Fun with H boundaries and PMC

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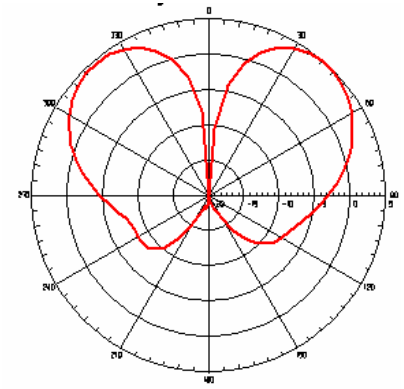
Agenda

H boundary/Perfect Magnetic Conductor (PMC) exercises:

Develop satellite radio design using H boundary/PMC, however impractical:



Goal: CP conical radiation pattern, most of energy between 20 and 60 degrees off the horizon.

f_o = 2.338 GHz, BW = 12.5 MHz

Goal: Don't make antenna too tall.

Develop low-profile Dipole over H plane

Goal: see if efficiency better than low-profile Dipole over E plane.

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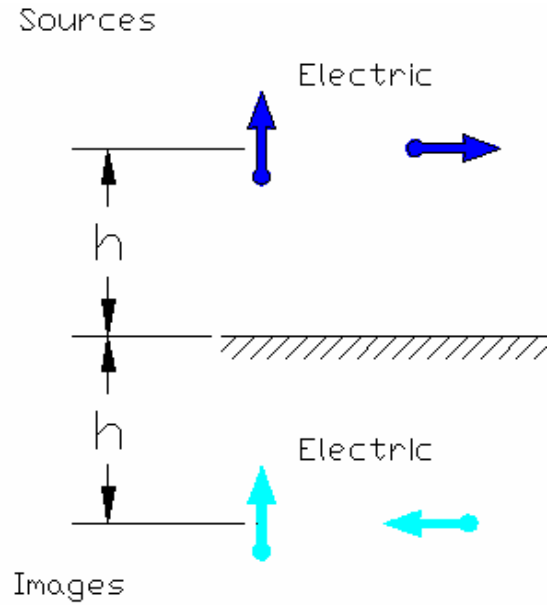
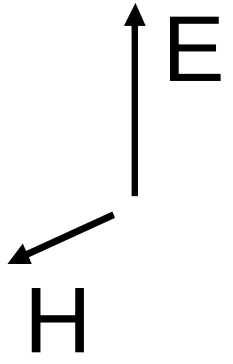
Background

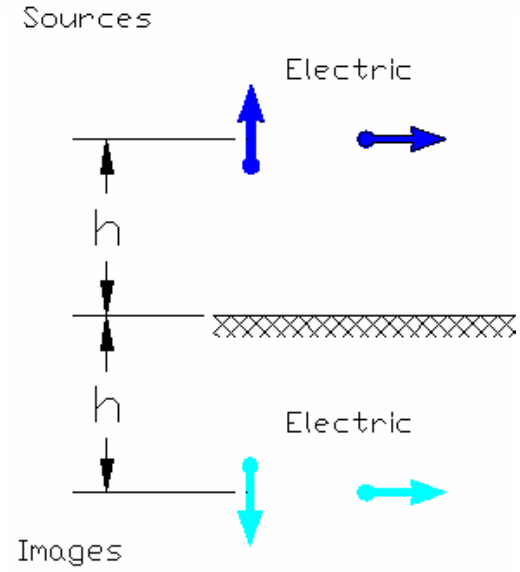


Out-of-phase image

Electric

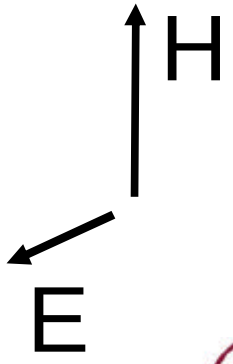
Fields on surface





In-phase image

Magnetic



From C. Balanis, "Antenna Theory"

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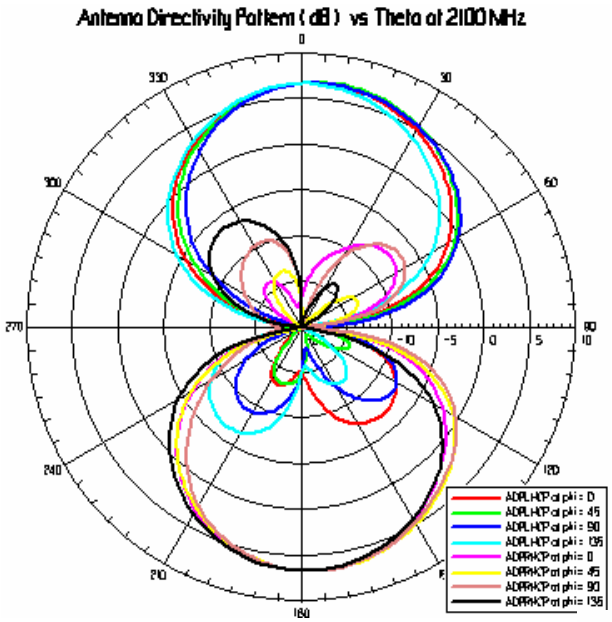
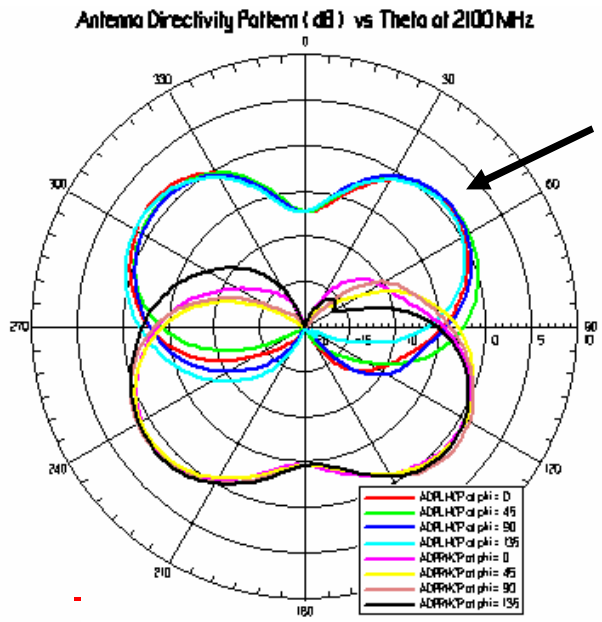
Image Ring

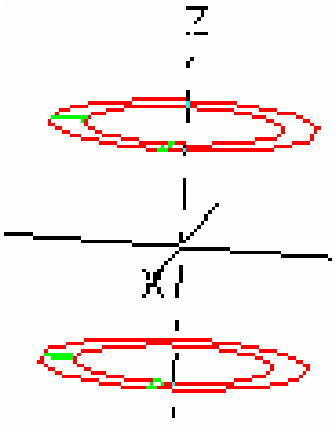




Good pattern

for satellite radio

Out-of-phase Image
Perfect conductor



In-phase Image
H boundary

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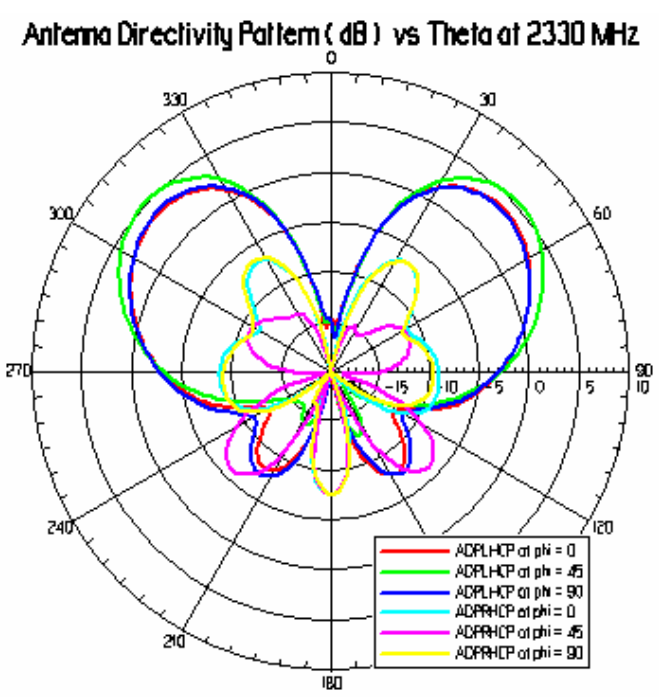
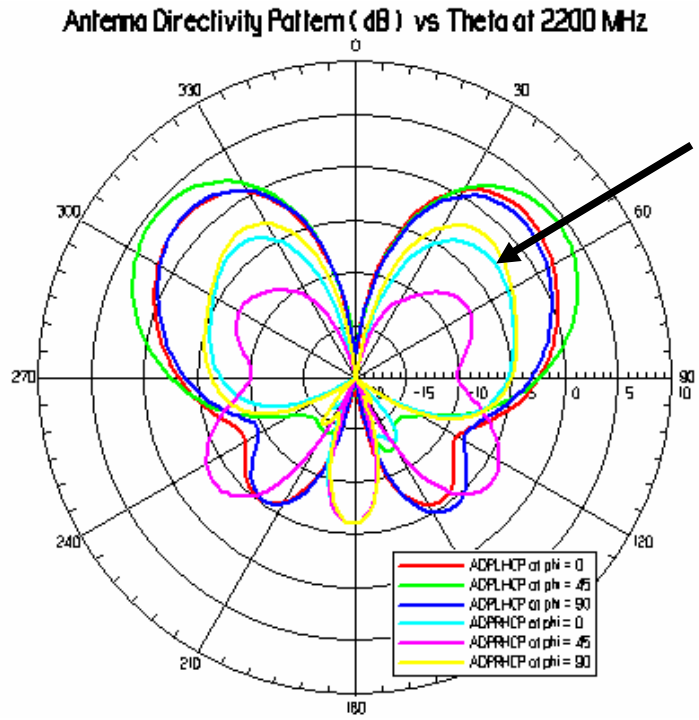
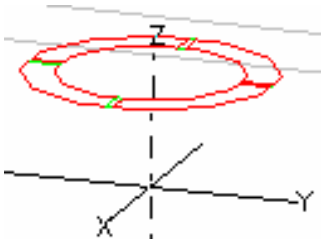
Why a Ring, not Crossed Dipoles?





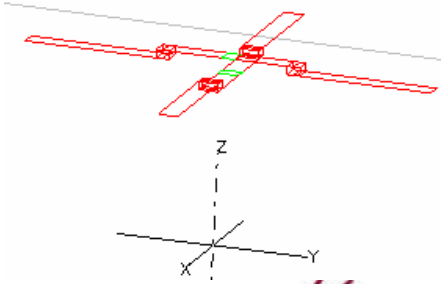
High

Cross-Pol



Lower Xpol

-dipoles are directional



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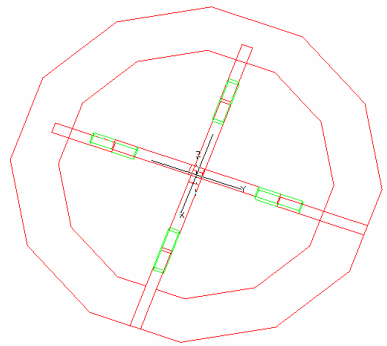
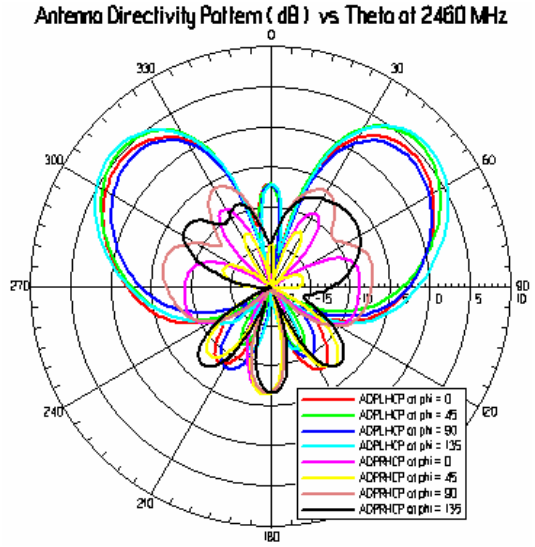
Design assuming H plane…

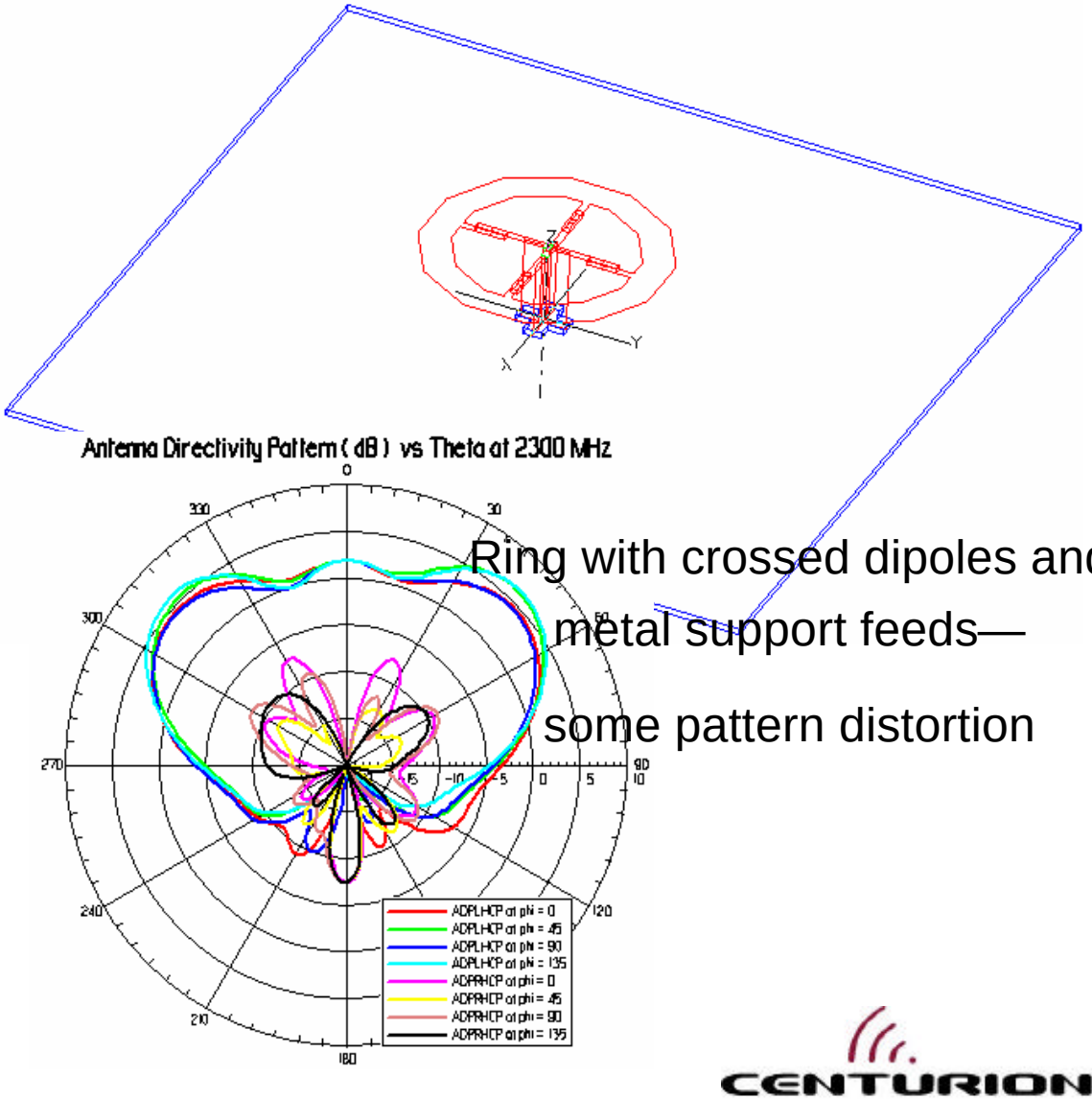


Ring with crossed dipoles

floating over H plane—

more ideal patterns





Ring with crossed dipoles and metal support feeds—

some pattern distortion

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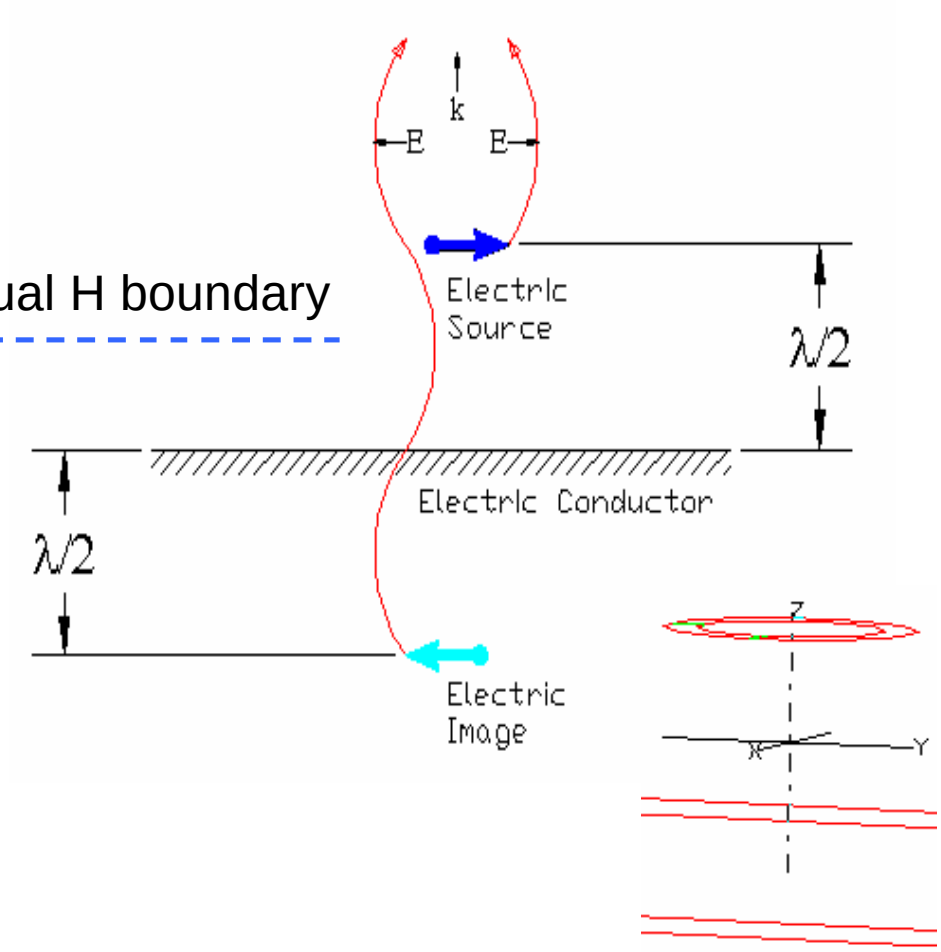
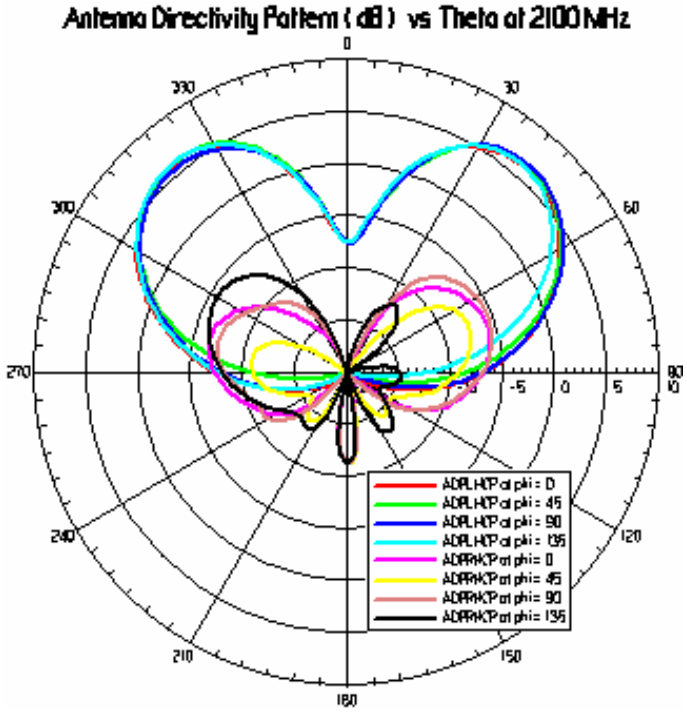
How to get H boundaries in real life…

Start with Ring ½ wave over metal





Equivalent to Ring ¼ wave Over an H plane.

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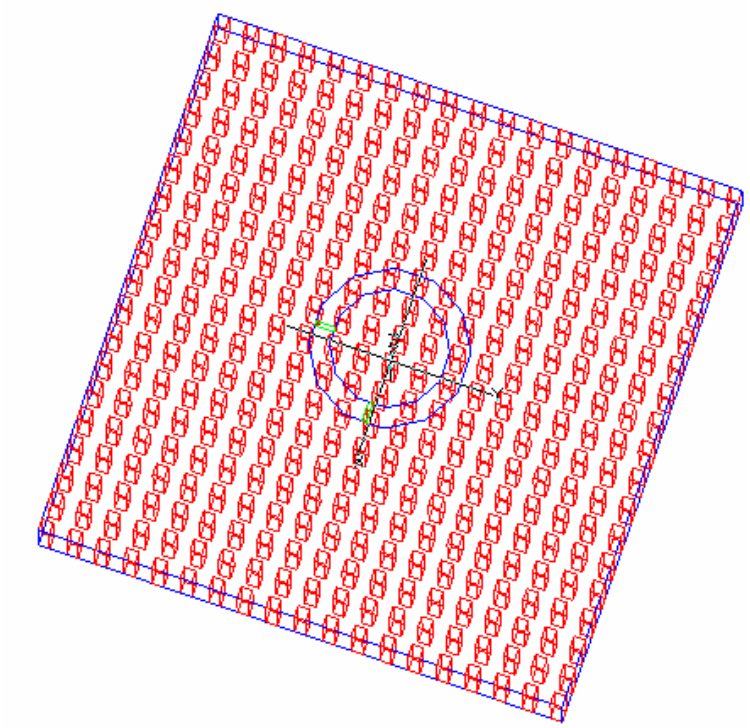
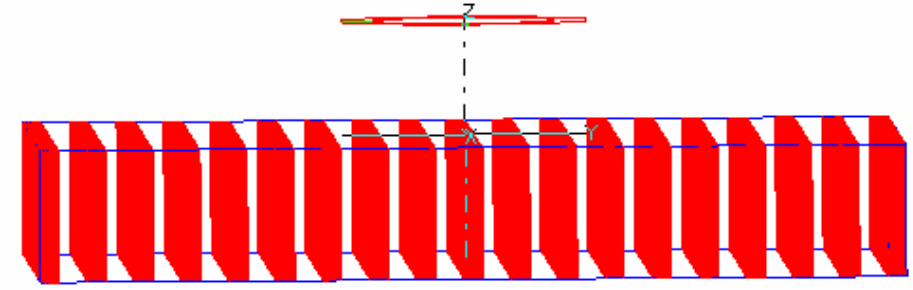
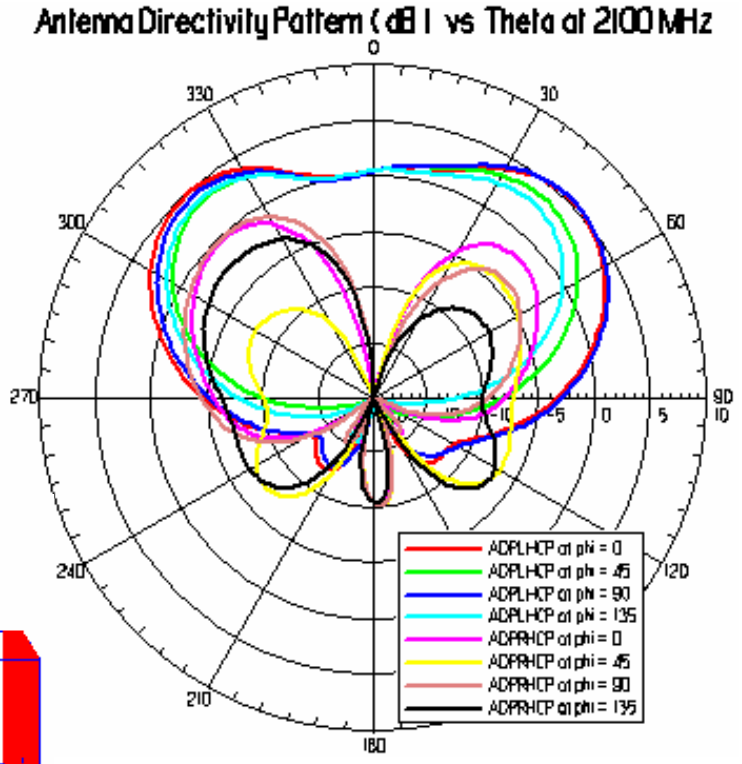
PMC, imitates H boundary
¼ wave chokes







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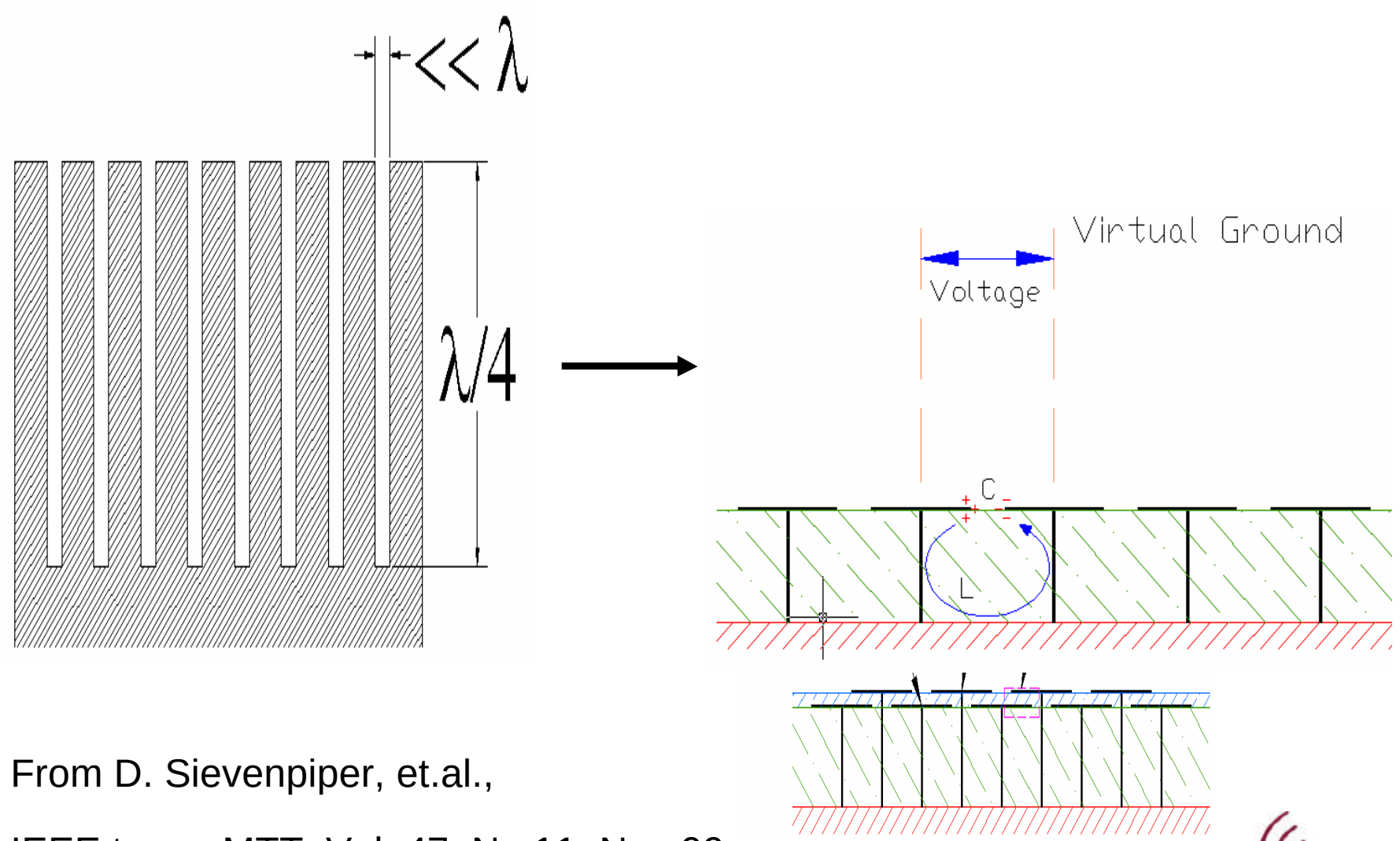
PMC, Top-loaded monopoles



From D. Sievenpiper, et.al.,

IEEE trans. MTT, Vol. 47, No 11, Nov 99

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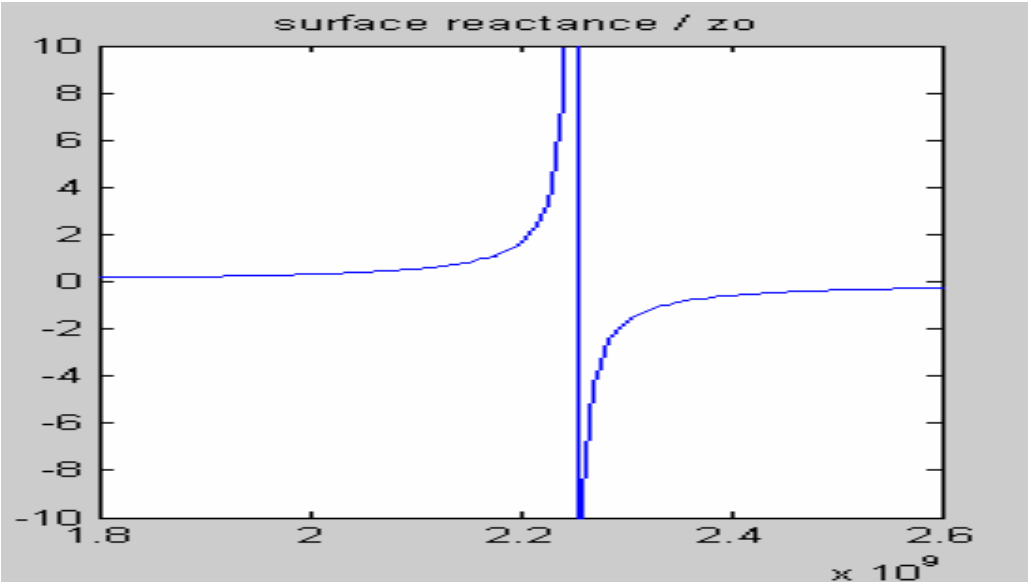
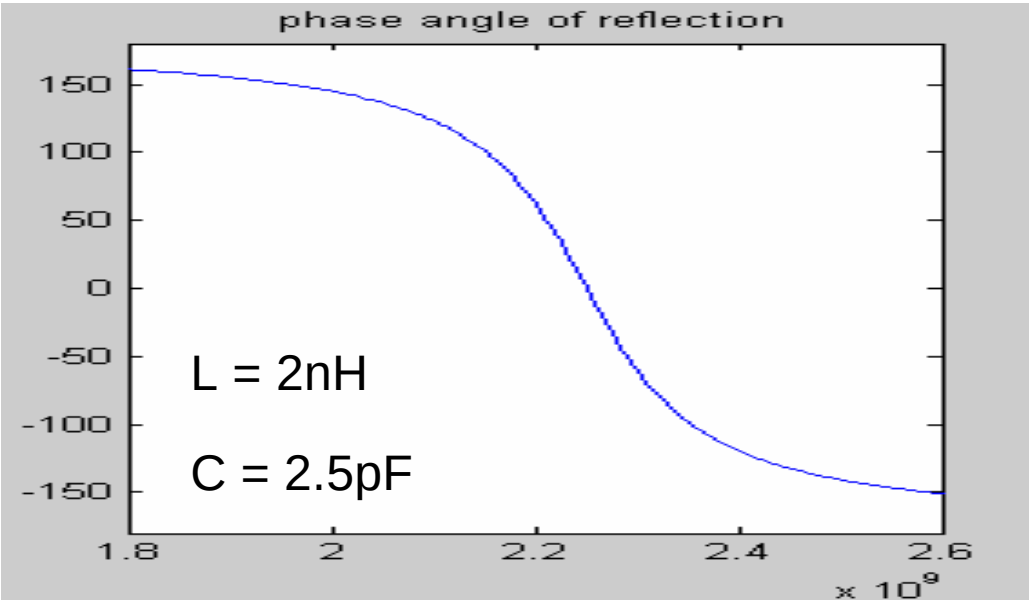
Qualitative model of the PMC structure using LC network





$$Z_{surface} = j\omega L/(1-\omega^2 LC)$$

$$\text{Reflection} = (Z_{surface}-Z_o)/(Z_{surface}+Z_o)$$

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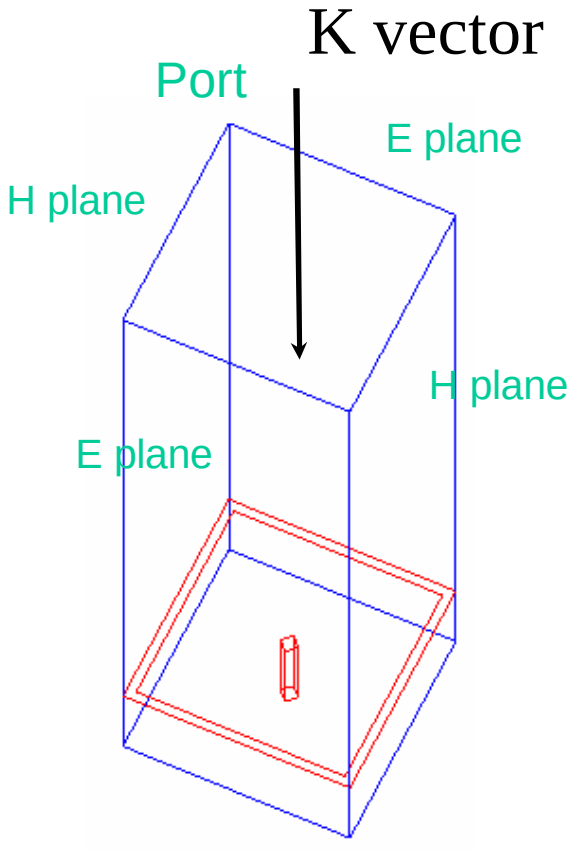
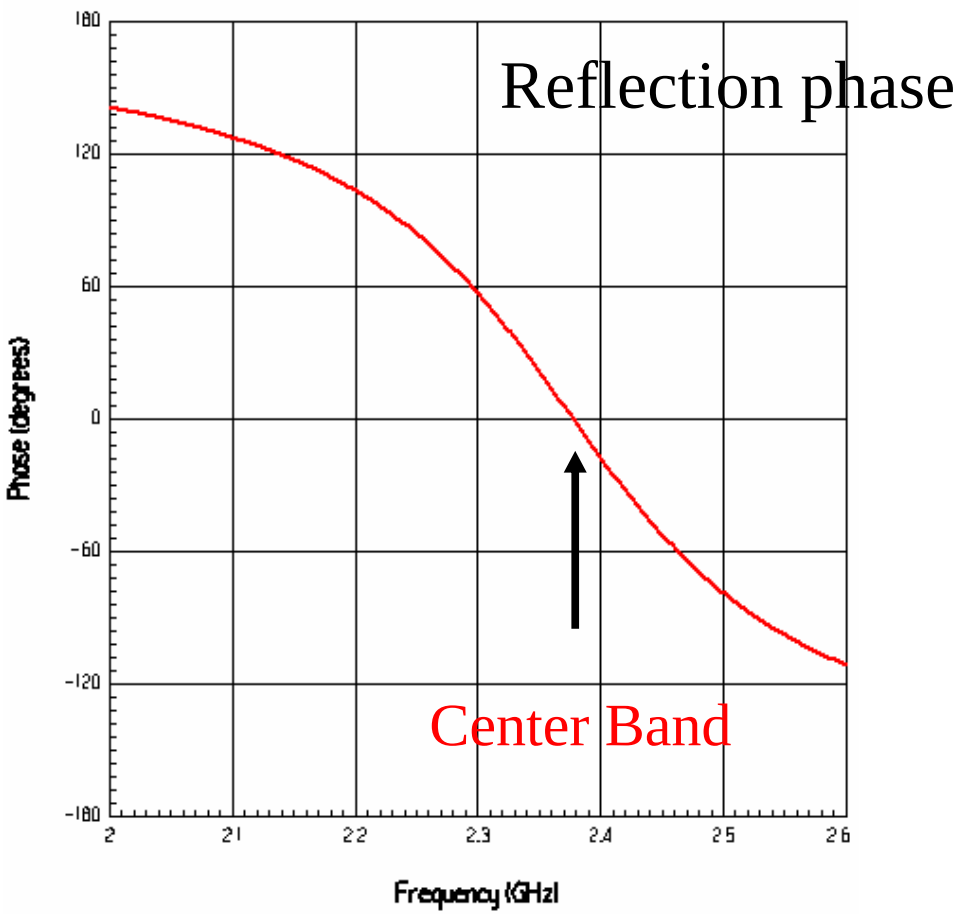
Tuning the PMC structure using HFSS





Need large ε_r to tune to 2.338 GHz

(ε_r =30, lattice spacing=0.25'', thick=0.1'')

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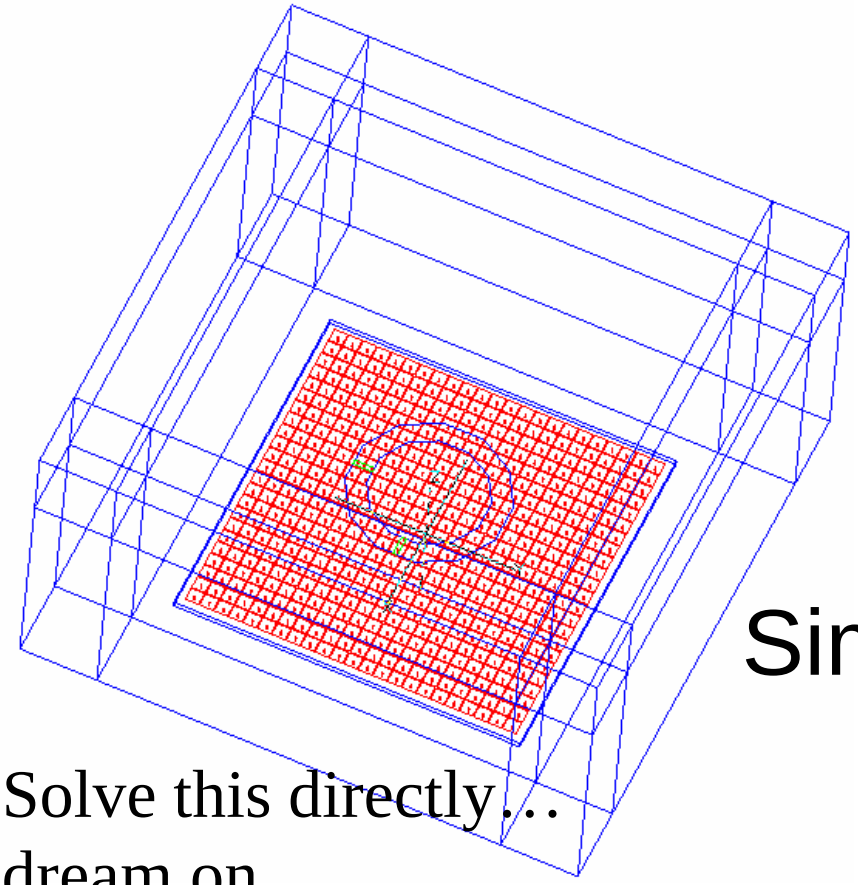
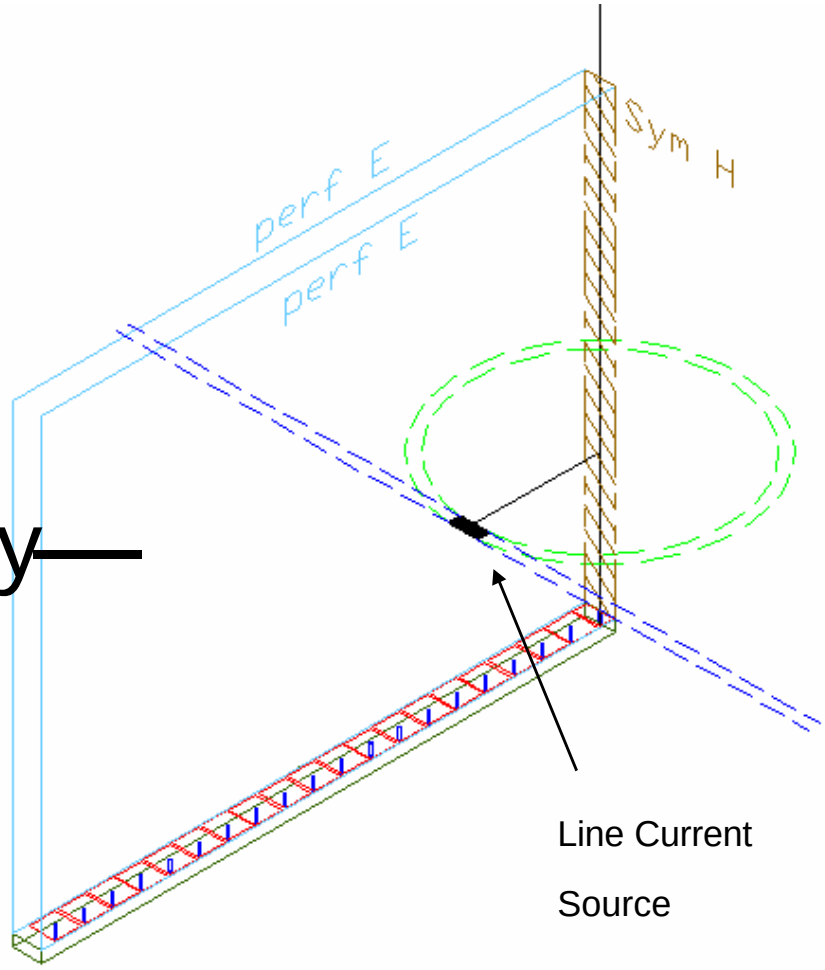
PMC, top-loaded monopoles



Solve this directly…
dream on…
too much memory

Simplify—



Can only model 2D line current, due
To memory limitations-the PMC has many resonant elements

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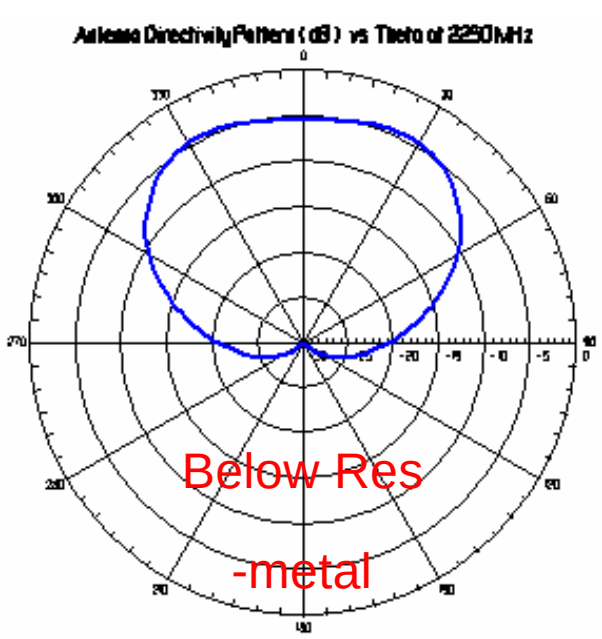
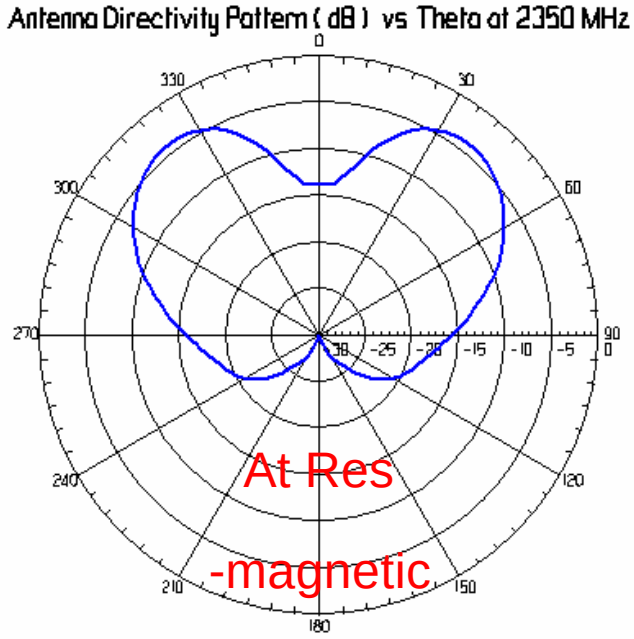
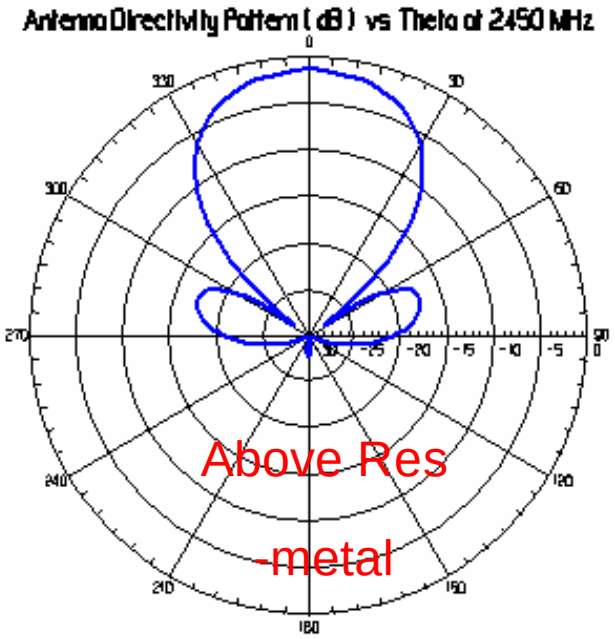
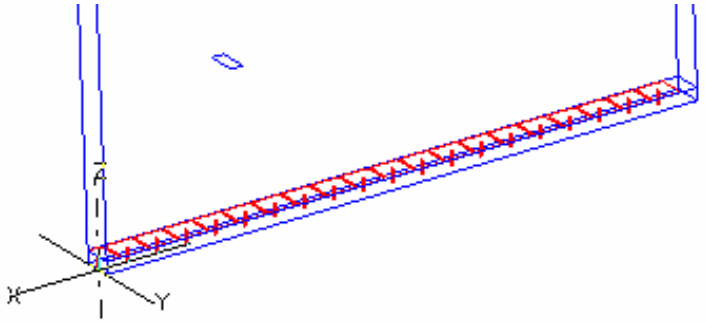
Satellite-Radio Ring over PMC







Use HFSS to get pattern shapes only



H boundary only effective within
+/- 30 degrees of center 0 degree reflection

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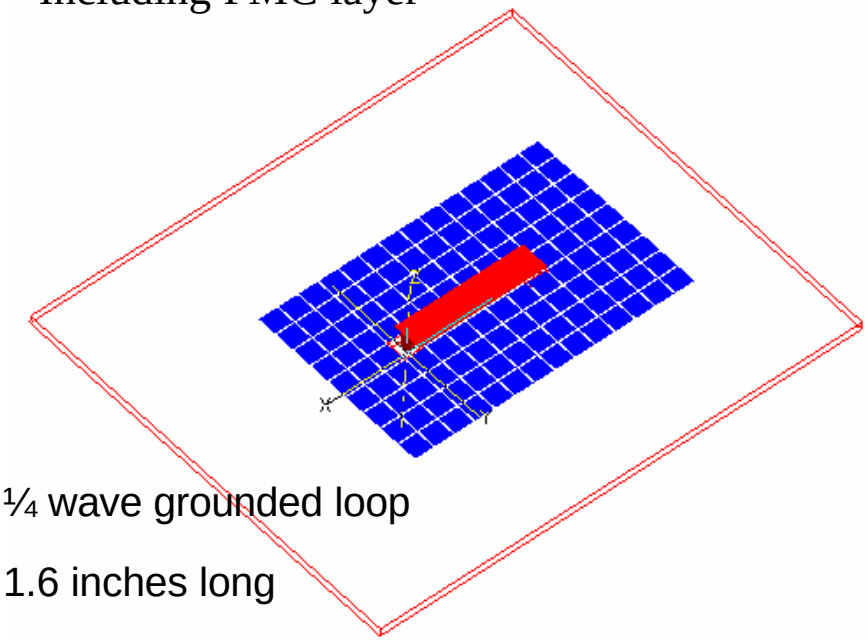
Low-Profile Dipole over H and E boundary

0.2 inches high,
Including PMC layer

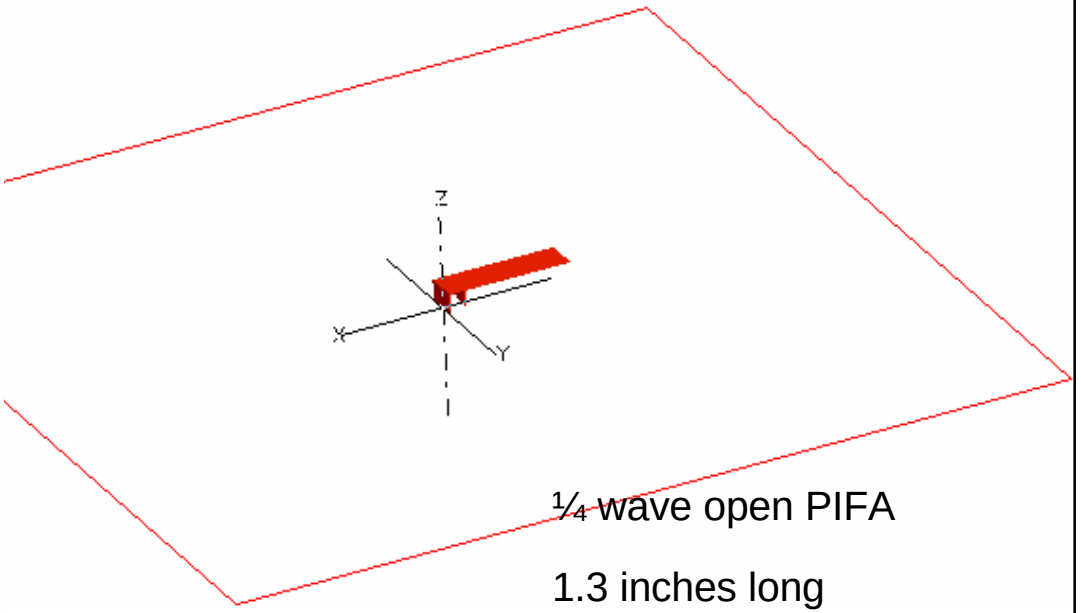


¼ wave grounded loop

1.6 inches long

PMC Boundary
Efficiency = 91%
(ε_r =30, L.T.=0.002)

0.2 inches high



¼ wave open PIFA

1.3 inches long

Metal Boundary
Efficiency > 99%

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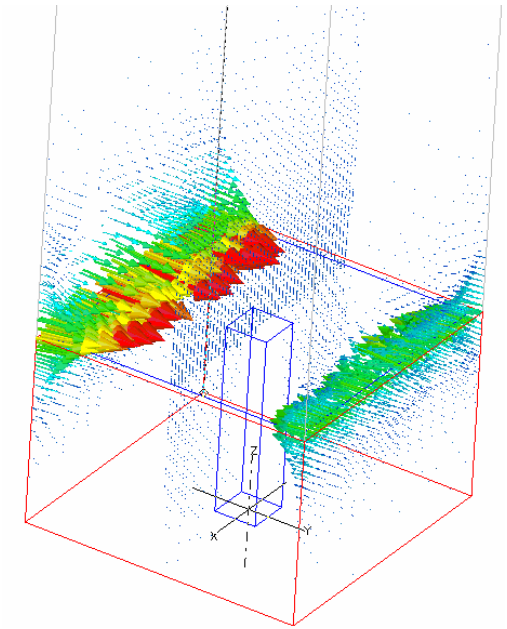
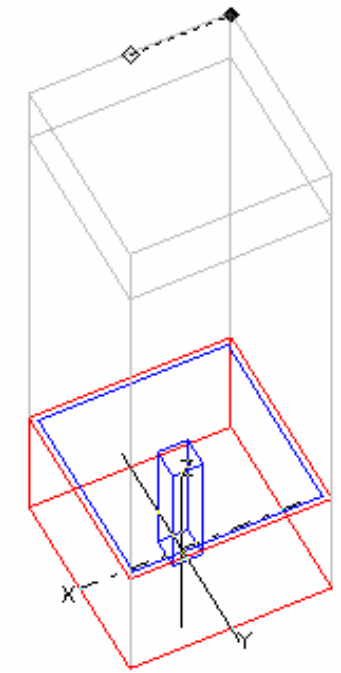
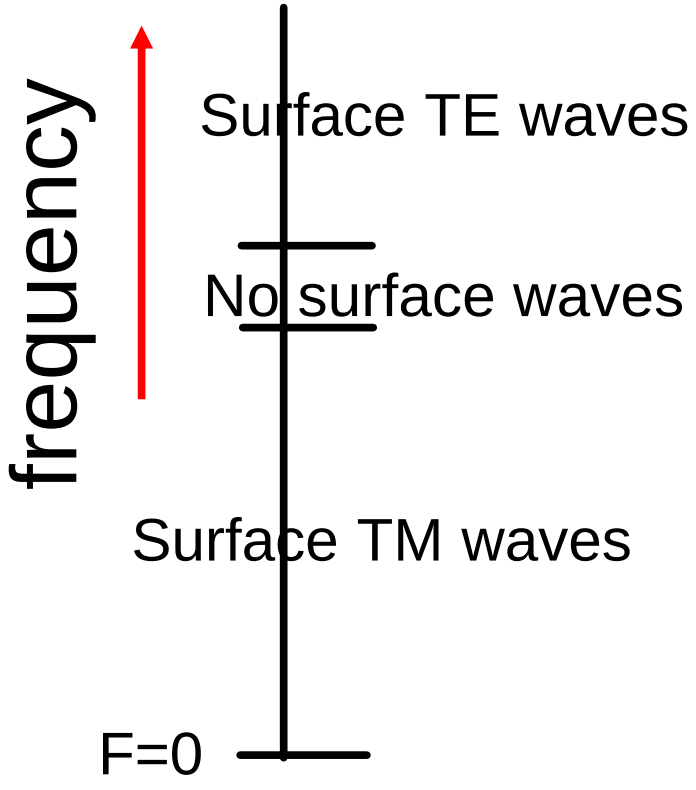
Surface-wave property of PMC

In the band gap of the structure,
neither TE nor TM waves can propagate along the surface







Refer to

R. Remski's HFSS reports

Eigenmode solution

With linked boundaries

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Conclusion

- H boundaries are useful
- Perfect Magnetic Conductors can be made
- They do not necessarily improve efficiency

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