

Artificial Dielectrics for Mobile Antenna Design

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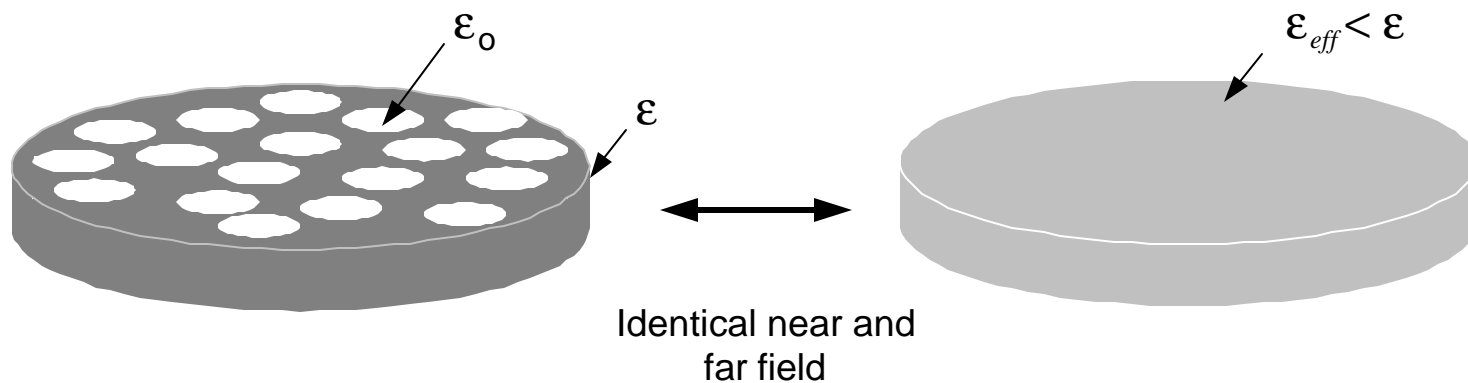
This work has been sponsored by The Army Research Office

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:

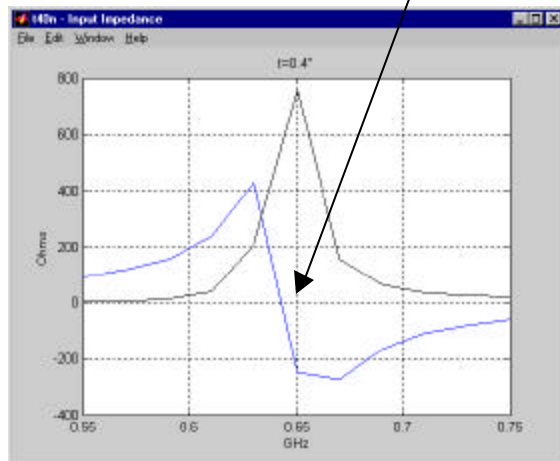
- Control the dielectric constant by introducing air voids
- Air voids are small in size compared to wavelength
- Establish effective dielectric constant as a function of volume density of air voids
- This will be a function of background dielectric constant and the size of the sample



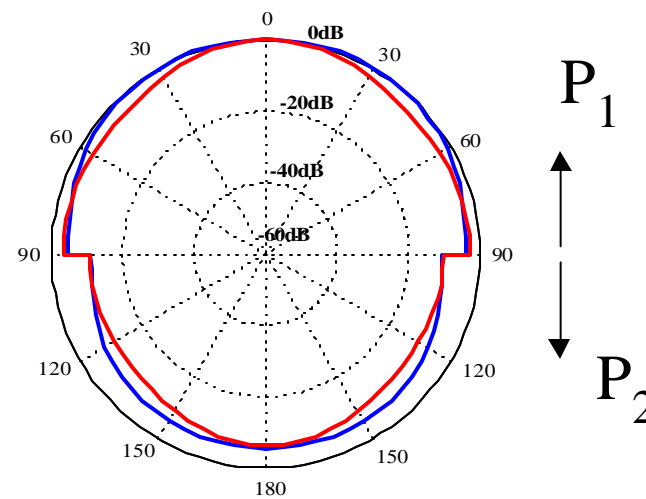
Parameters for establishing equivalance

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

Resonance Frequency

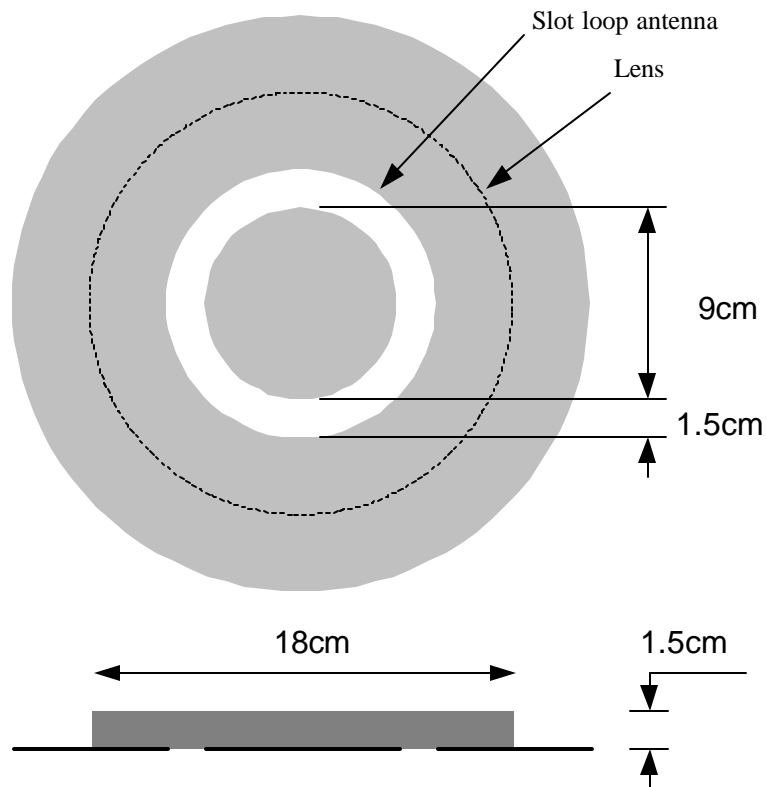


$$FBR = P_1 - P_1$$

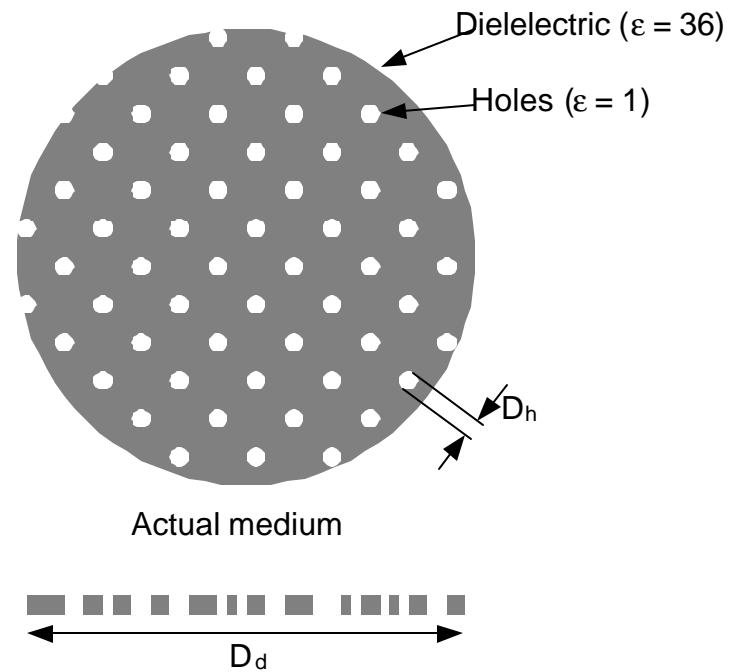


Simulated results

Finite Element Method



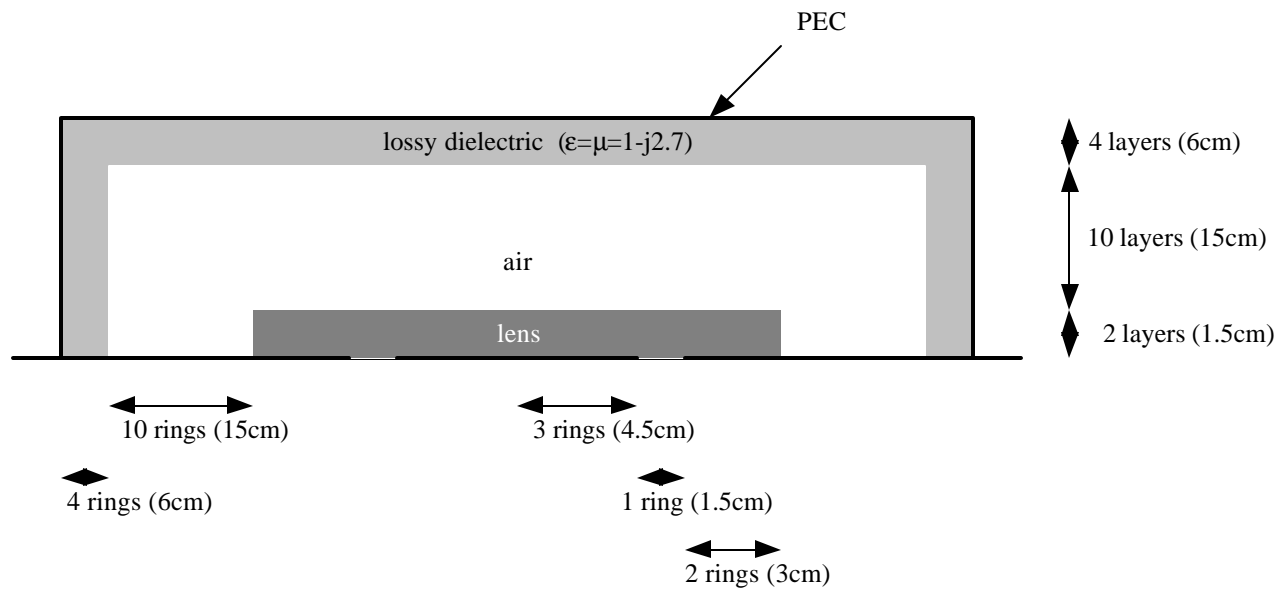
APS 2001, Boston



EMAG Technologies, Inc.

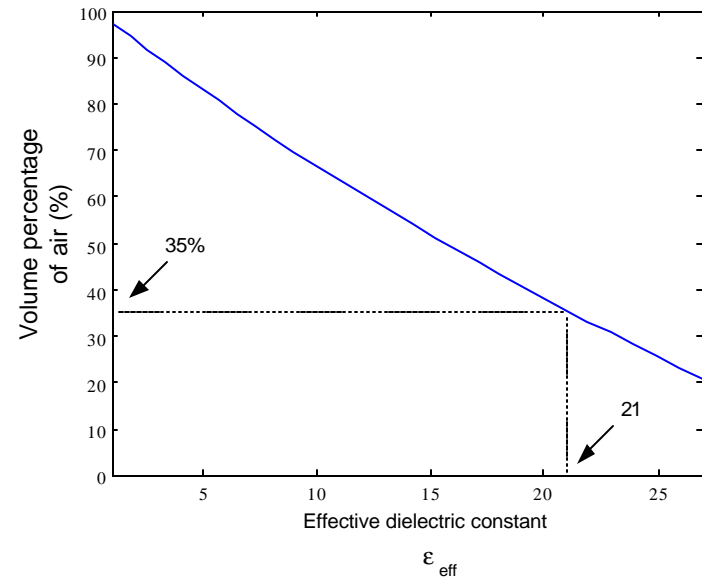
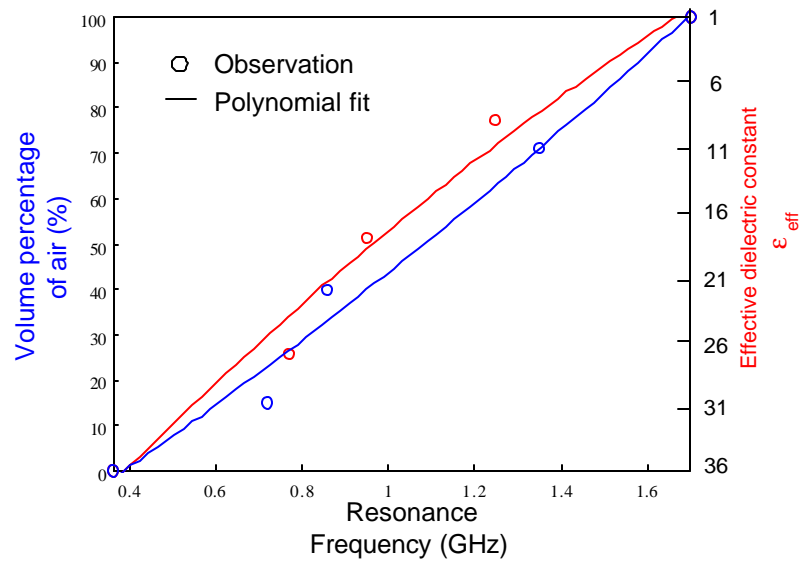
Simulated results

Finite Element Method



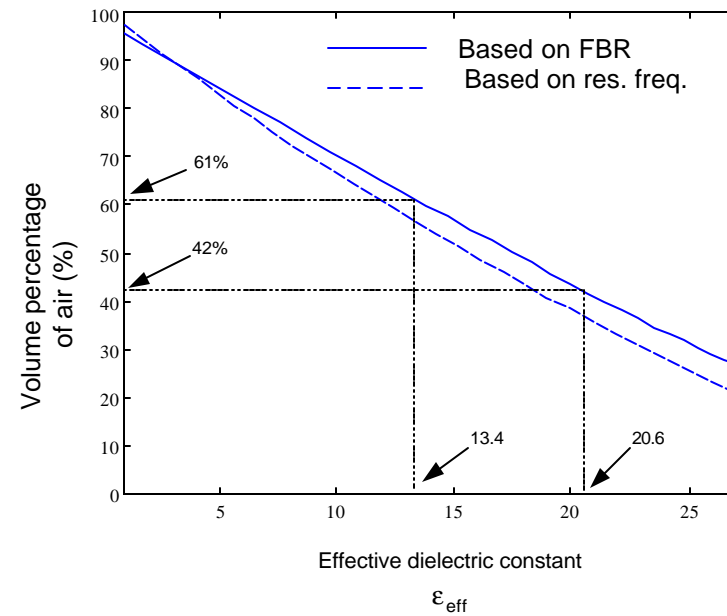
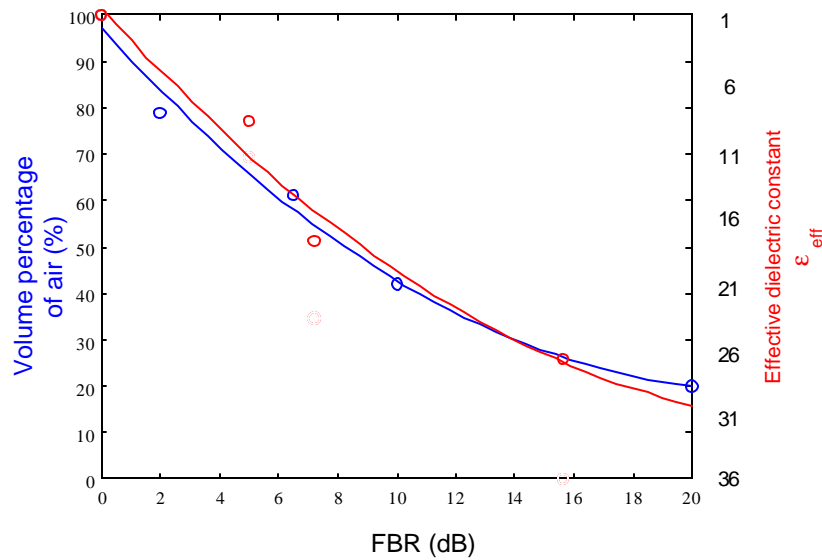
Simulated results

Equivalence through "Resonance Frequency"



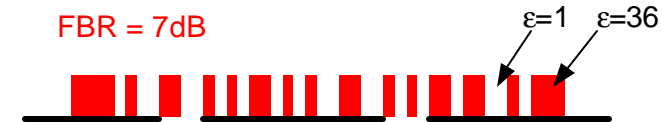
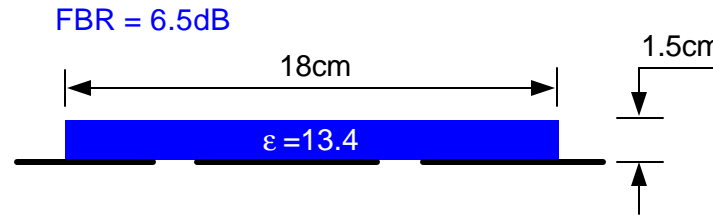
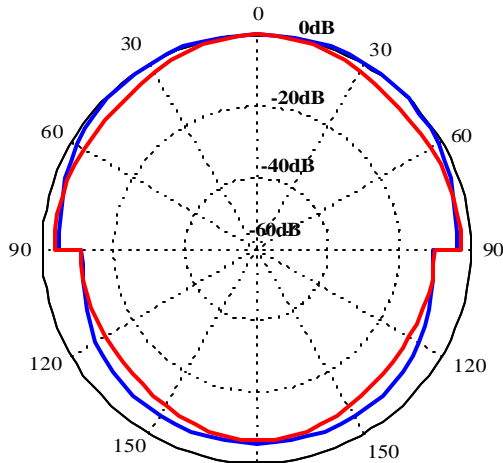
Simulated results

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

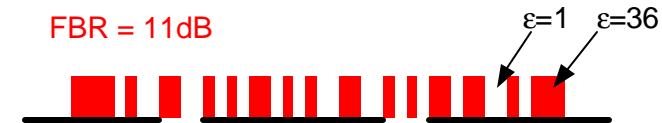
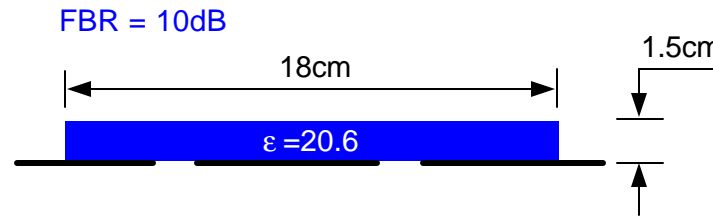
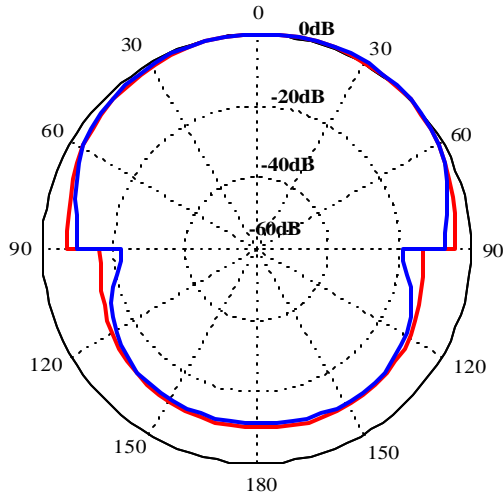


Simulated results

Validating equivalence



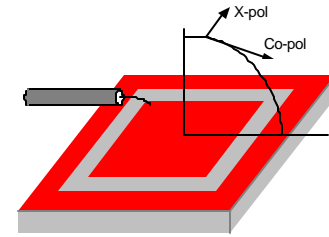
Volume percentage of air = 61%



Volume percentage of air = 42%

Experimental results

Square slot loop antenna



3"x3"x0.2"

Uniform substrate

Equivalent through
"resonance frequency"



Substrate with holes $\epsilon_r=9.2$



$\epsilon_r=9.2$



0%



$\epsilon_r=6.0$



26%



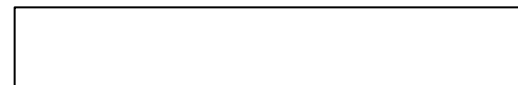
$\epsilon_r=3.2$



52%



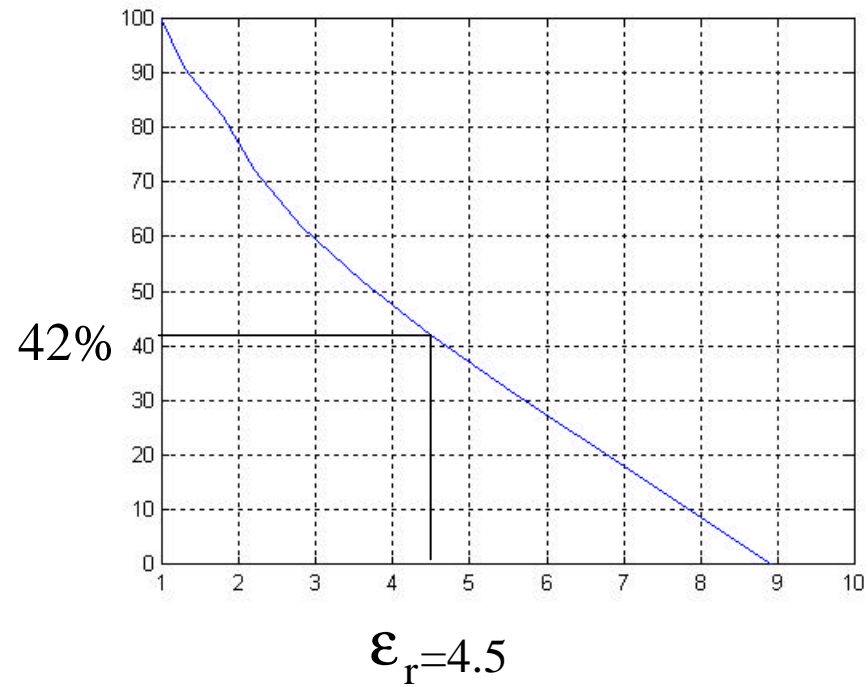
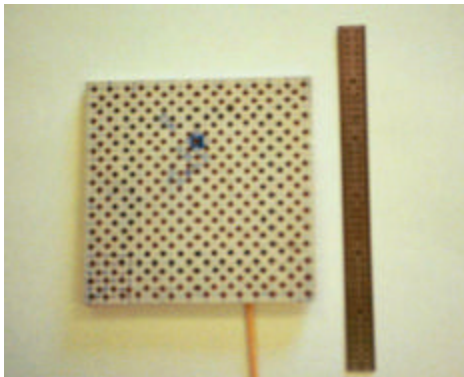
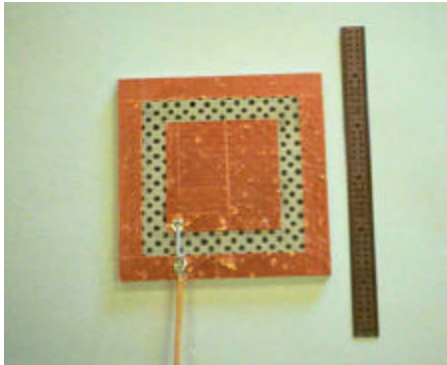
$\epsilon_r=1.0$



100%

Experimental results

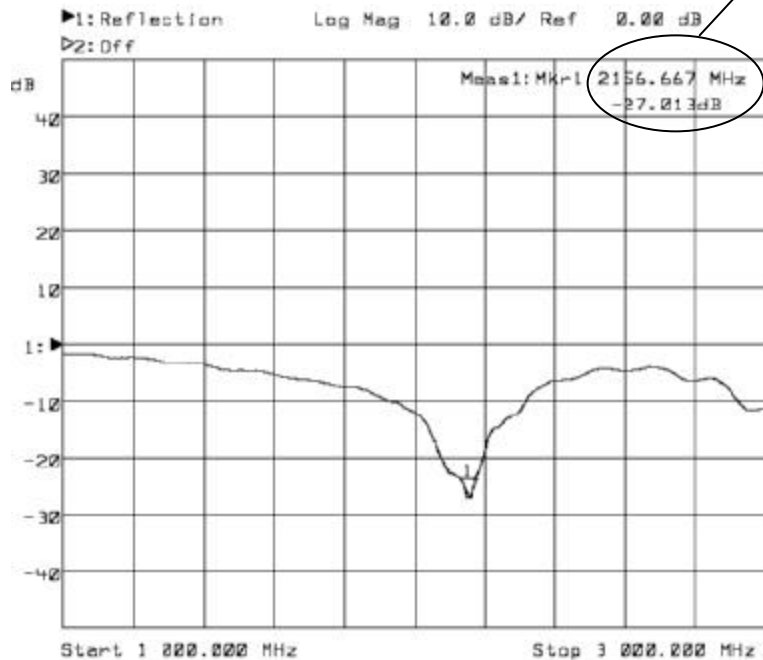
Equivalence through "resonance frequency"



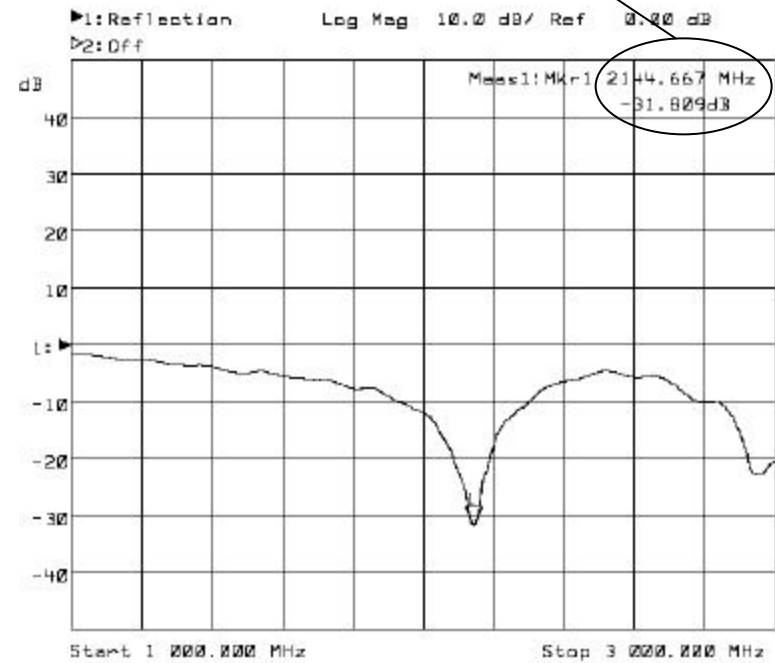
Experimental results

Validating equivalence

Uniform: $\epsilon_r = 4.5$



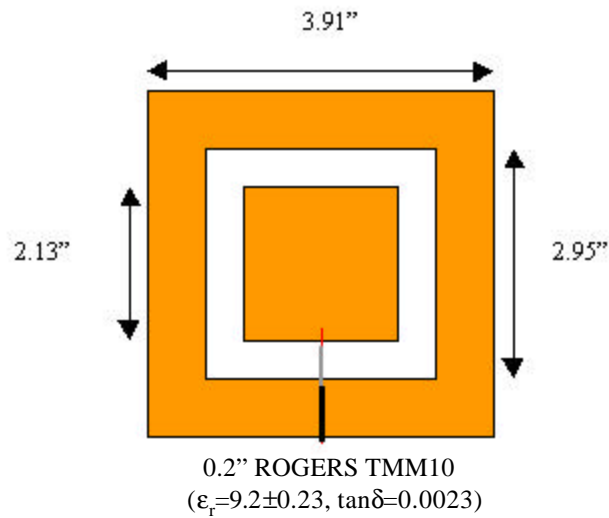
With air voids: 42%



2157 vs. 2145 MHz (Error: 0.6%)

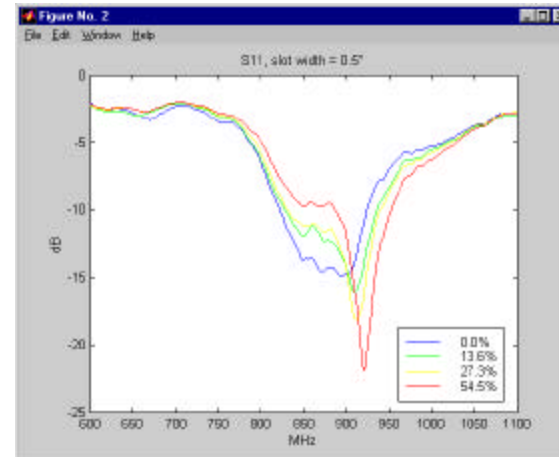
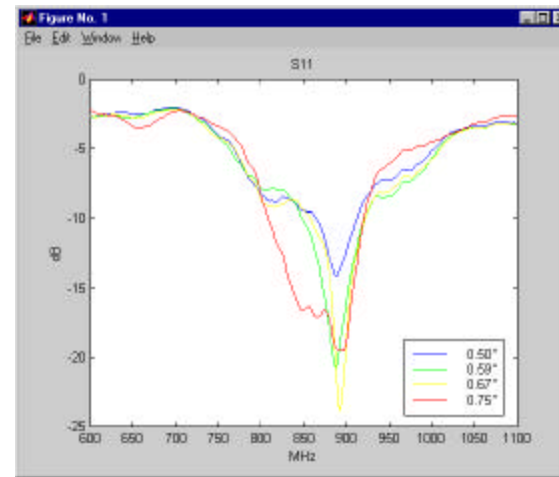
Experimental results

Local tuning



(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