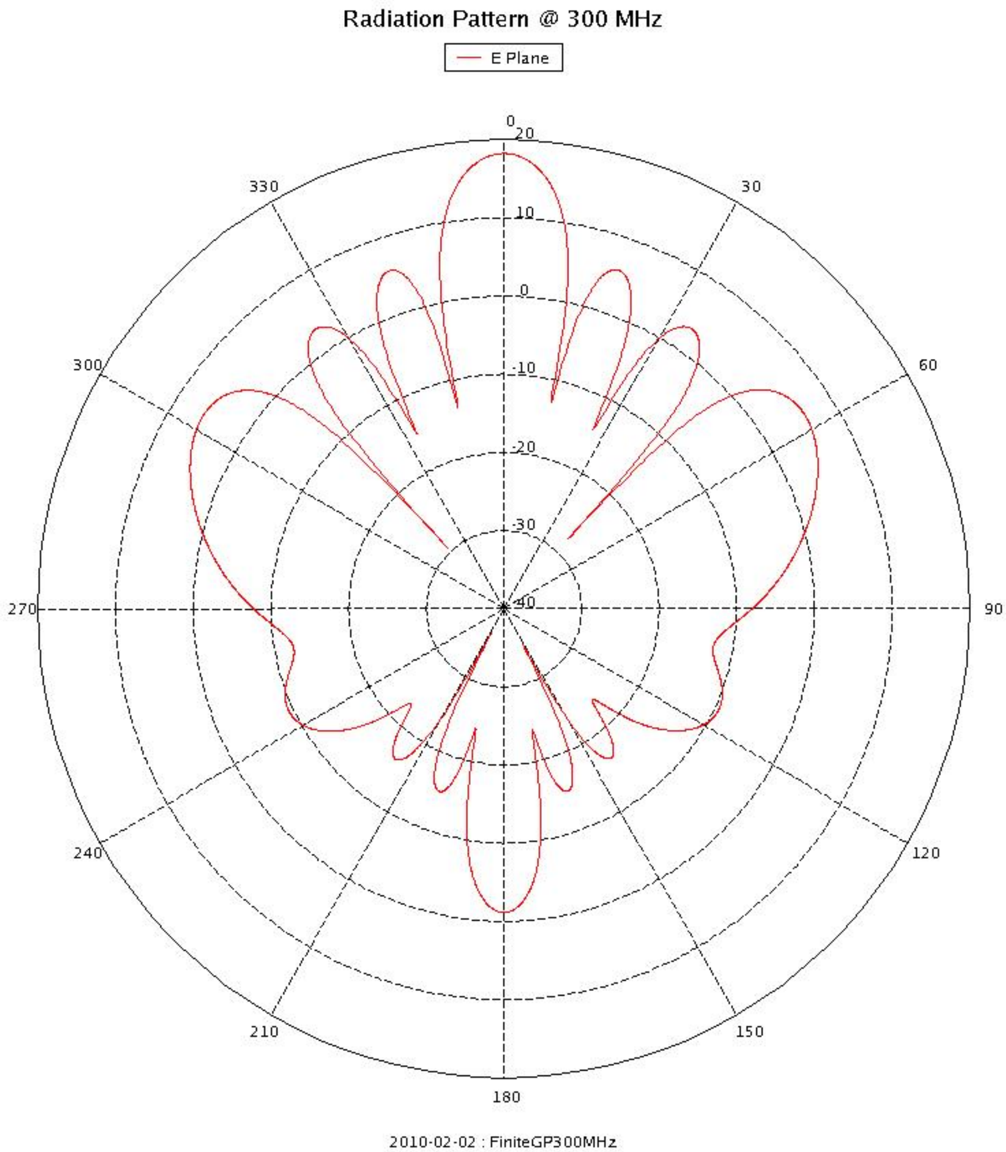
2010-02-02 : FiniteGP200MHz

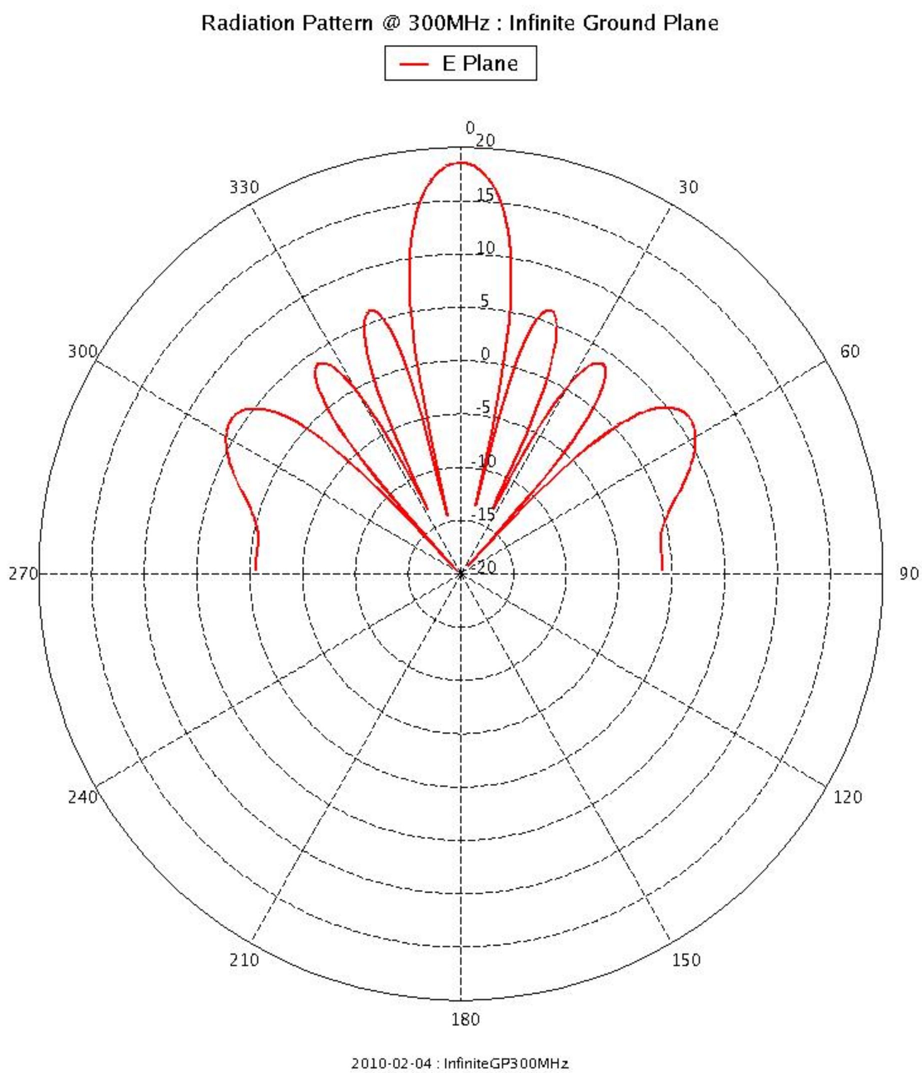
Radiation Pattern @ 200 MHz: Infinite Ground Plane



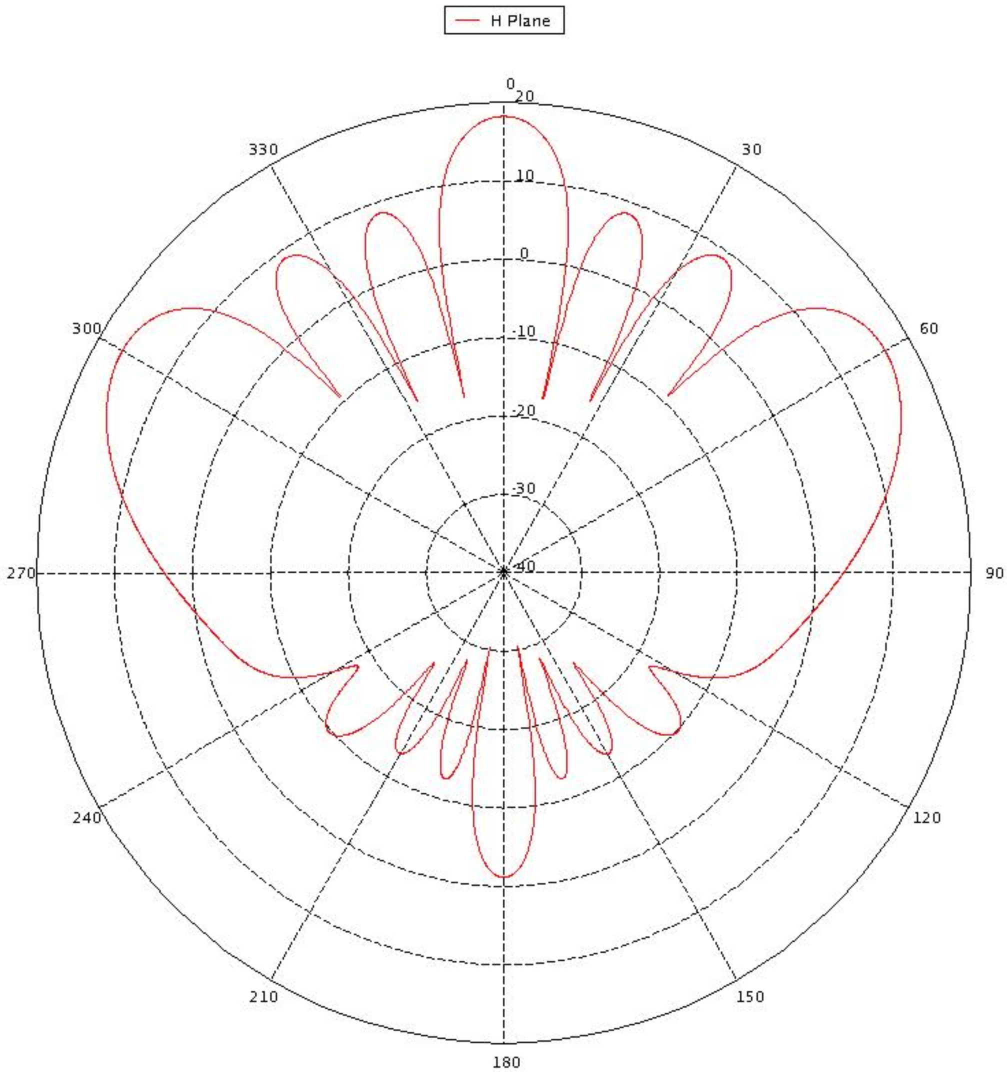
2010-02-04 : InfiniteGP200MHz

iii) 300 MHz


Radiation Pattern @ 300 MHz
E Plane
0
30
60
90
120
150
180
210
240
270
300
330
20
10
0
-10
-20
-30
-40
2010-02-02 : FiniteGP300MHz

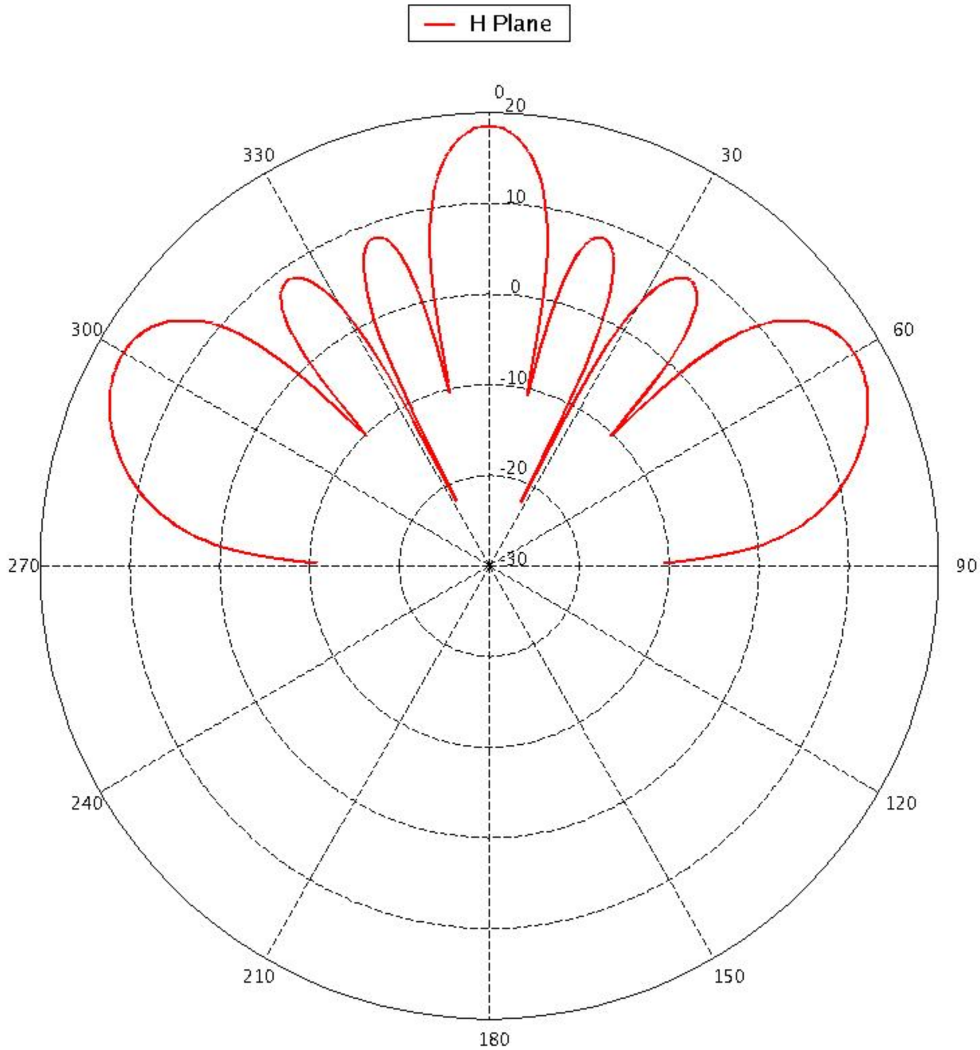

Radiation Pattern @ 300MHz : Infinite Ground Plane
E Plane
0
30
60
90
120
150
180
210
240
270
300
330
20
15
10
5
0
-5
-10
-15
-20
2010-02-04 : InfiniteGP300MHz

Radiation Pattern @ 300 MHz



2010-02-02 : FiniteGP300MHz

Radiation Pattern @ 300MHz : Infinite Ground Plane



2010-02-04 : InfiniteGP300MHz

4] Noise Temperature

For these simulations the antenna is assumed to be located in free space. While the bottom half of the antenna is physically located in the near field of the earth, the front to back ratio can be used to estimate the noise temperature being received through the mesh from the ground.

The front to back ratio is roughly 20dB at 300MHz, which is the worst case frequency. The input referred ground pickup can be approximated by;

$$T_{rec,gnd} = T_{gnd} / R_{fb}$$

T_{gnd} = 300K, the ambient ground temperature
R_{fb} = 100, front to back ratio

This gives approximately 3K noise contribution from the ground. Note that this does not include noise contribution from objects that are in or near the horizon where the antenna gain is higher.