Artificial Dielectrics for Mobile Antenna Design

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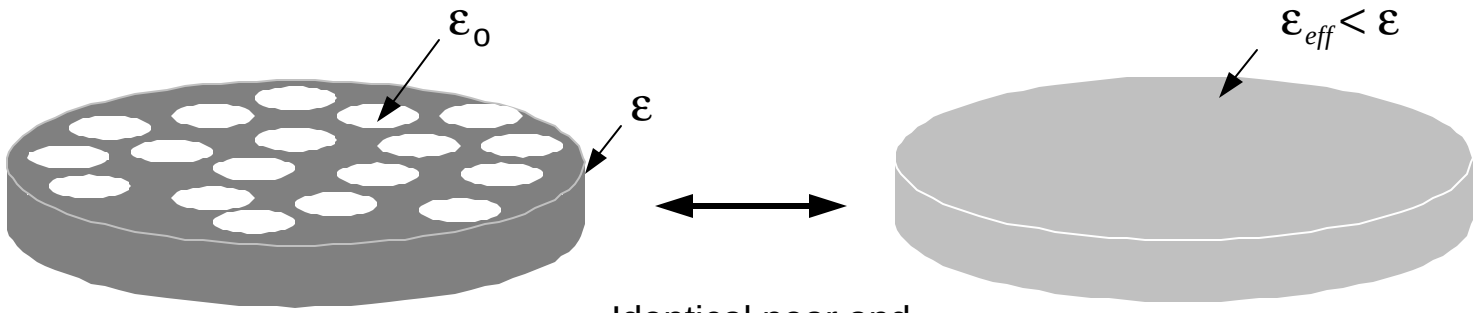
Why artificial dielectrics?

- Mobile antennas need to be small
- High-dielectric constant for miniaturization
- Difficulty of controlling dielectric constant
- Artificial Dielectrics provide for fine-tuning of dielectric constant

Approach:

- Control the dielectric constant by introducing air voids
- Air voids are small in size compared to wavelength
- Establish effective dielectric constant as a function of volume density of air voids
- This will be a function of background dielectric constant and the size of the sample

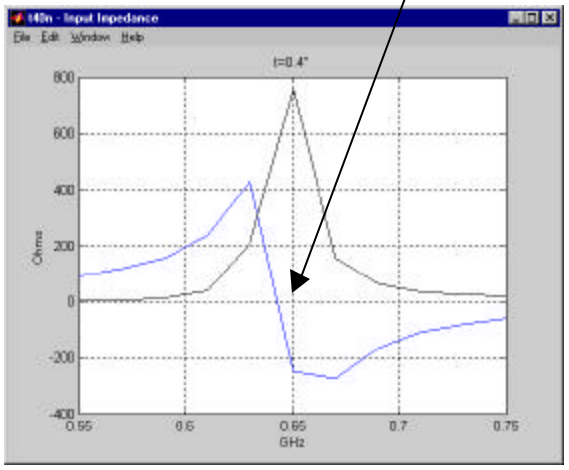


Identical near and far field

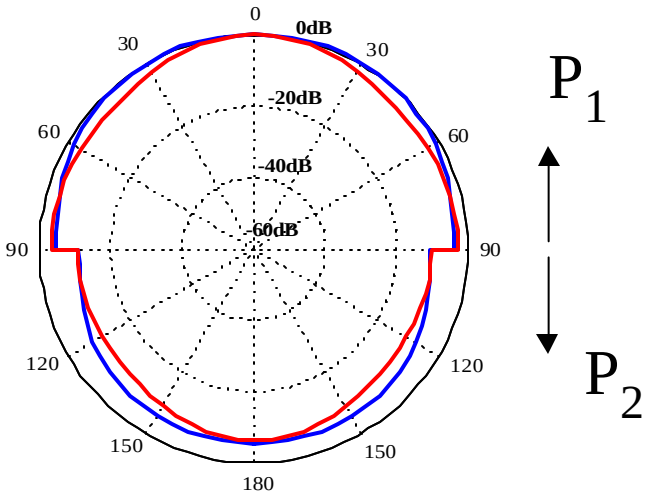
Parameters for establishing equivalance

- **Resonance frequency** - ***near field***
- **Front-to-back ratio (FBR)** - ***far field***

Resonance Frequency

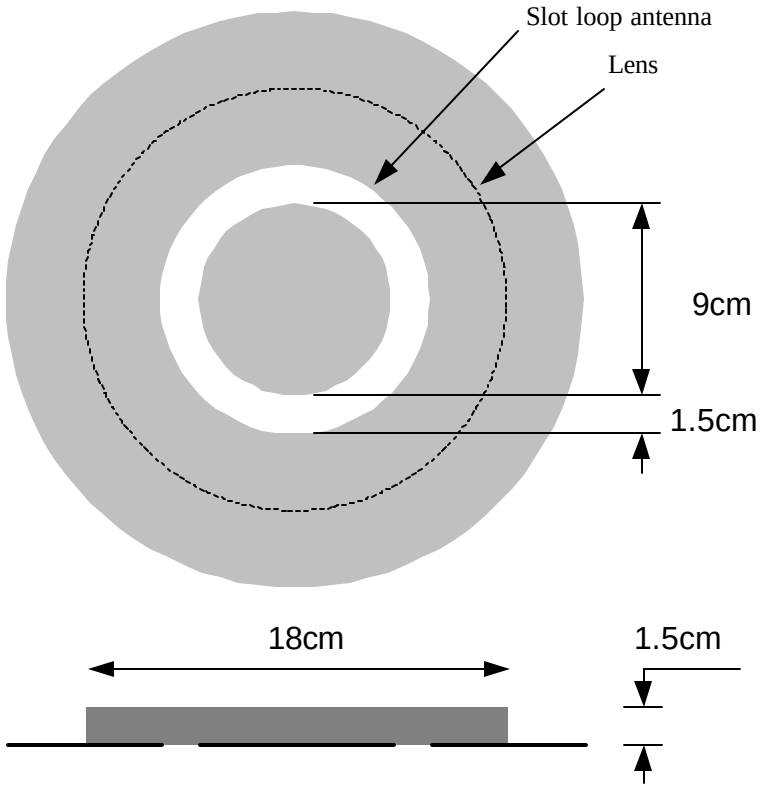


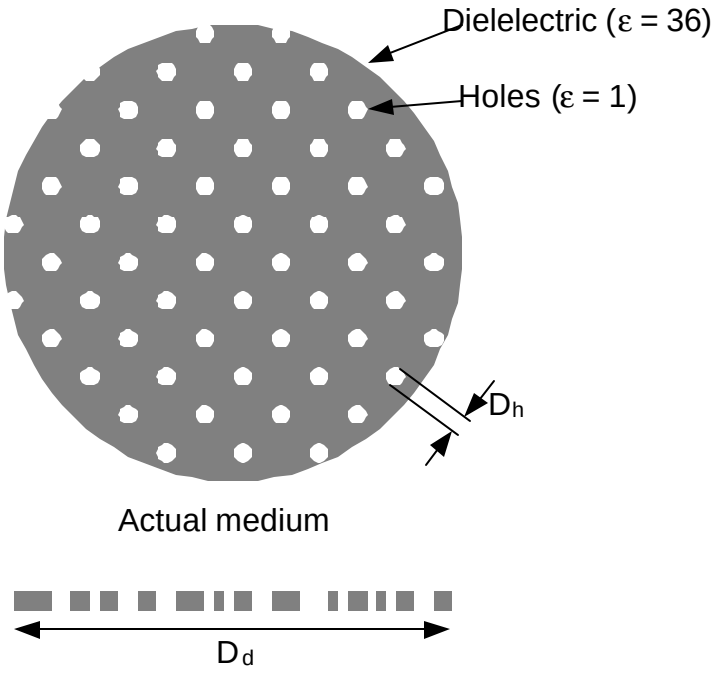
$$FBR = P_1 - P_1$$



Simulated results

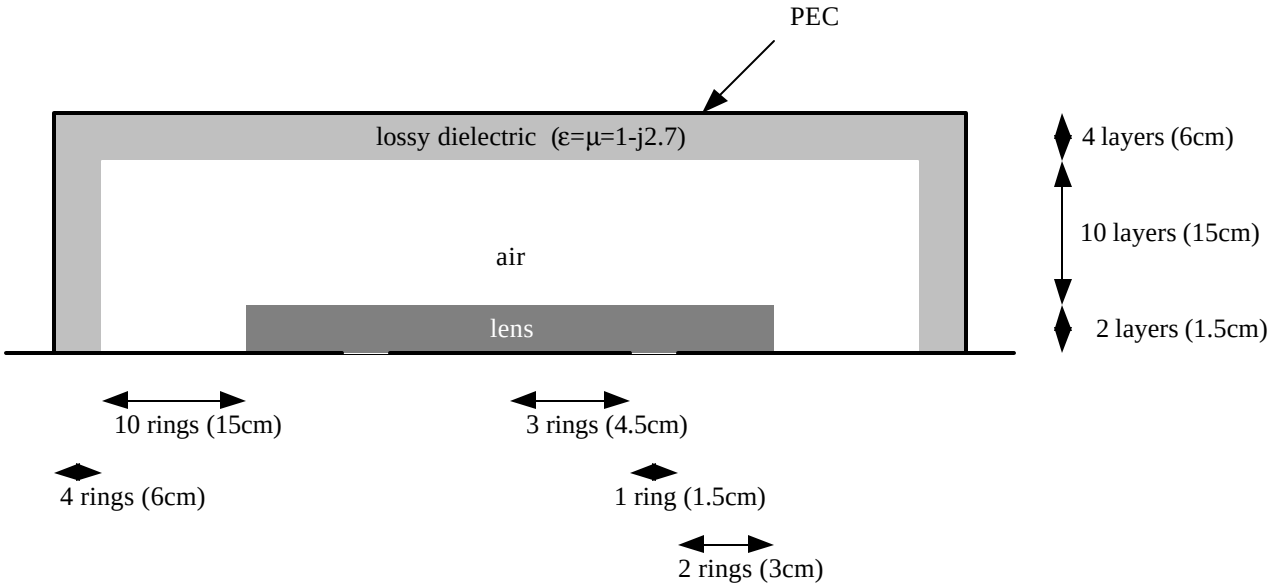
Finite Element Method





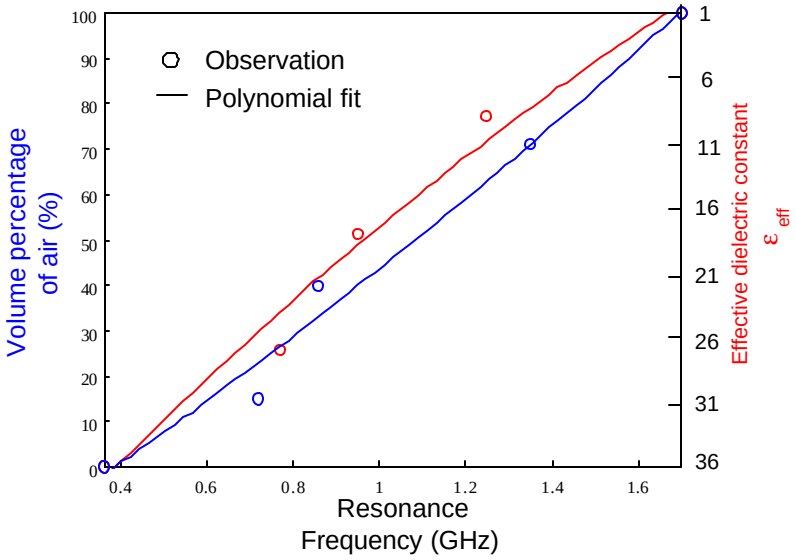
Simulated results

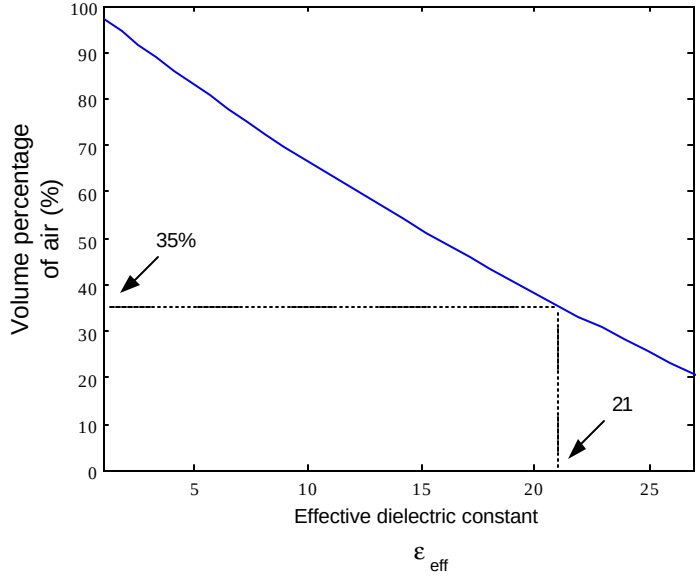
Finite Element Method



Simulated results

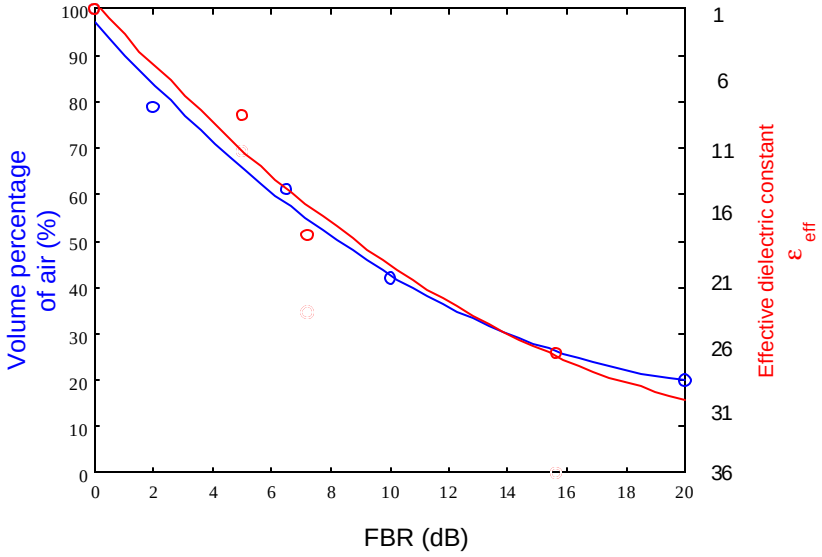
Equivalence through "Resonance Frequency"

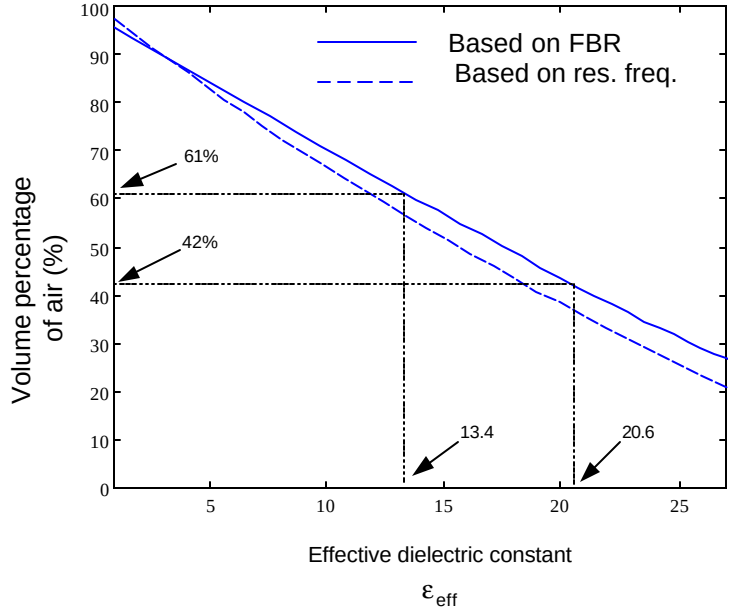




Simulated results

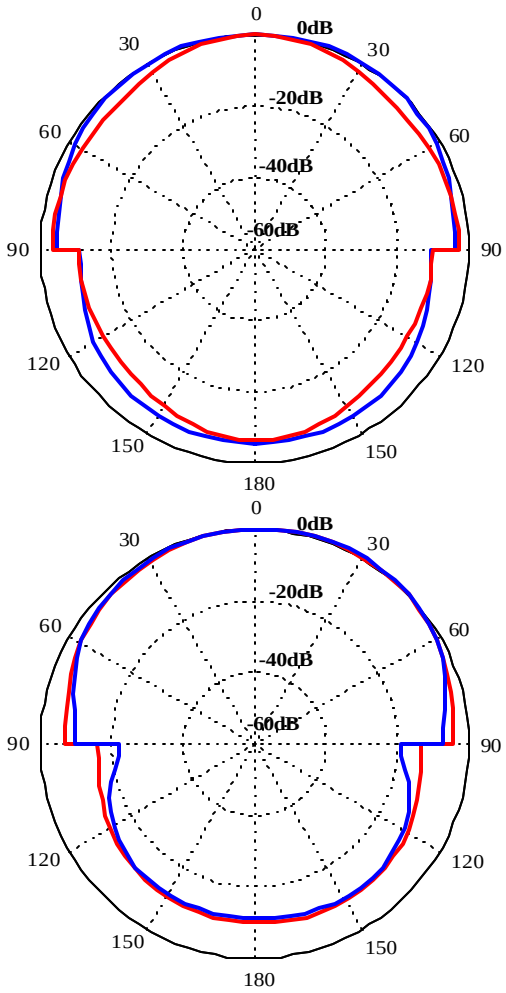
Equivalence through "Front-to-back ratio (FBR)"



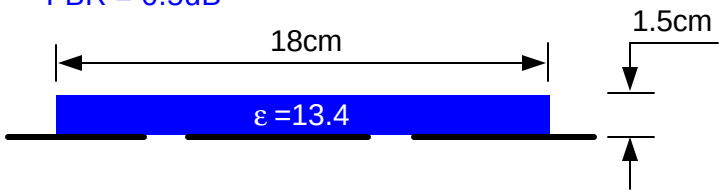


Simulated results

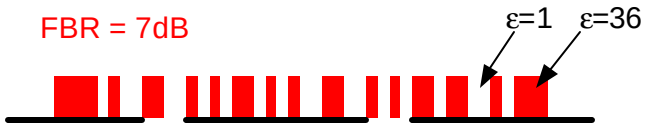
Validating equivalence



FBR = 6.5dB

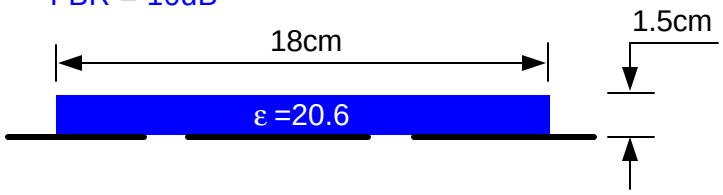


FBR = 7dB

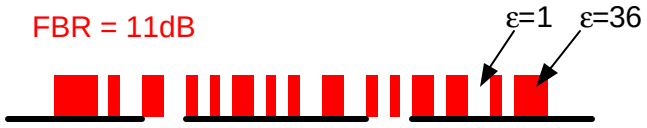


Volume percentage of air = 61%

FBR = 10dB



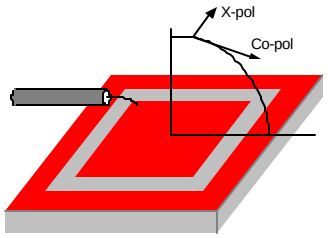
FBR = 11dB



Volume percentage of air = 42%

Experimental results

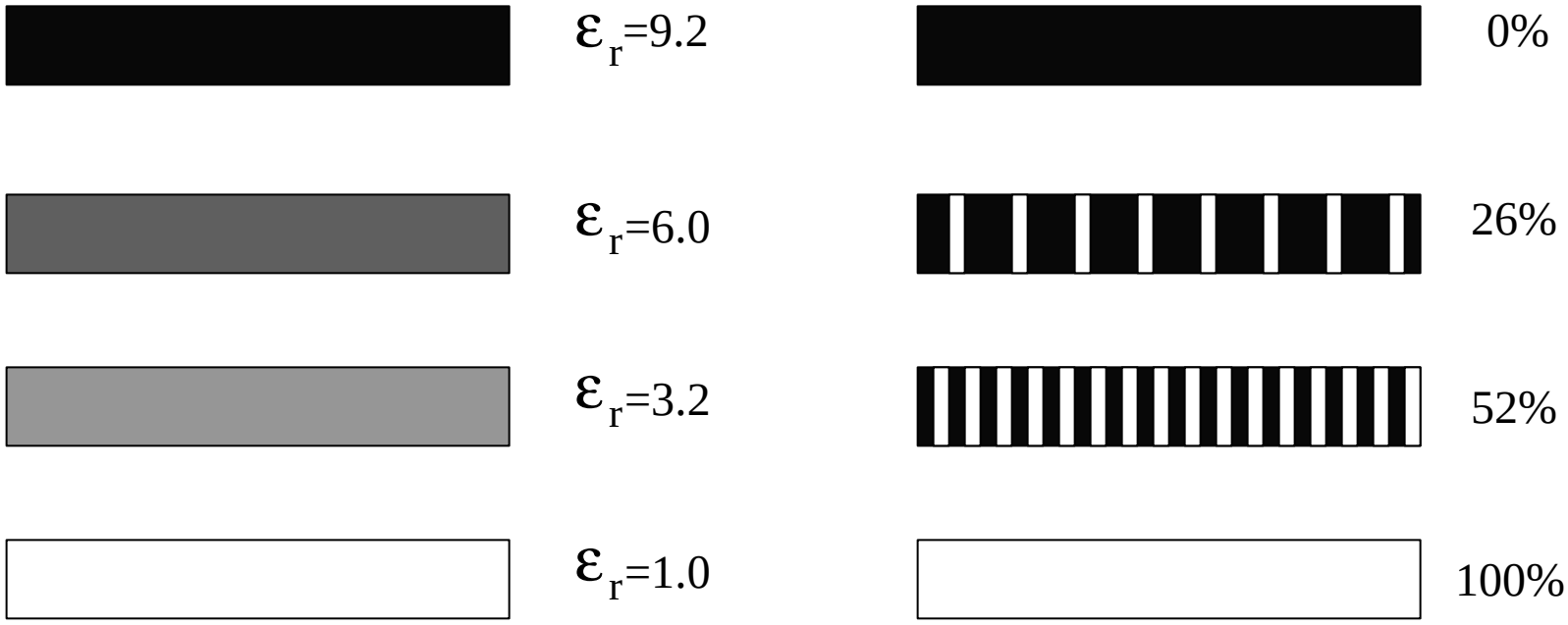
Square slot loop antenna



3”x3”x0.2”

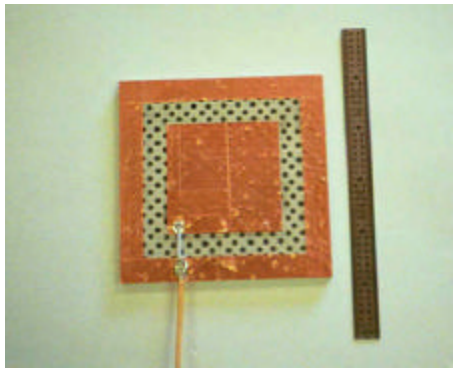
Equivalent through “resonance frequency”

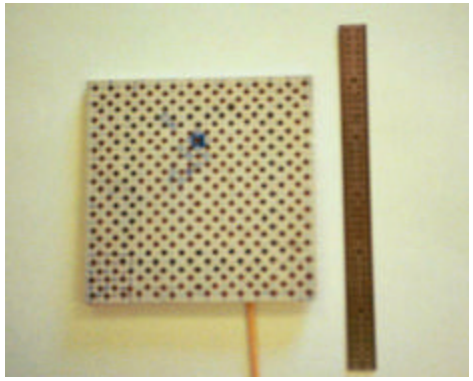
Uniform substrate ⟷ Substrate with holes ε_r=9.2

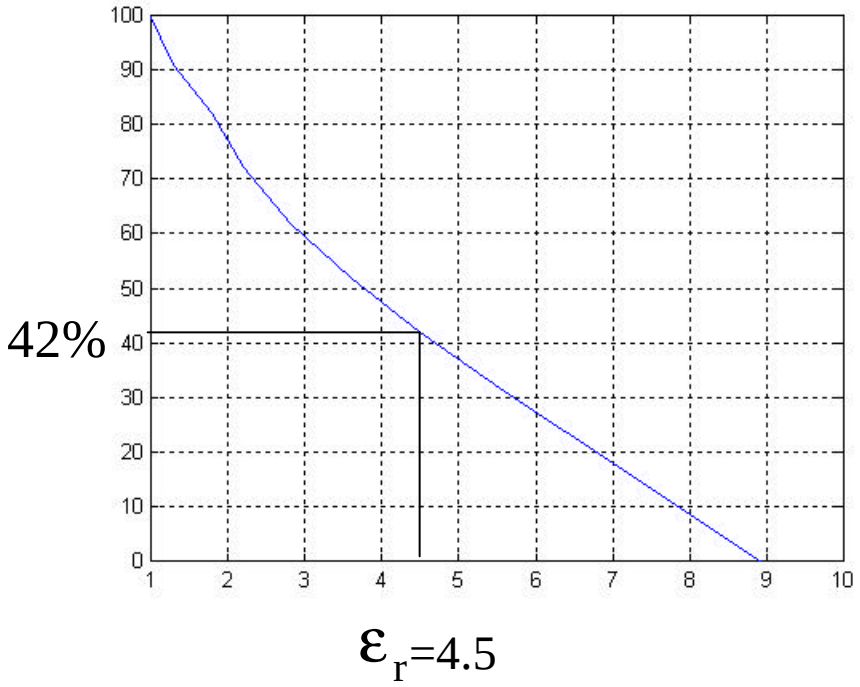


Experimental results

Eauivalence through "resonance frequency"







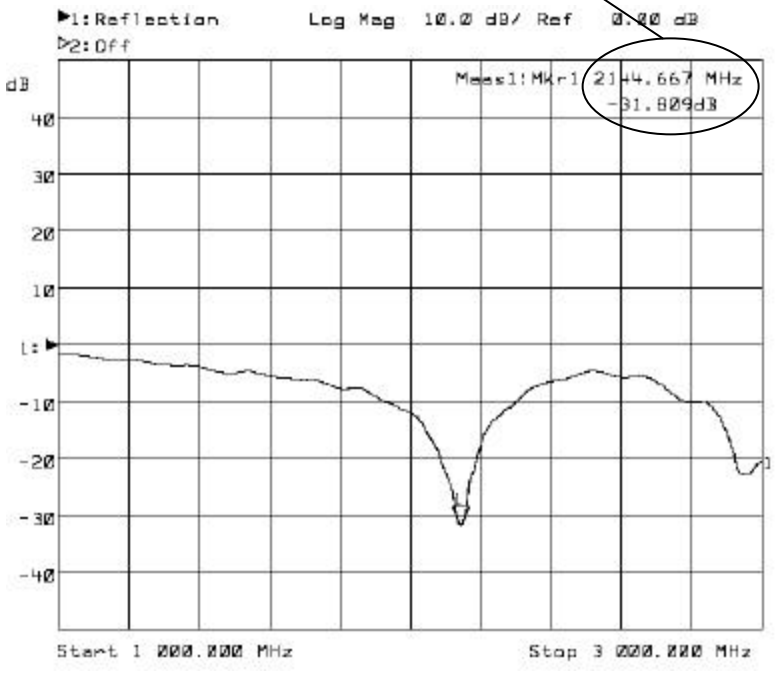
Experimental results

Validating equivalence

2157 vs. 2145 MHz (Error: 0.6%)

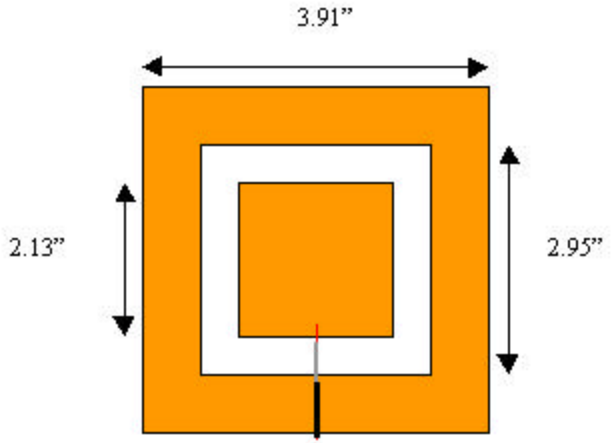
Uniform: ε_r=4.5

With air voids: 42%

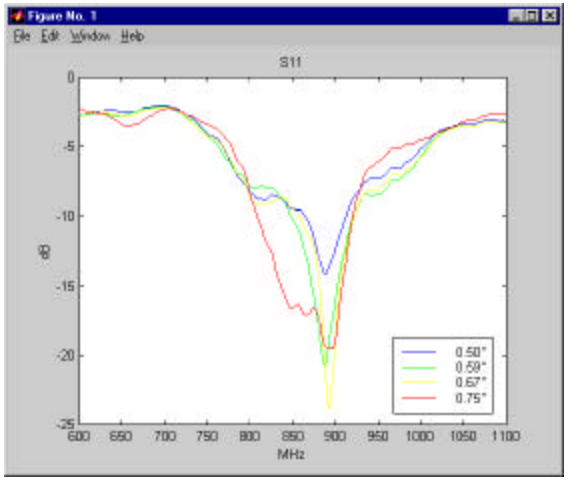


Experimental results

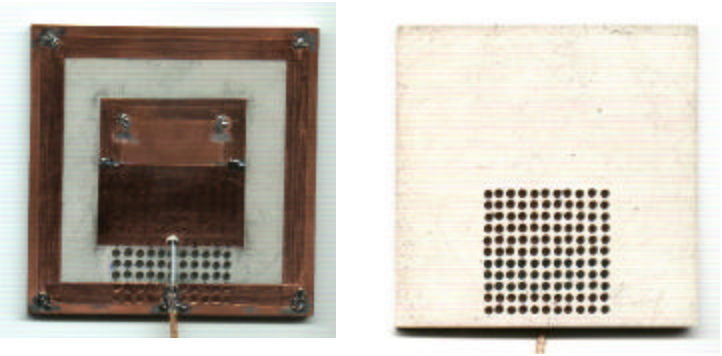
Local tuning

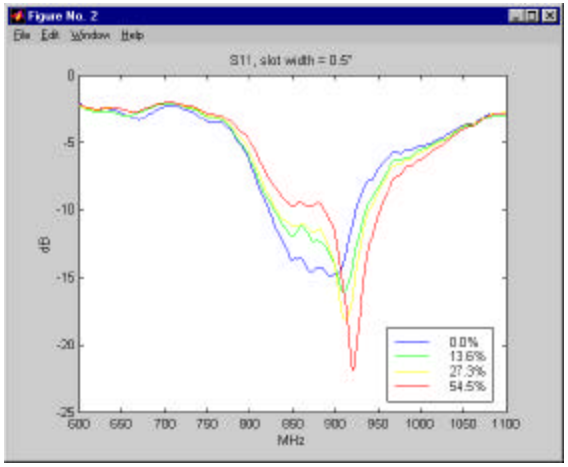


0.2” ROGERS TMM10
(ε_r=9.2±0.23, tanδ=0.0023)



(top) (bottom)





Summary

- Generation of artificial dielectrics through air voids
- Near and far field quantities respond well
- Presented quantitative data relating effective dielectric constant to air volume density
- Idea demonstrated through both simulation and experimental study

Future

- Compare simulated and experimental data for the same structure
- Collection of equivalence data for different type, size and dielectric constant