COMSOL CONFERENCE
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EM Simulation of a Low-Pass Filter Based on a Microstrip Defected Ground Structure Using COMSOL

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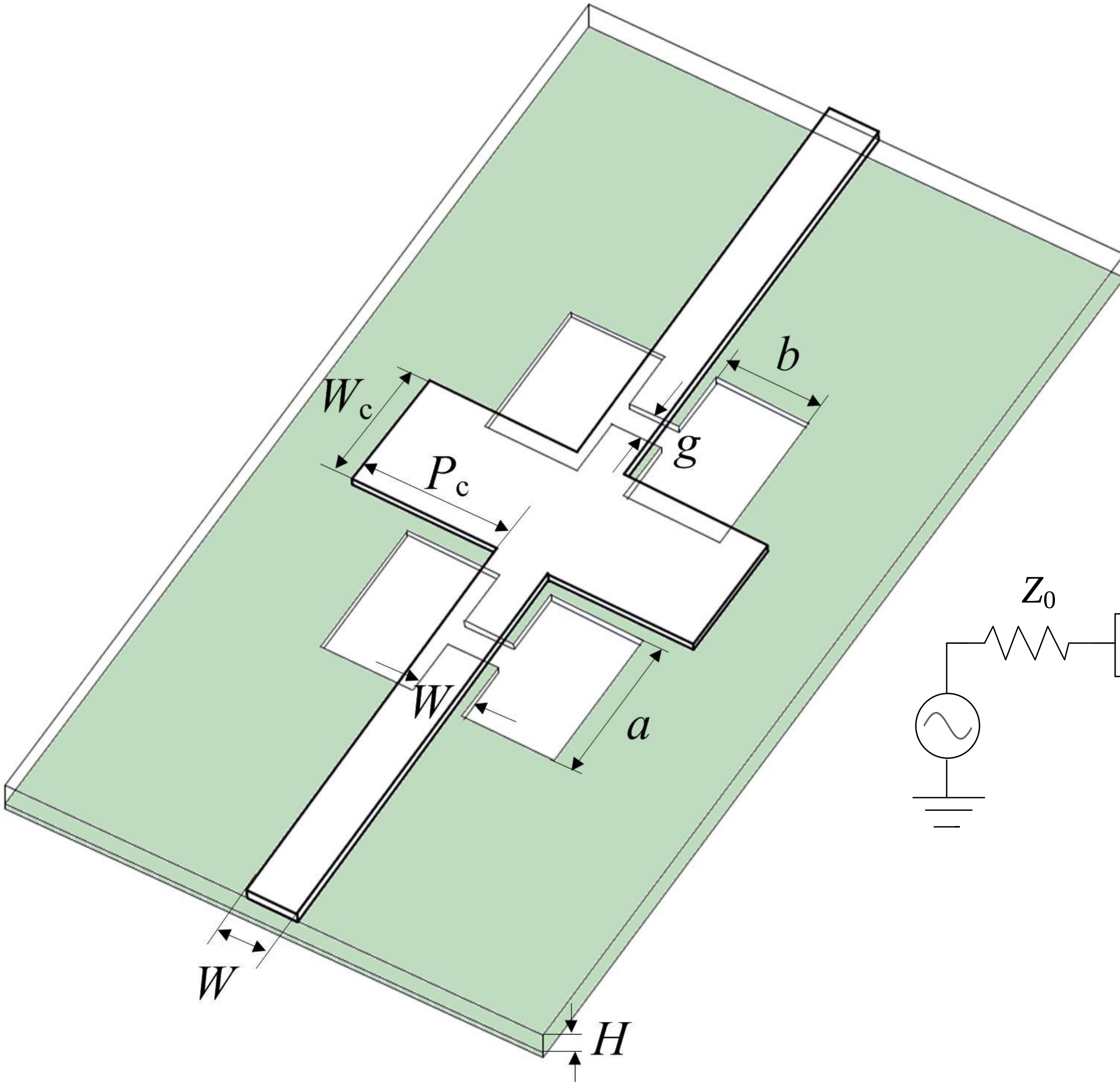
Outline

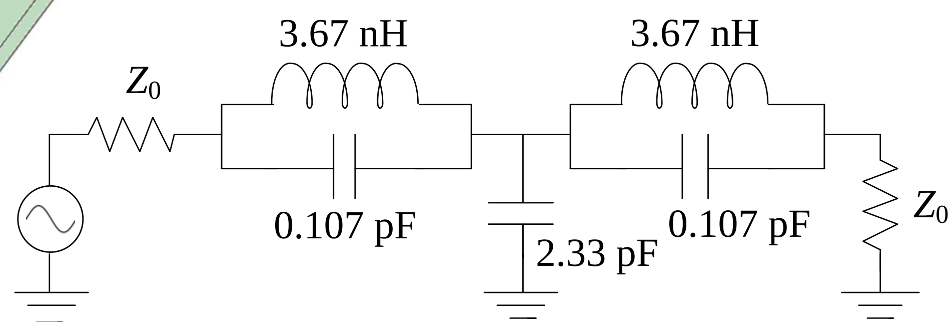
- Introduction
- Low-pass filter based on defected ground structure (DGS) units
- Fine and coarse model implementations
- EM responses
- Comparisons with measured data
- Fields and radiation losses
- Conclusions

Introduction

- DGS units have been introduced as high-performance bandgap structures
- Enhanced DGS-based filters have been developed with very high attenuation and wide rejection bands
- However, radiation in DGS can be significant
- We implement fine and coarse models of a low-pass filter based on DGS units

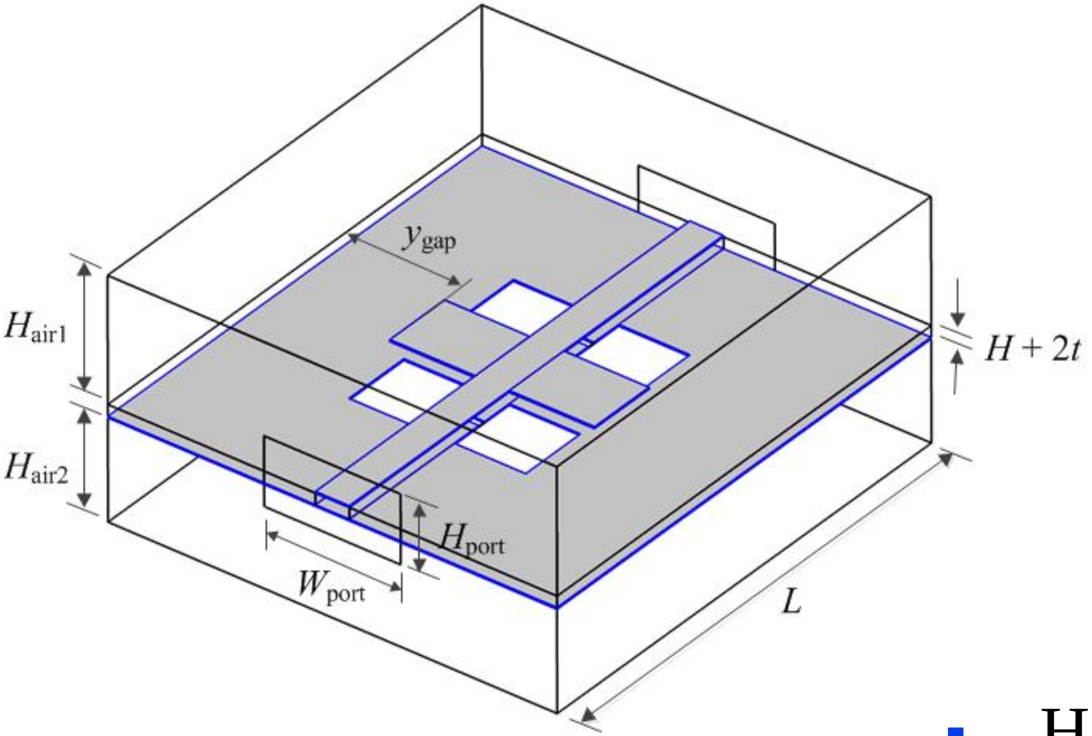
Low-Pass Filter Based on DGS Units

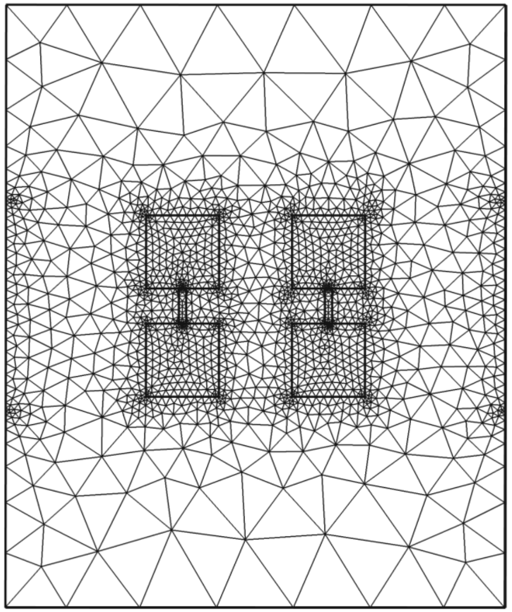




(*Ahn et. al. 2001*)

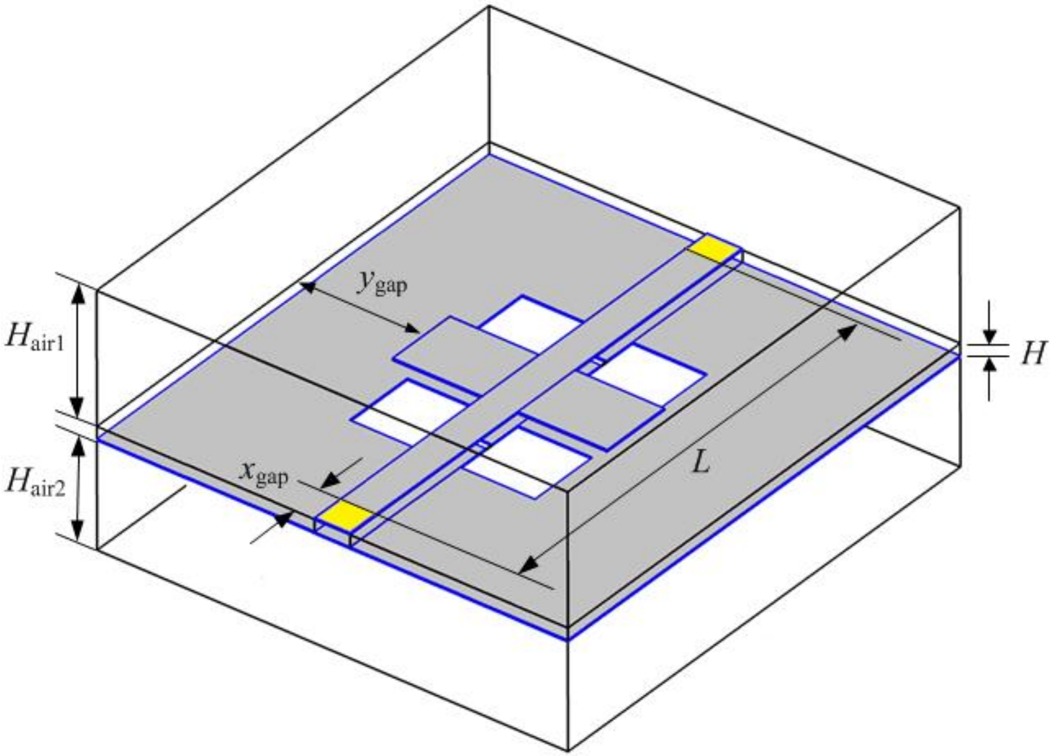
Fine Model Implementation

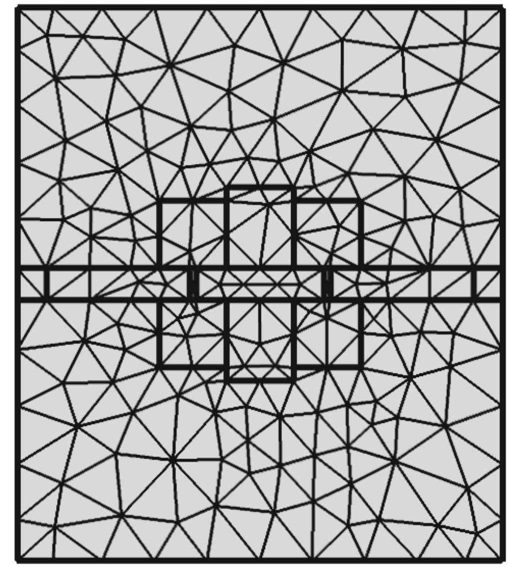




- Lossy microstrips and ground plane
- Lossy dielectric
- High-mesh resolution
- 48, 542 elements in mesh
- 57min (100 frequency points)

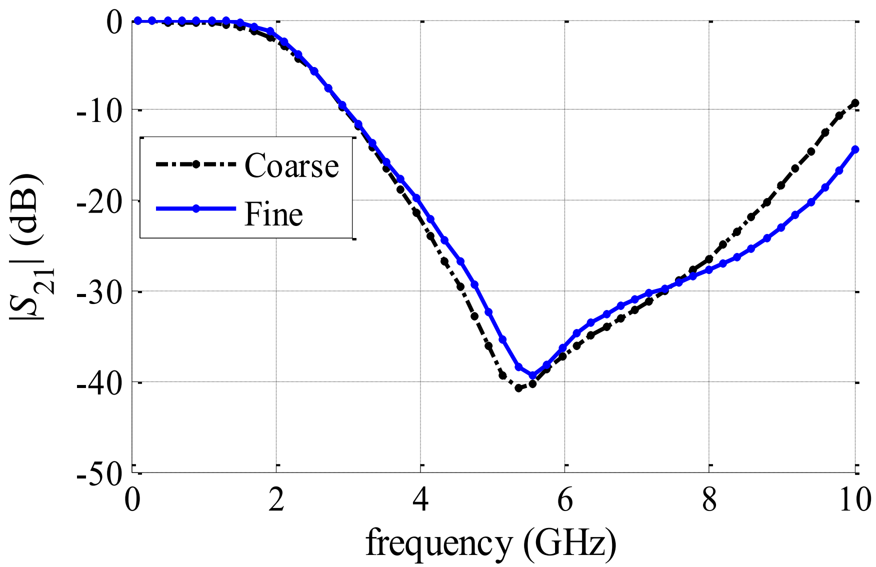
Coarse Model Implementation

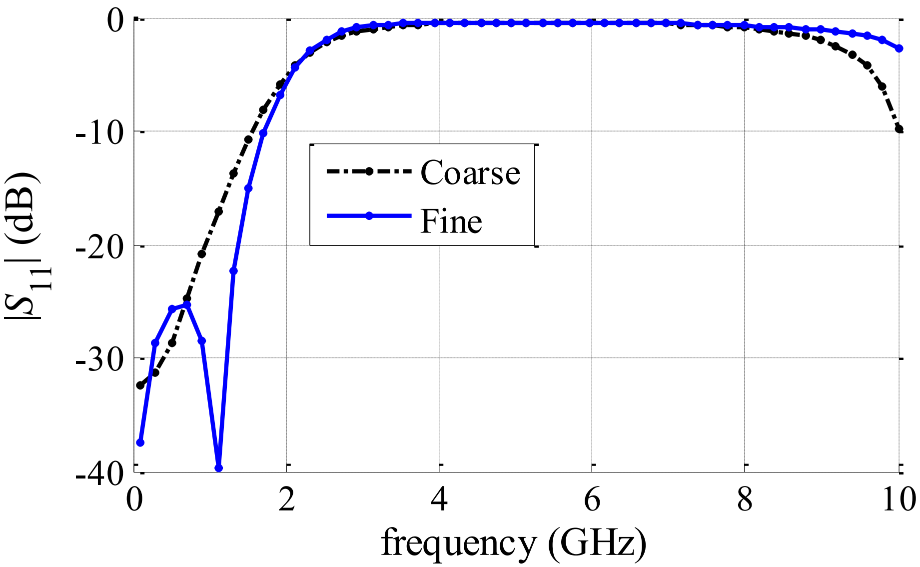




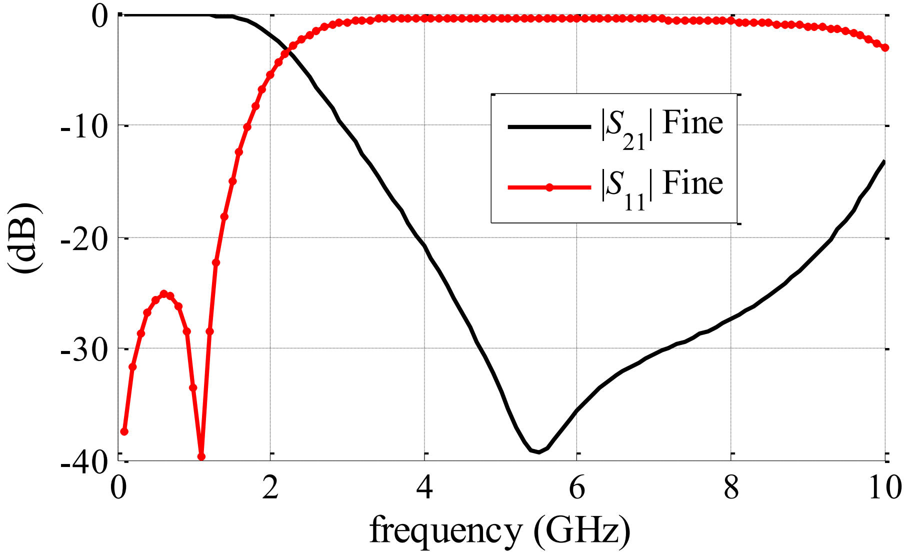
- Lossless microstrips and ground plane
- Lossless dielectric
- Low-mesh resolution
- 3,269 elements in mesh
- 53s (50 frequency points)

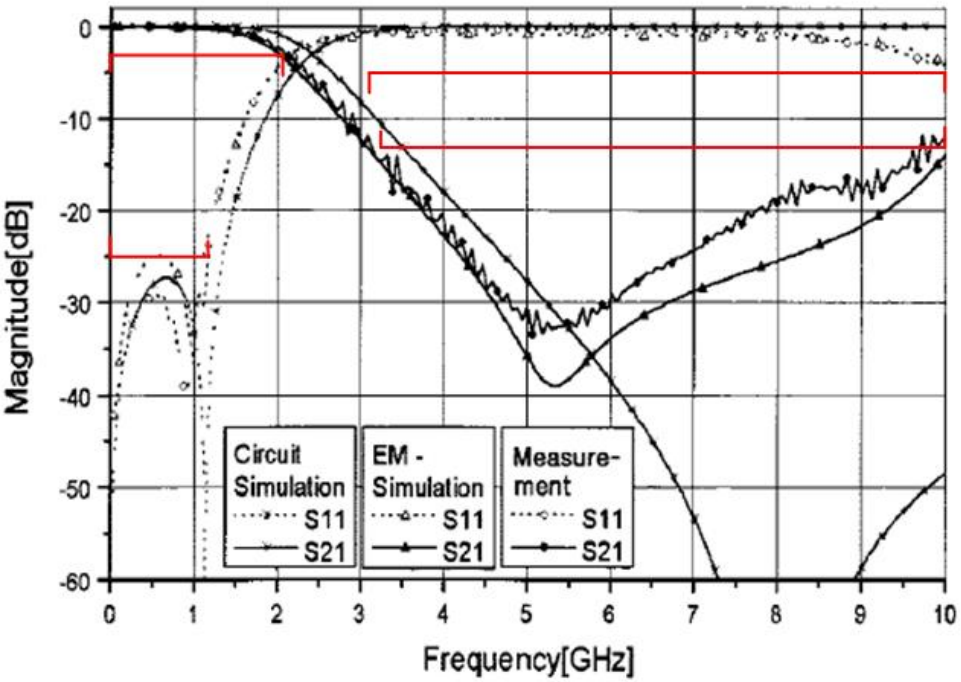
EM Responses





Comparison with Measured Data



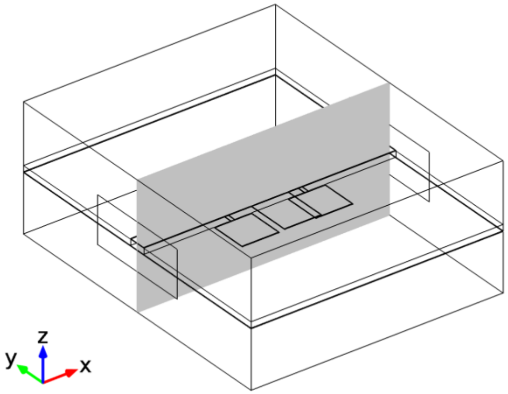


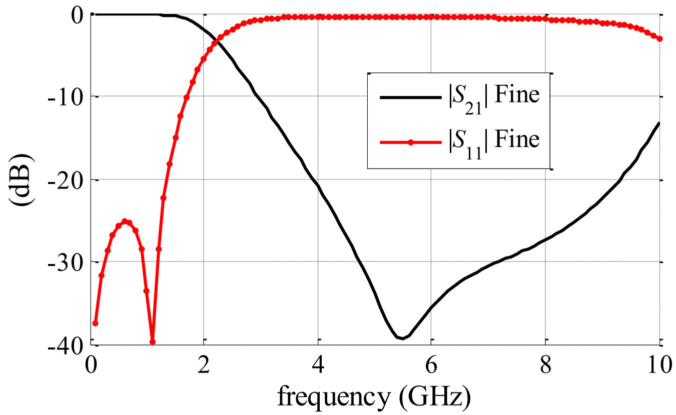
D. Ahn, J. Park, C. Kim, J. Kim, Y. Qian, and T. Itoh, "A design of the low-pass filter using the novel microstrip defected ground structure," *IEEE Trans. Microwave Theory Tech.*, vol. 49, pp. 86-93, Jan. 2001.

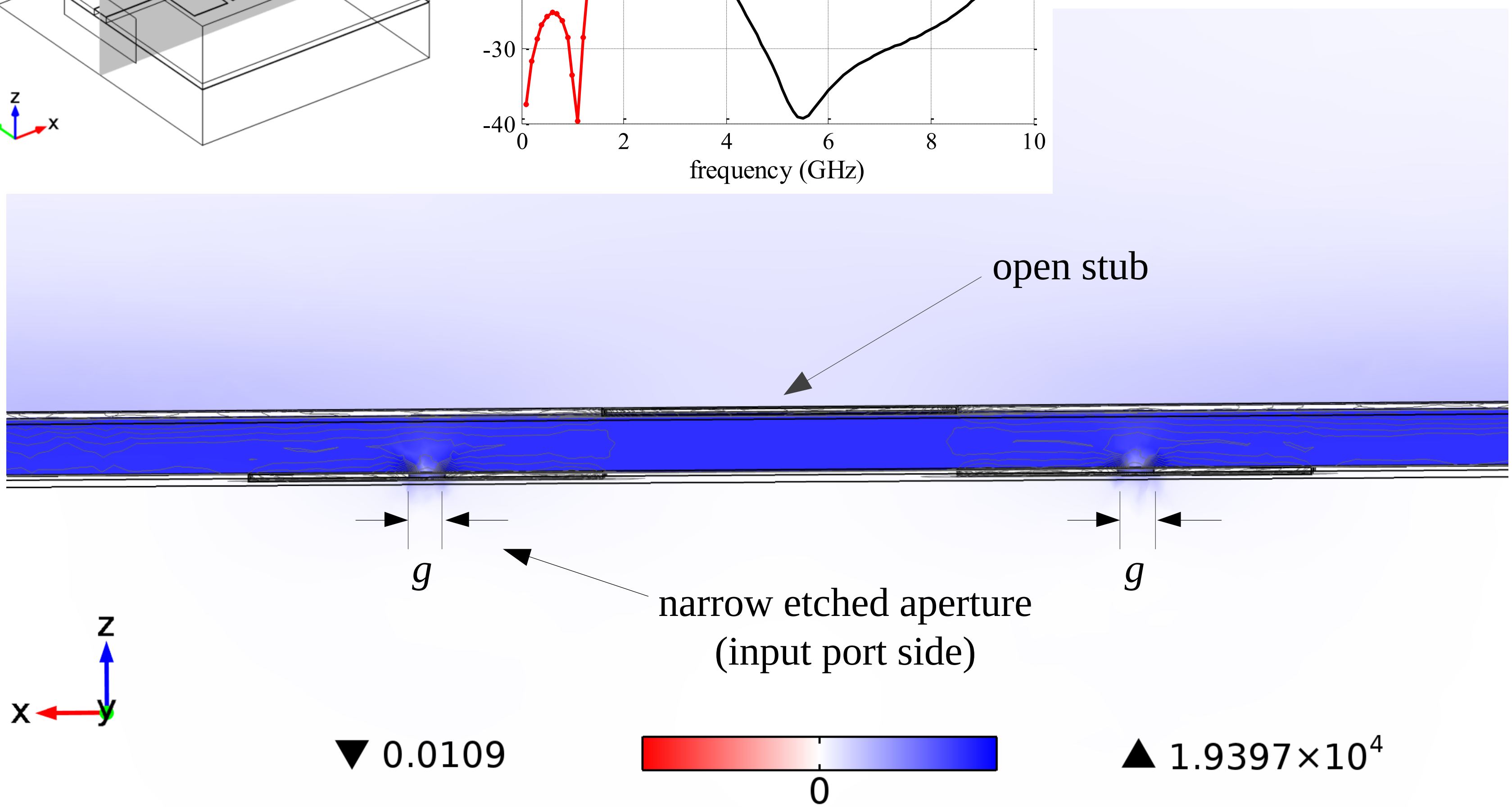
(*Ahn et. al. 2001*)

Electric Field, ***E*** (V/m)

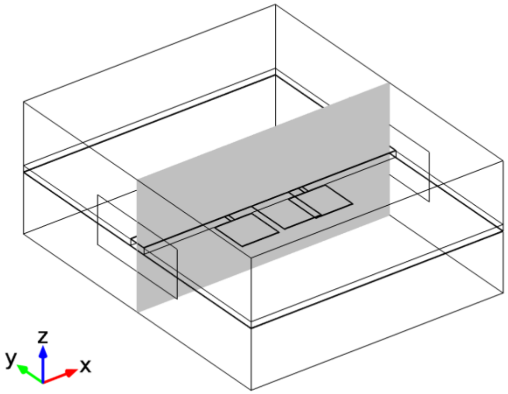
(0.1 GHz)

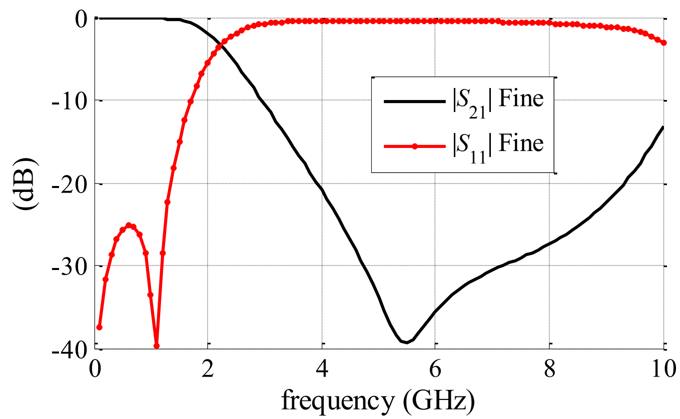




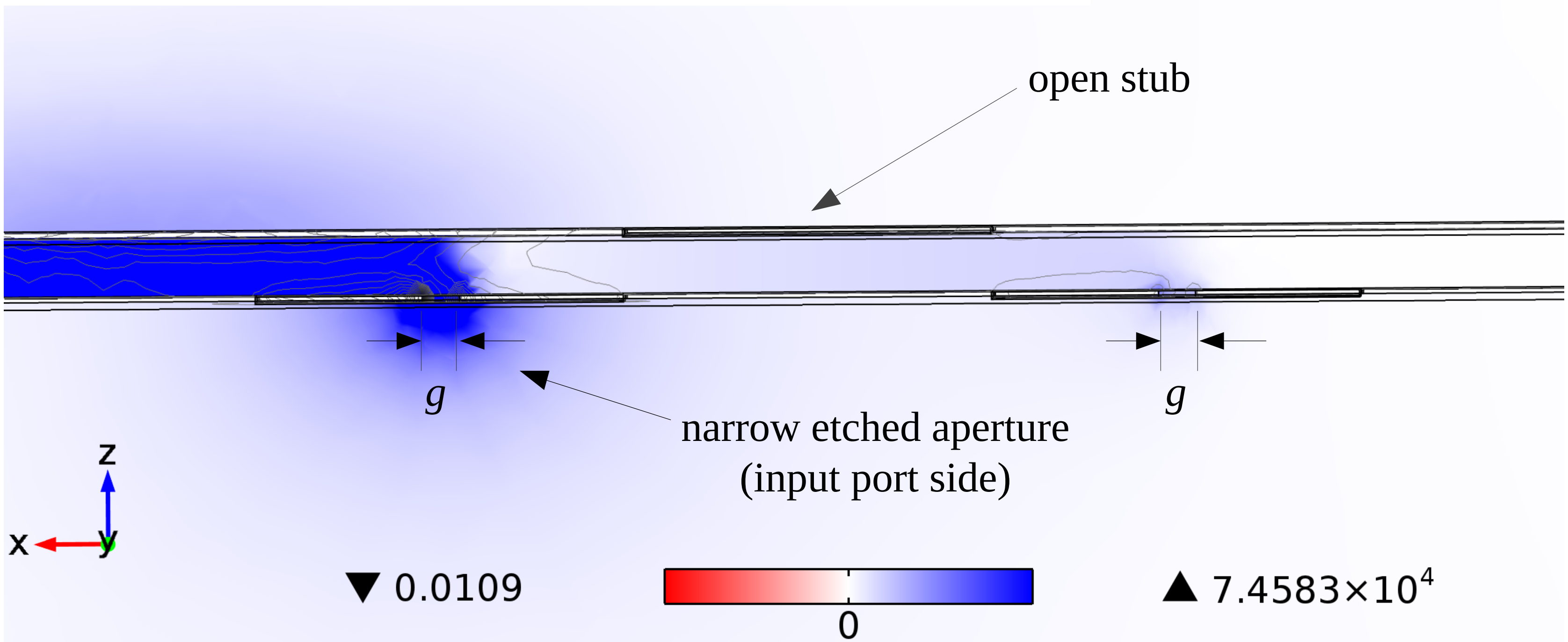


Electric Field, ***E*** (V/m) (cont.)



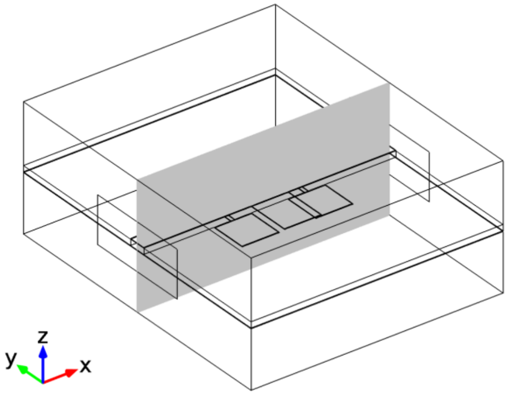


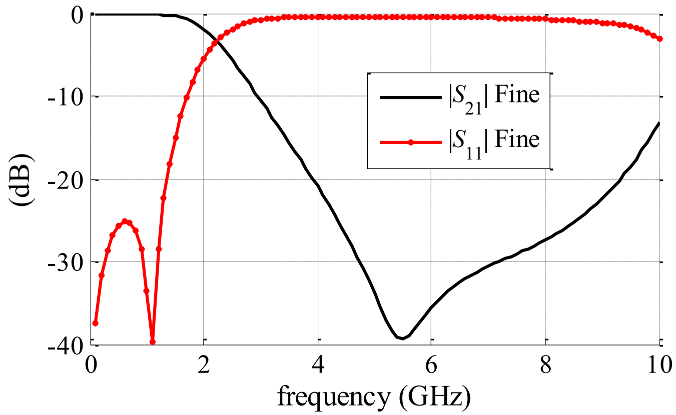
(5.5 GHz)

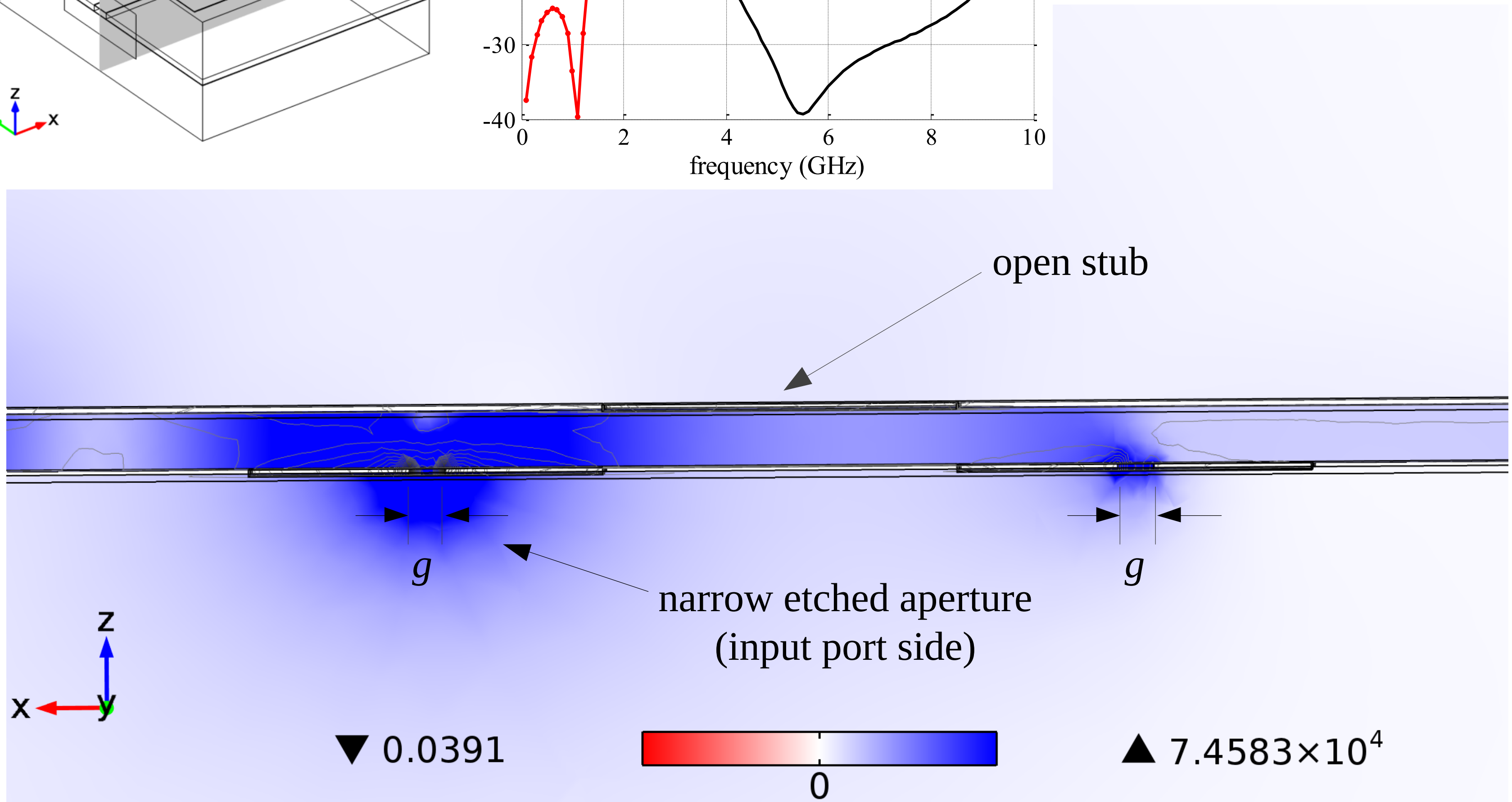


Electric Field, ***E*** (V/m) (cont.)

(10 GHz)

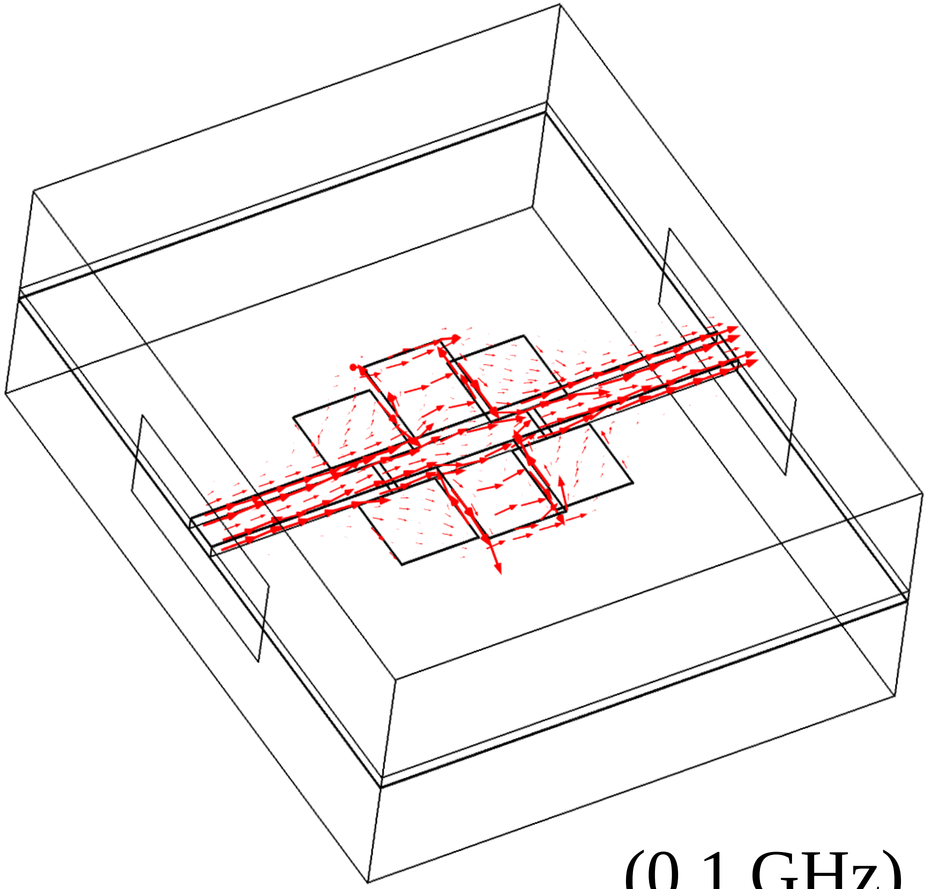




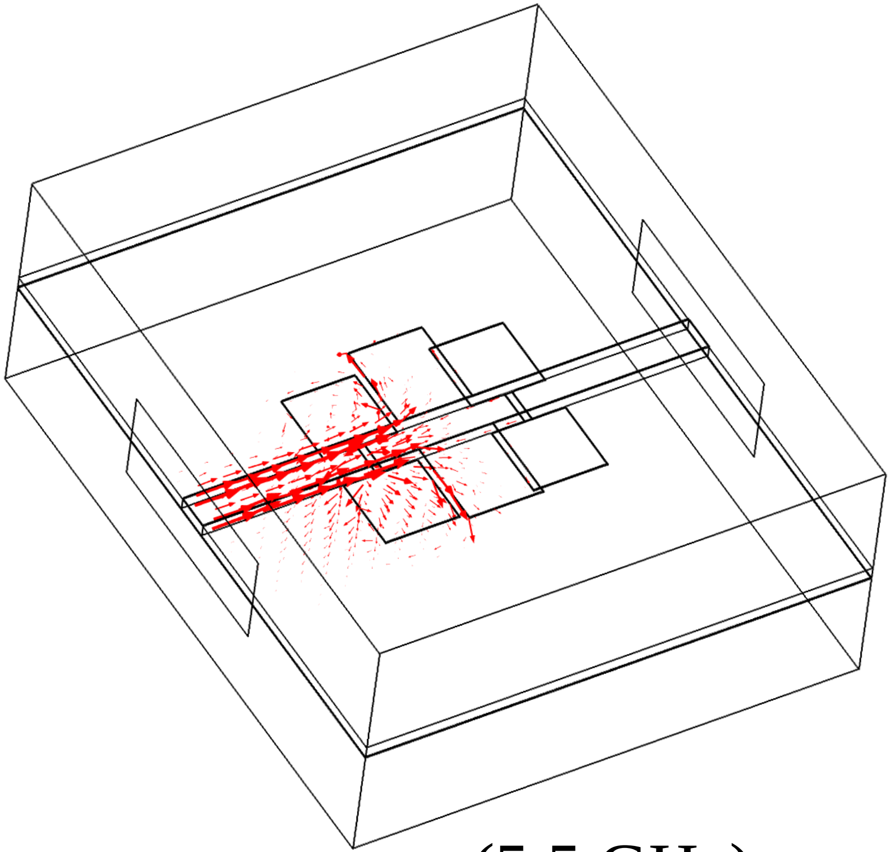


Power Flow

$$\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H} \quad (\mathrm{W/m^2})$$



(0.1 GHz)



(5.5 GHz)

Power Flow (cont.)

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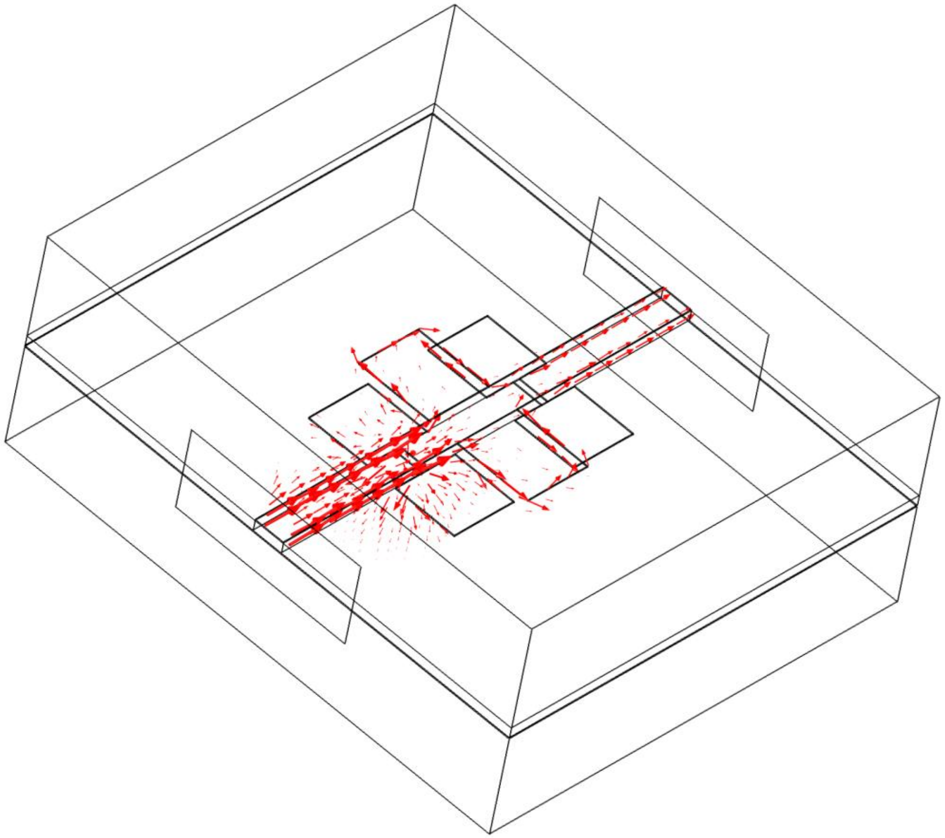
$$\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H} \quad (\mathrm{W/m^2})$$



(10 GHz)

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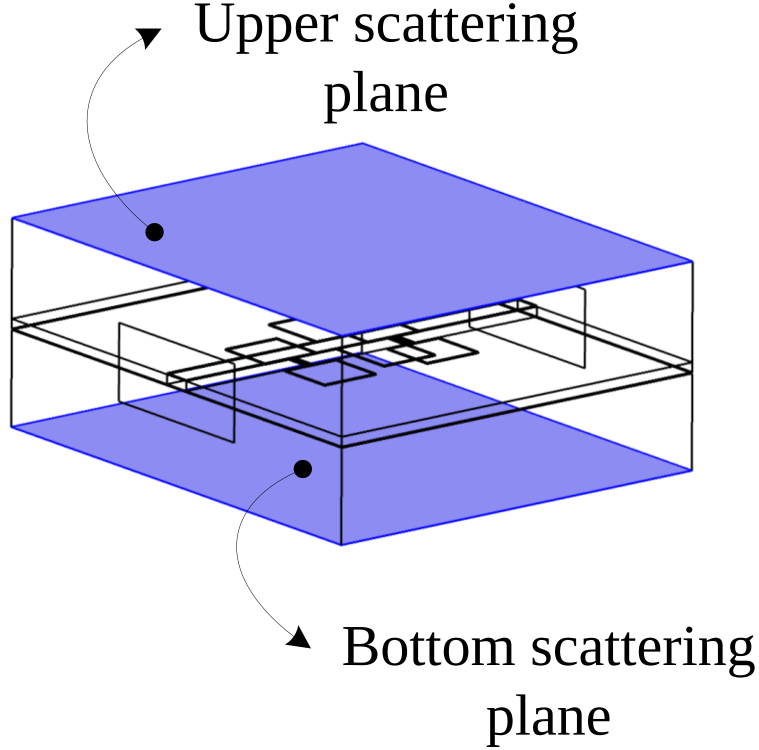
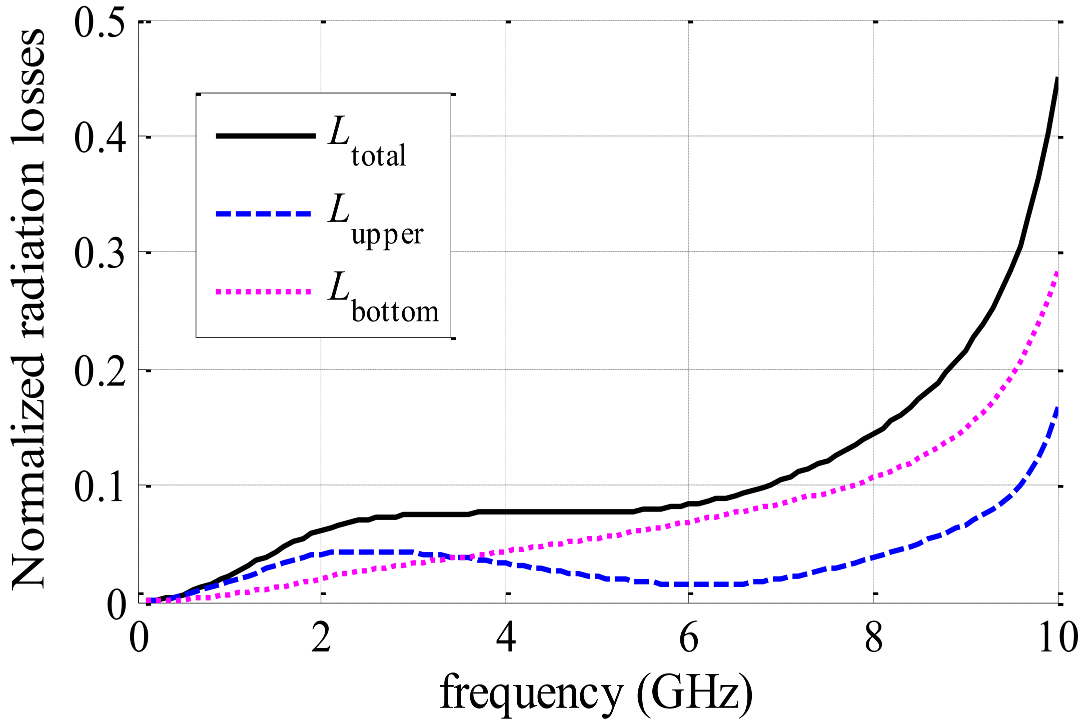
Radiation Loss





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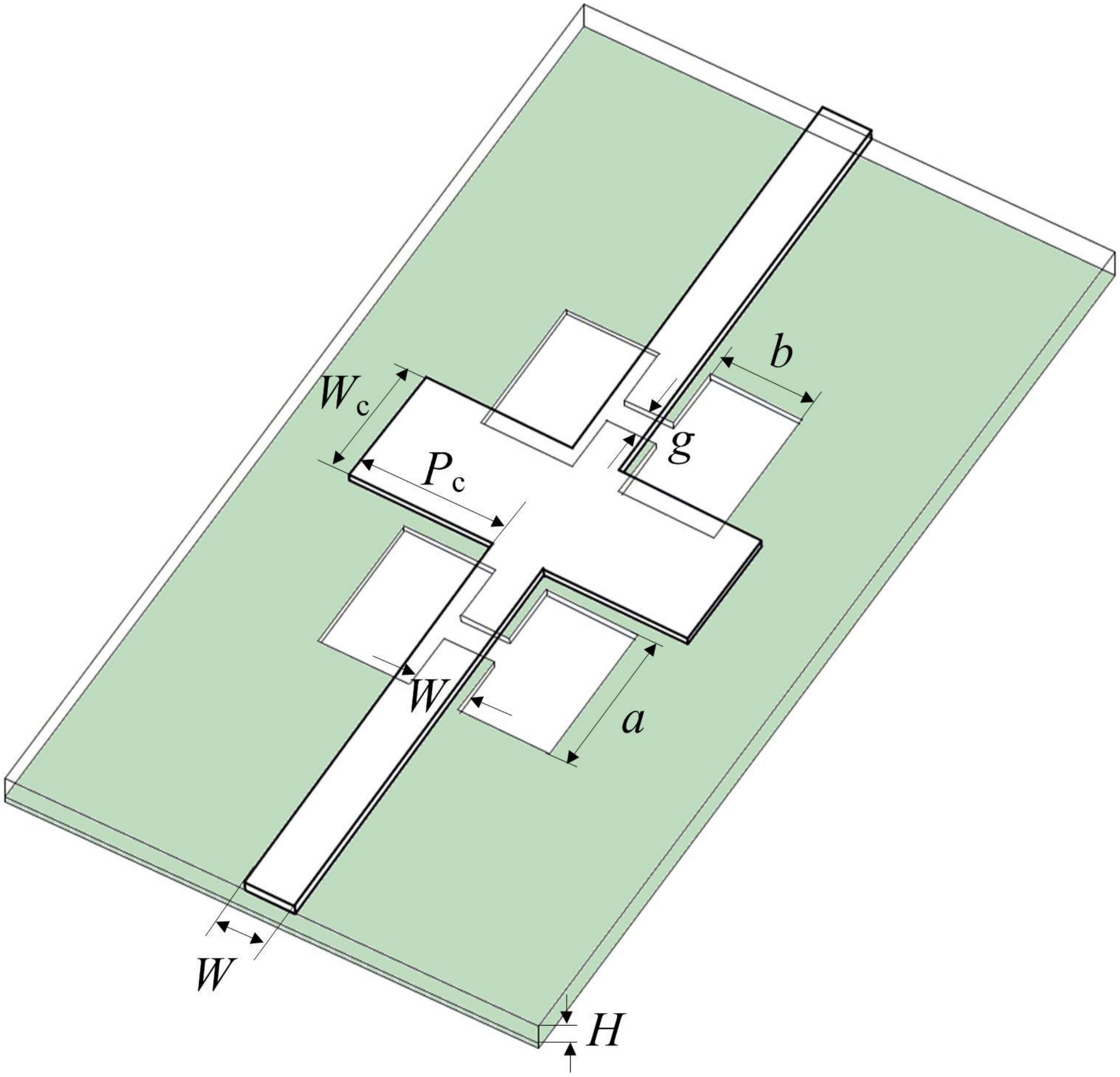
Conclusions

- We analyzed a low-pass filter based on DGS units
- Coarse and fine models were implemented
- The coarse model is a good representation of the fine model over certain frequency interval
- Coarse model reduces significantly simulation time (approximately 35 times faster)
- Fine model results are in excellent agreement with measured data
- Large radiation loss is the main disadvantage of the defected ground technique

Backup Slides

Low-Pass Filter (cont.)



$g = 0.5$ mm

$W = 2.4$ mm

$a = 5$ mm

$b = 5$ mm

$W_c = 5$ mm

$P_c = 6$ mm

$H = 0.787$ mm

(*Ahn et. al. 2001*)

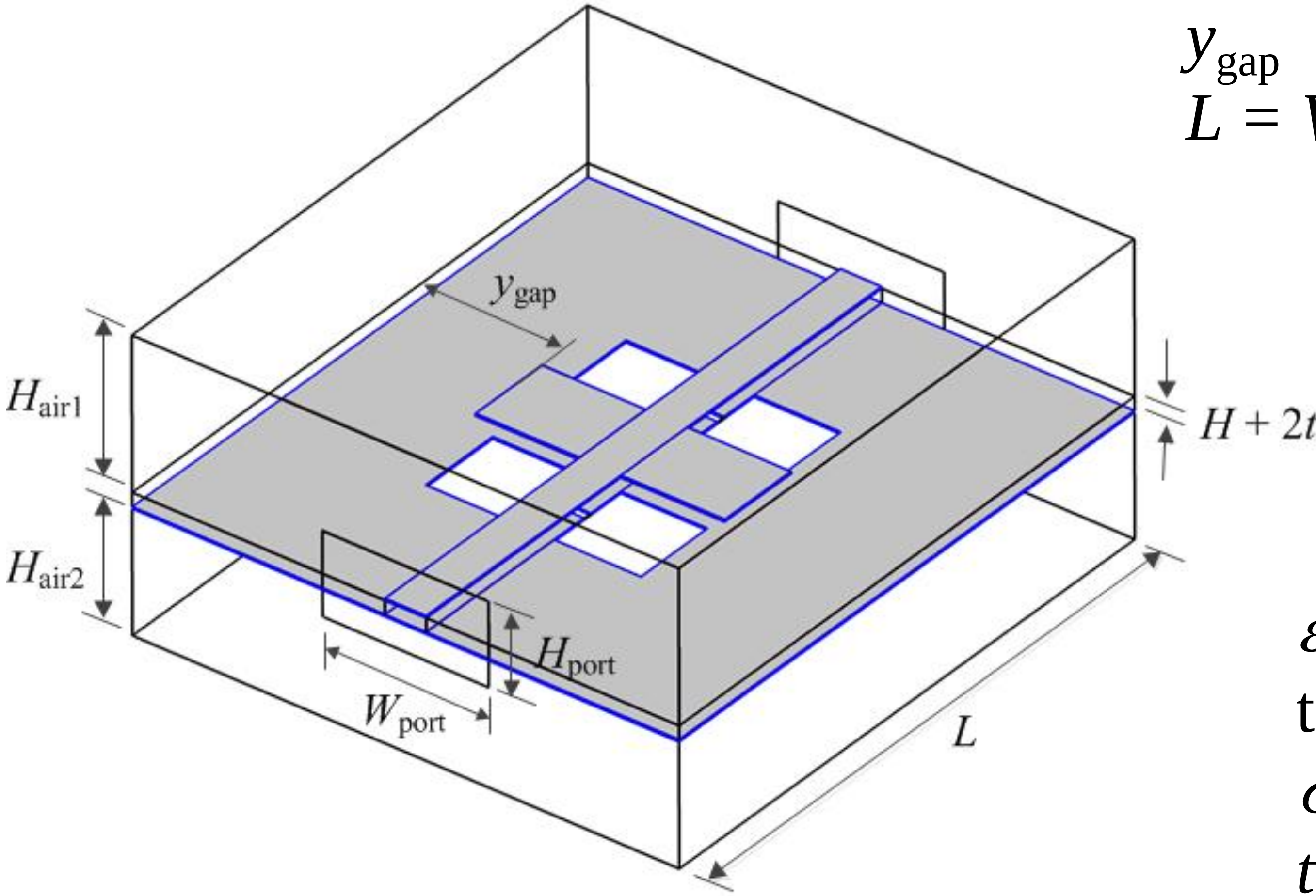
Meshing

- Coarse and fine model meshing based on λ_a and λ_m

Parameter	Fine model	Coarse model
$\delta_{max\text{-}air}$, $\delta_{max\text{-}sub}$	$\lambda_a/5$, $\lambda_m/20$	$\lambda_a/2$, $\lambda_m/4$
$\delta_{min\text{-}air}$, $\delta_{min\text{-}sub}$	$\lambda_a/50$, $\lambda_m/200$	$\lambda_a/20$, $\lambda_m/40$
Number of elements in mesh	48,542	3,269
Number of degrees of freedom	398,890	21,922
Frequency points	100	50
Simulation time	57min 24s	53s

- FEM COMSOL solver (ver. 4.3)
- Platform Dell XPS8300 Intel Core i7-2600 at 3.4 GHz and 16 GB RAM

Fine Model Implementation



$H_{air1} = 10H$
$H_{air2} = 10H$
$y_{gap} = 6W$
$L = W_c + 2a + 8W$

$W_{port} = 6W$
$H_{port} = 8H$

$\varepsilon_r = 2.94$
$\tan(\delta) = 0.0009$
$\sigma = 5.8\times10^7$ S/m
$t = 0.65$ mil

Coarse Model Implementation

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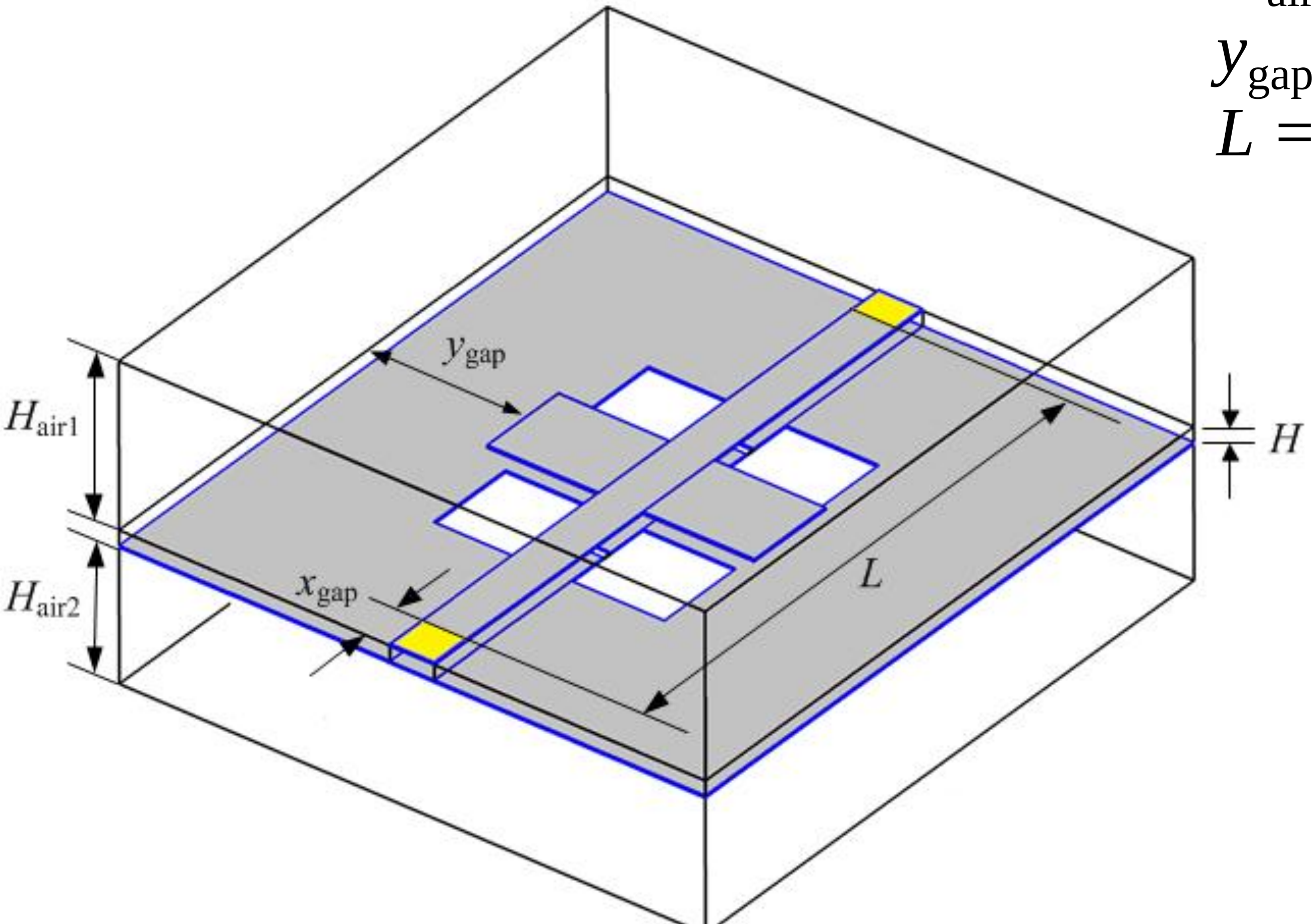

$H_{air1} = 10H$

$H_{air2} = 10H$

$y_{gap} = 6W$

$L = W_c + 2a + 8W$

$x_{gap} = 0.9W$

$\varepsilon_r = 2.94$

$\tan(\delta) = 0$

$\sigma = \infty$ S/m

$t = 0$ mil

Power Loss Prediction