Using S-Parameters for High Performance Simulation

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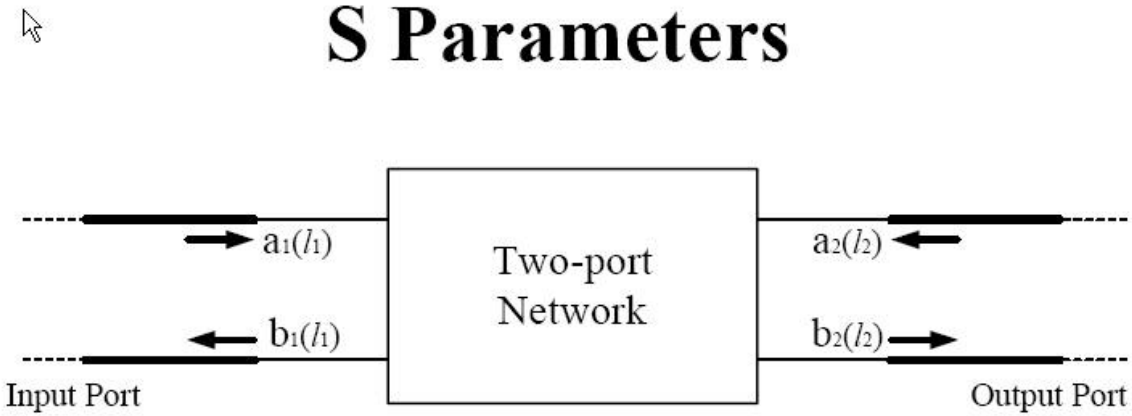
ANSOFT

What's S-Parameter

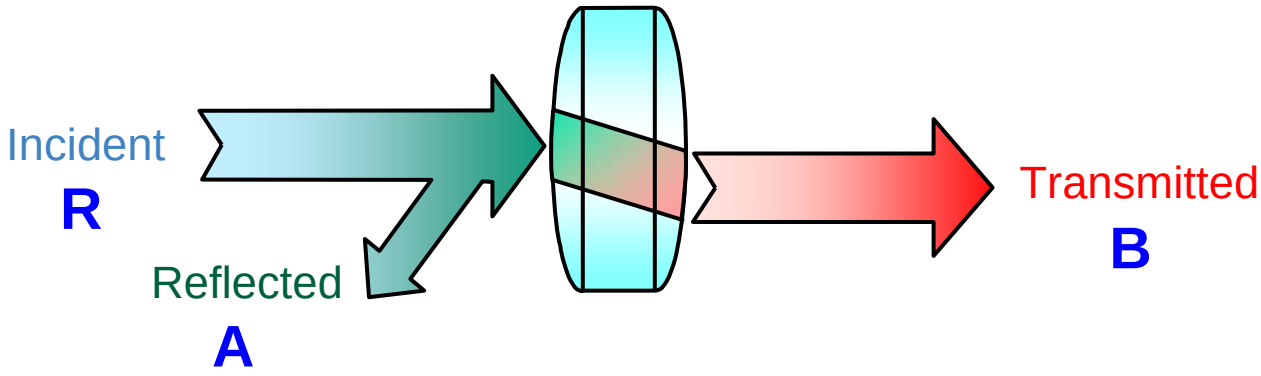
- S-parameter-- Scattering parameter



Return Loss $S_{11} = \left.\frac{b_1}{a_1}\right|_{a_2=0}$ $S_{22} = \left.\frac{b_2}{a_2}\right|_{a_1=0}$

Insertion Loss $S_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0}$ $S_{12} = \left.\frac{b_1}{a_2}\right|_{a_1=0}$

Insertion Loss & Return Loss



REFLECTION

$$\frac{\text{Reflected}}{\text{Incident}} = \frac{A}{R}$$

Return Loss

TRANSMISSION

$$\frac{\text{Transmitted}}{\text{Incident}} = \frac{B}{R}$$

Insertion Loss

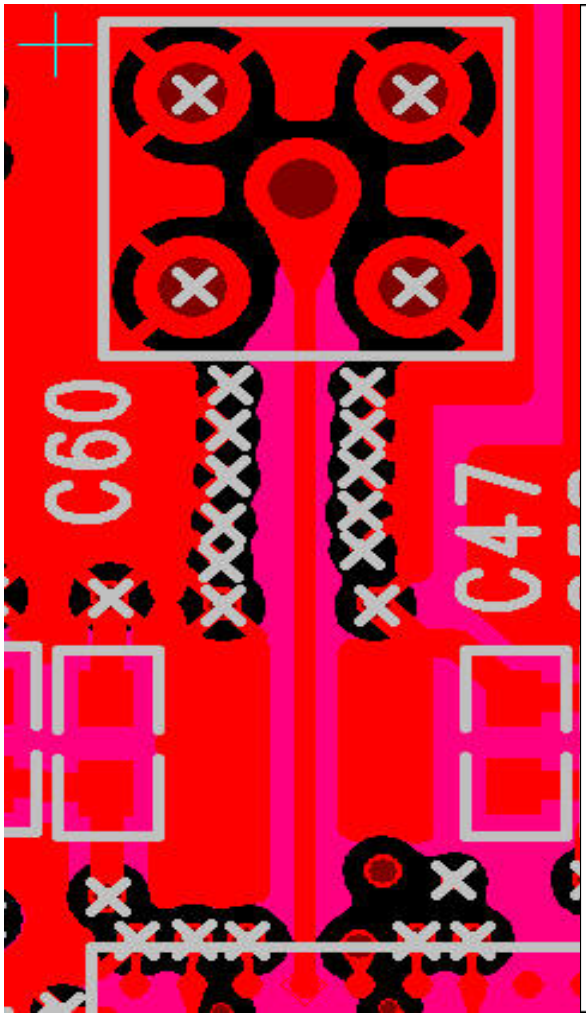
How to get S-Parameter

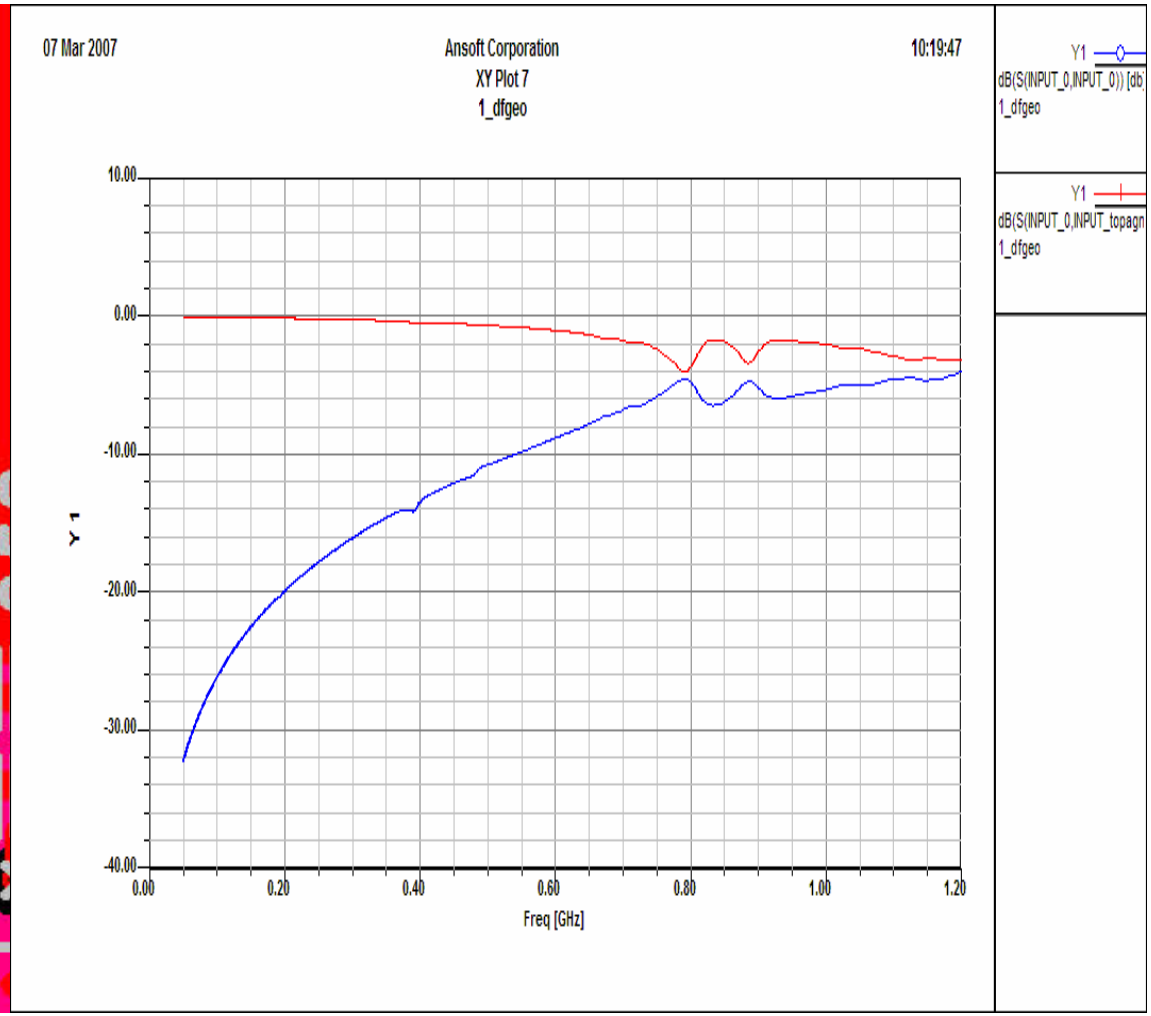
- Simulation: Full Wave EM Simulation
  - Including complex 3D construction and non-idea return path
- Measurement
  - Vector Network Analyzer
  - Test fixture de-embedding

What's S-Parameter tell you

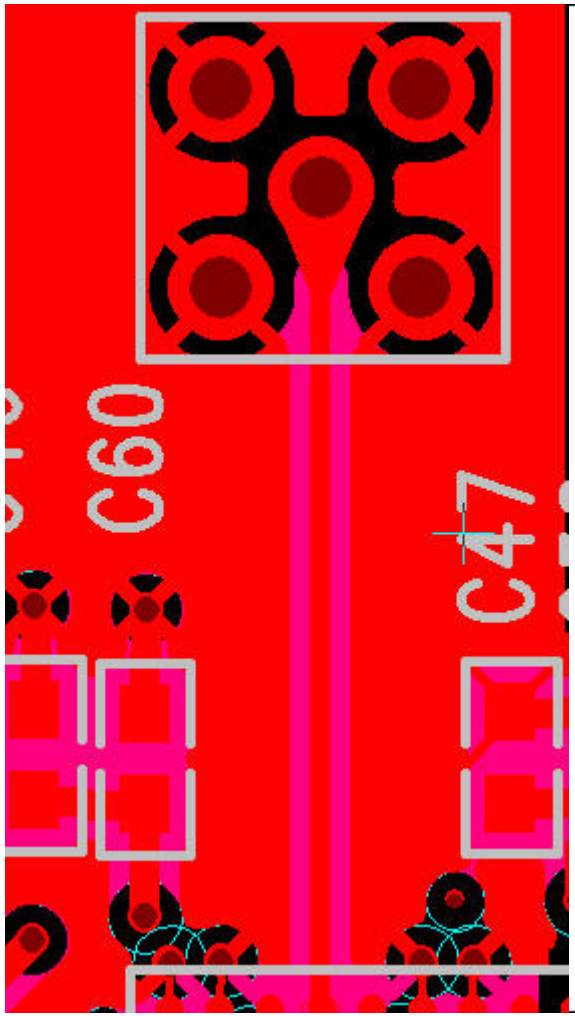
- Accurately describe the electrical characteristics of passive structures over a very wide bandwidth
  - Insertion loss and return loss of non-idea T-Line
  - Isolation of separate plane
  - Multi-coupling of signals and power nets

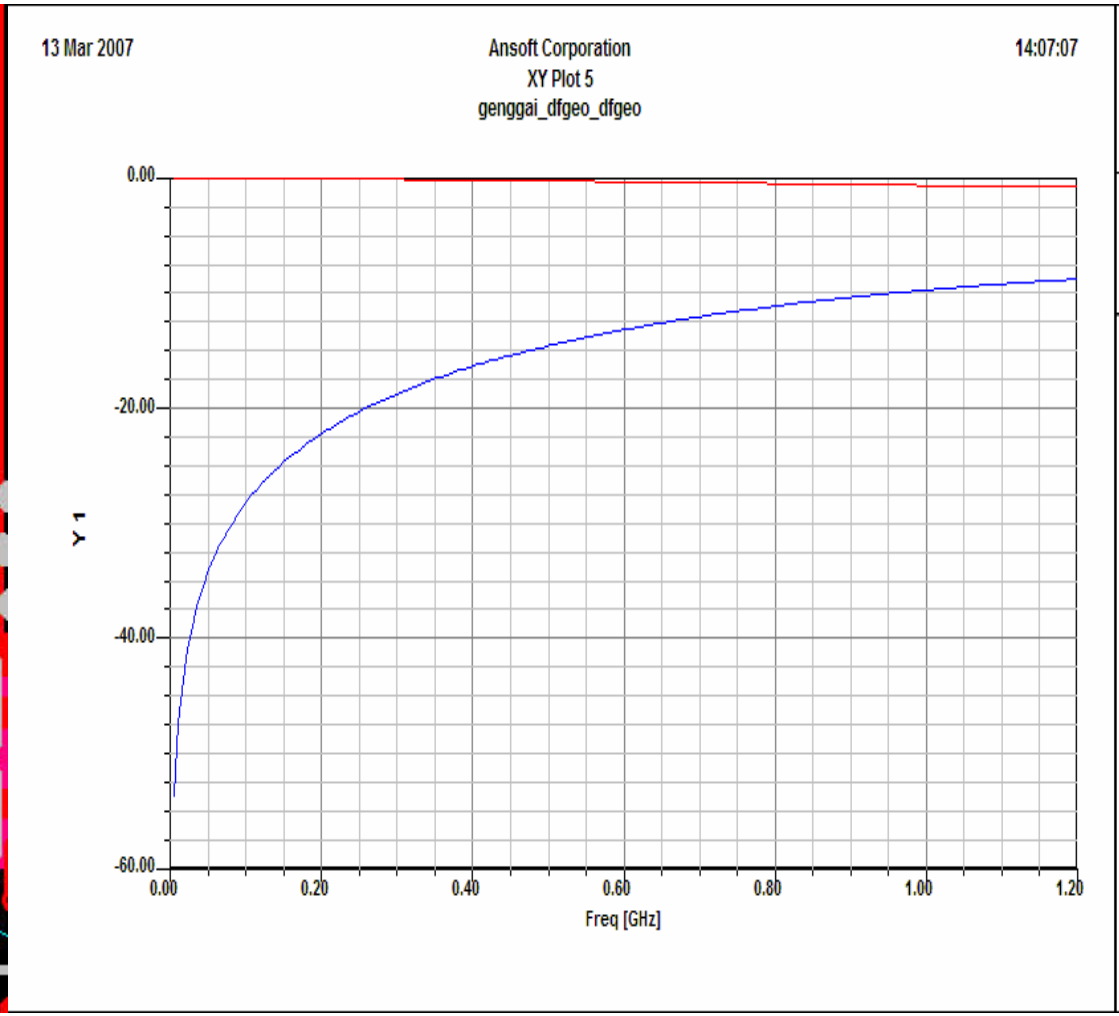
S-Parameter of Non-idea plane



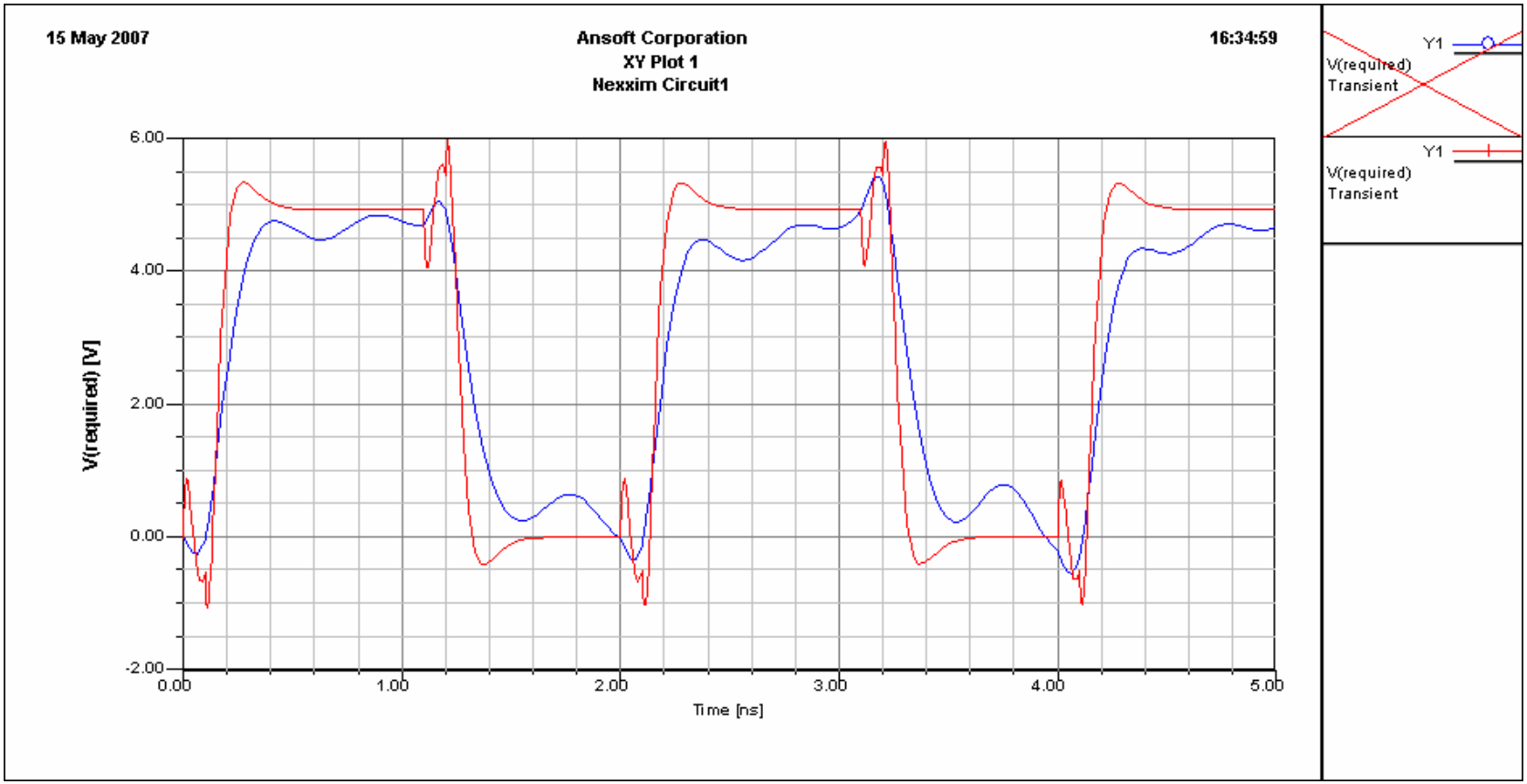


S-Parameter of idea plane





Transient analysis results

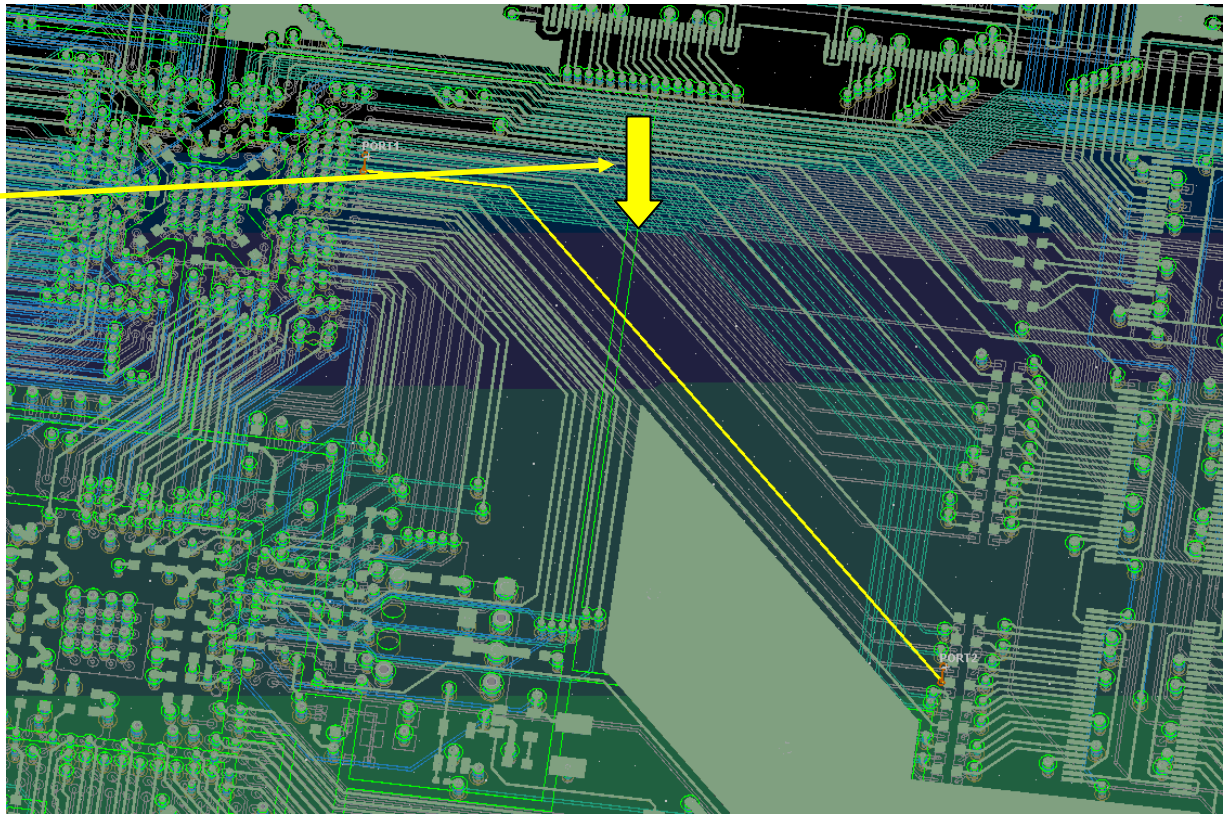


- 100ps Tr/Tf，1GHz pulse

Cross gap analysis

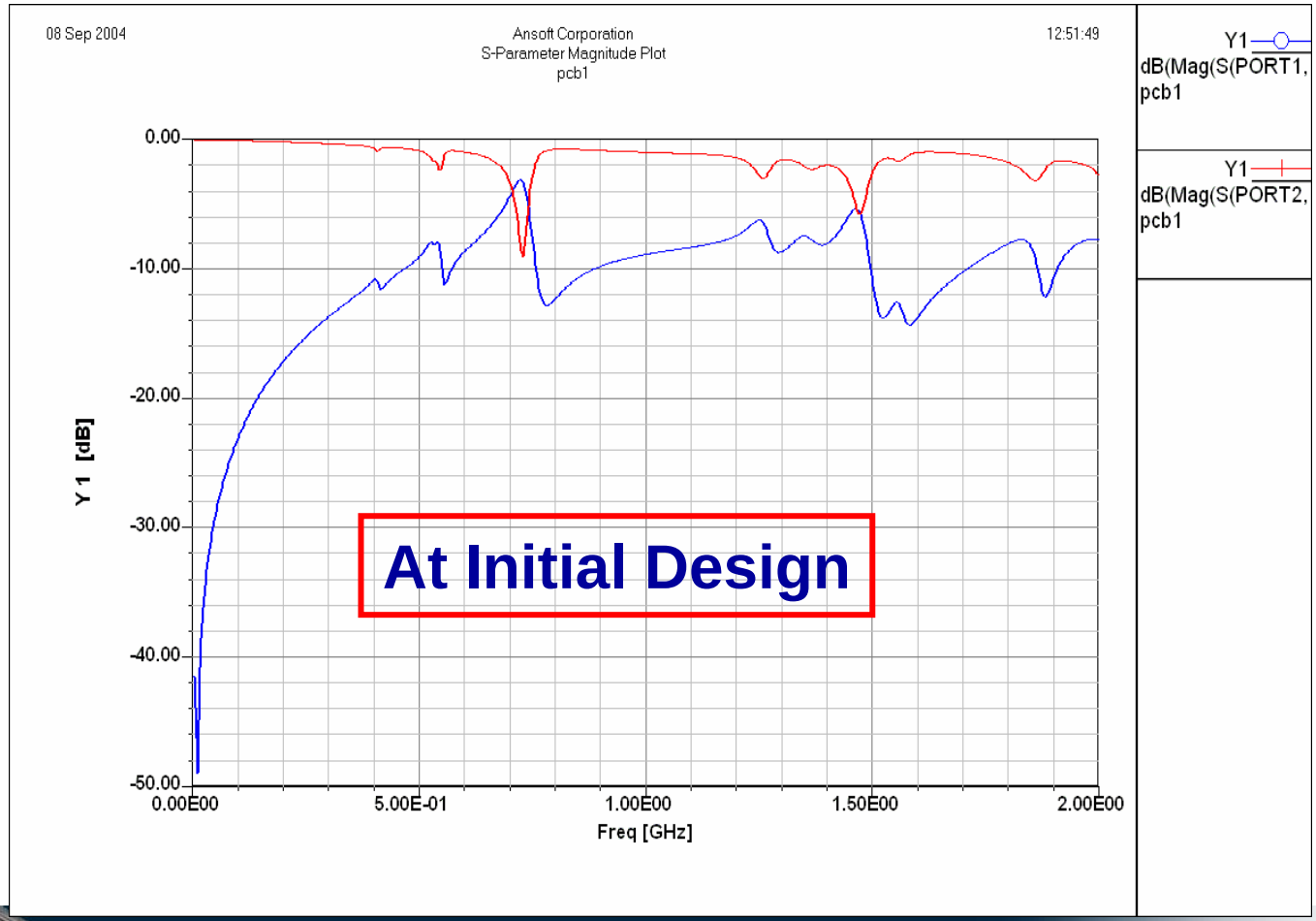
SI Investigation ---Signal Net IOA8 Cross Split Power Plane: Reference Changed

Power Plane Split Here



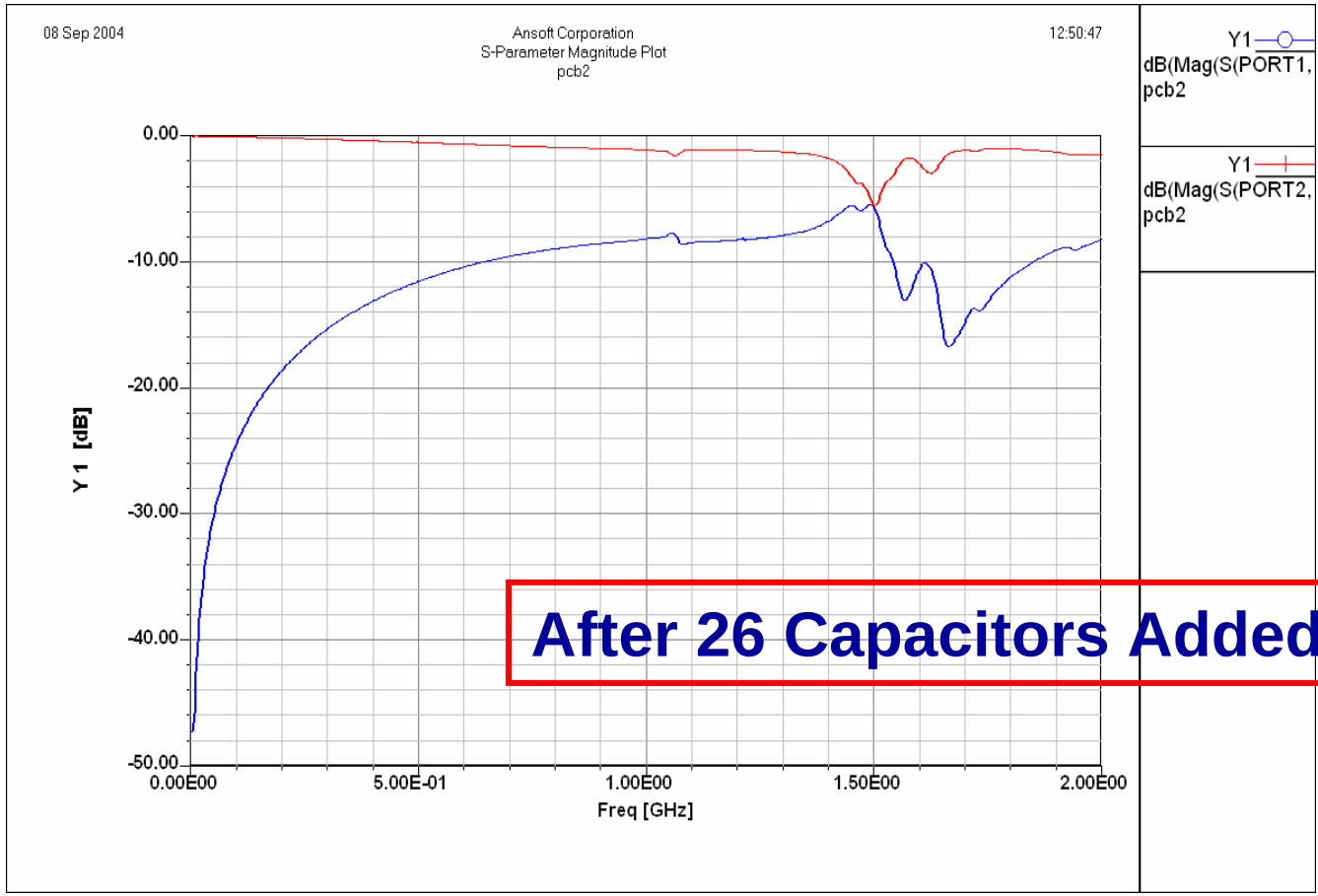
Cross gap analysis

Signal Trace Transmission / Reflection(S21 /S11)

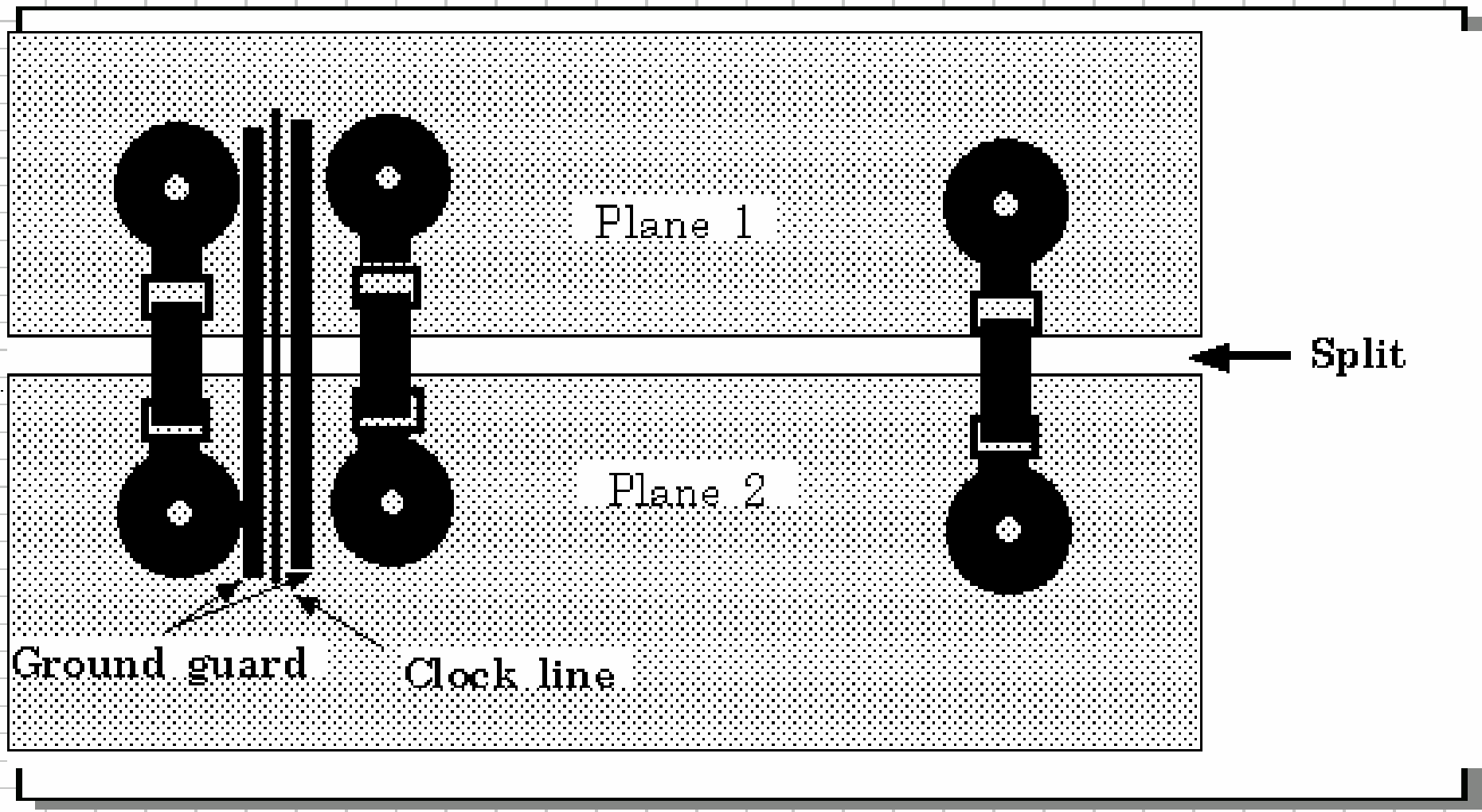


Cross gap analysis

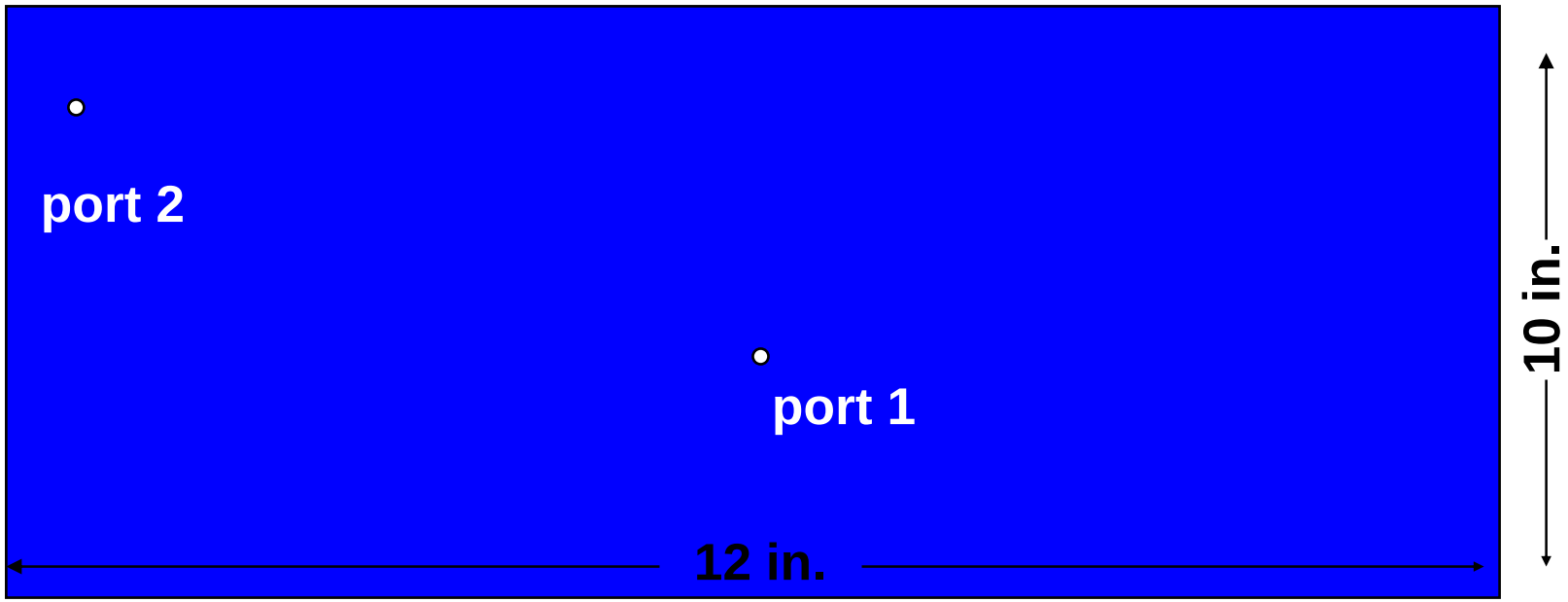
Signal Trace Transmission / Reflection(S21 /S11)



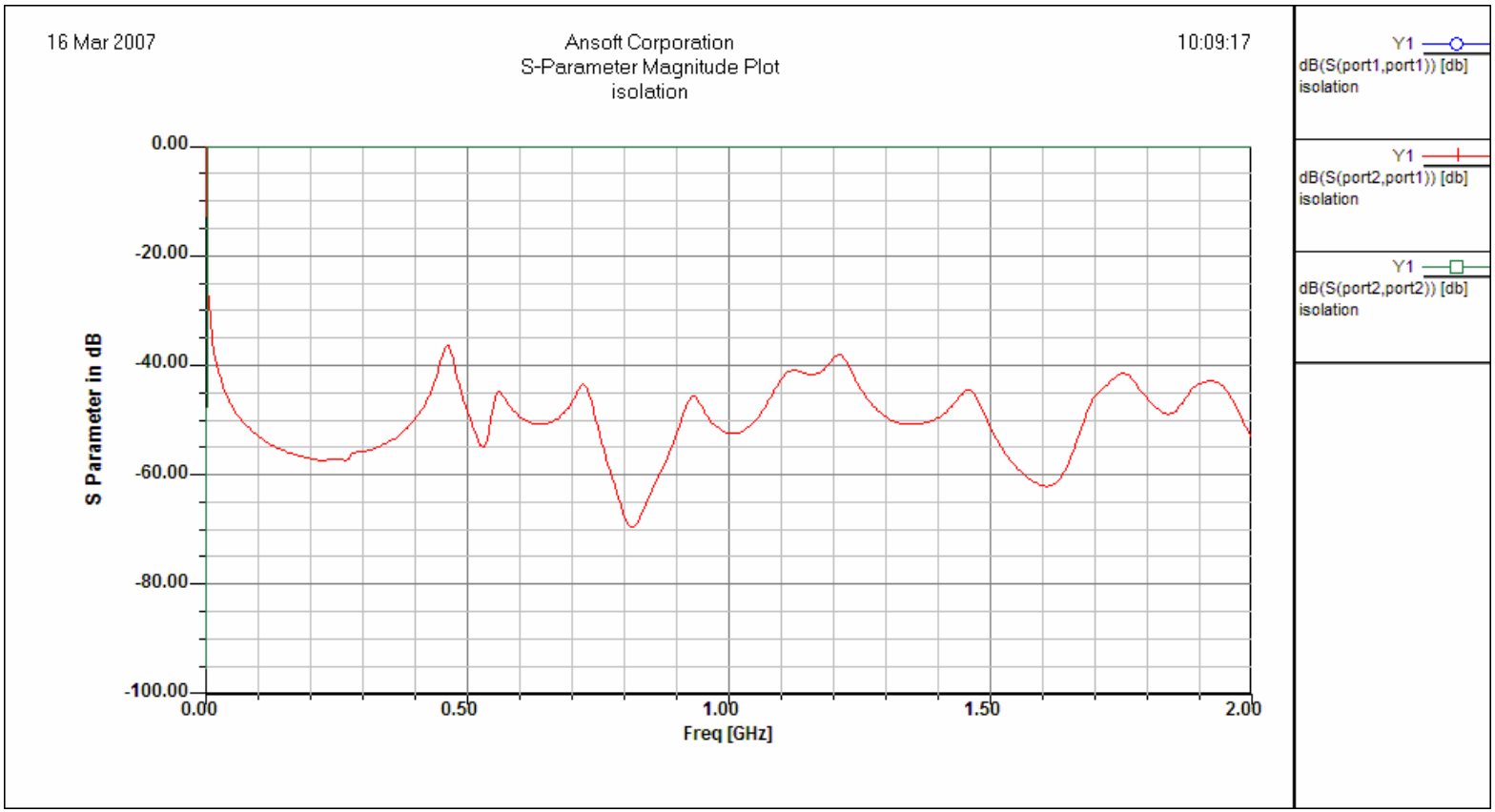
Isolation of split plane



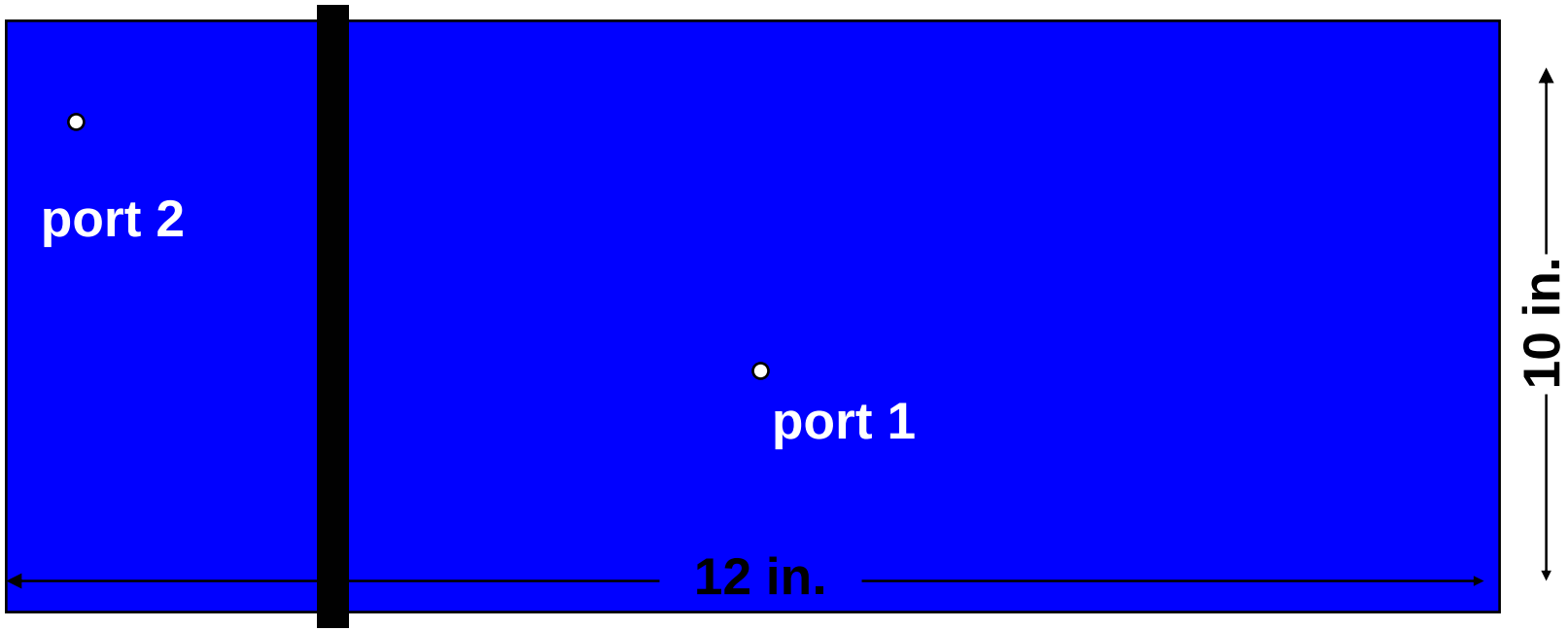
Isolation analysis



Result

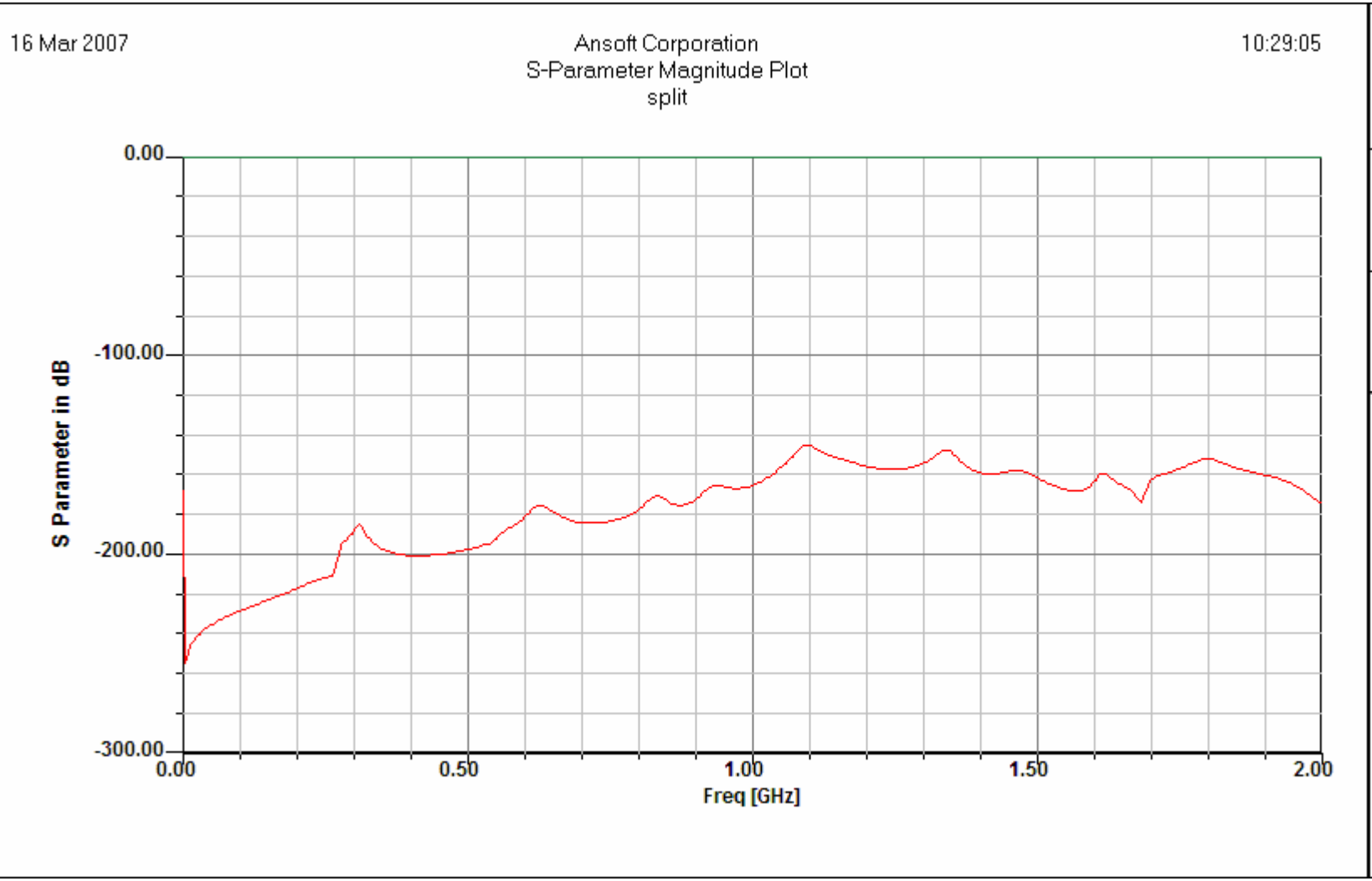

16 Mar 2007
Ansoft Corporation
S-Parameter Magnitude Plot
isolation
10:09:17
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
S Parameter in dB
0.00
0.50
1.00
1.50
2.00
Freq [GHz]
Y1
dB(S(port1,port1)) [db]
isolation
Y1
dB(S(port2,port1)) [db]
isolation
Y1
dB(S(port2,port2)) [db]
isolation

Isolation analysis

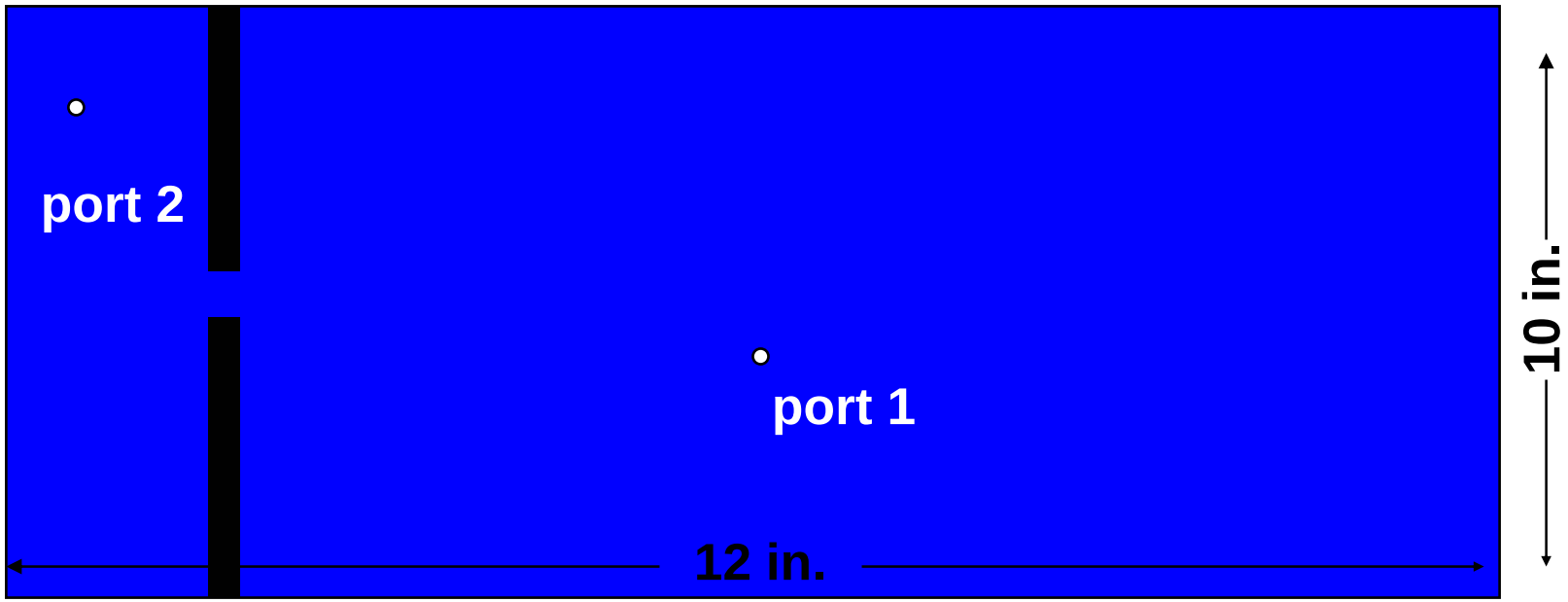


Separate

Result

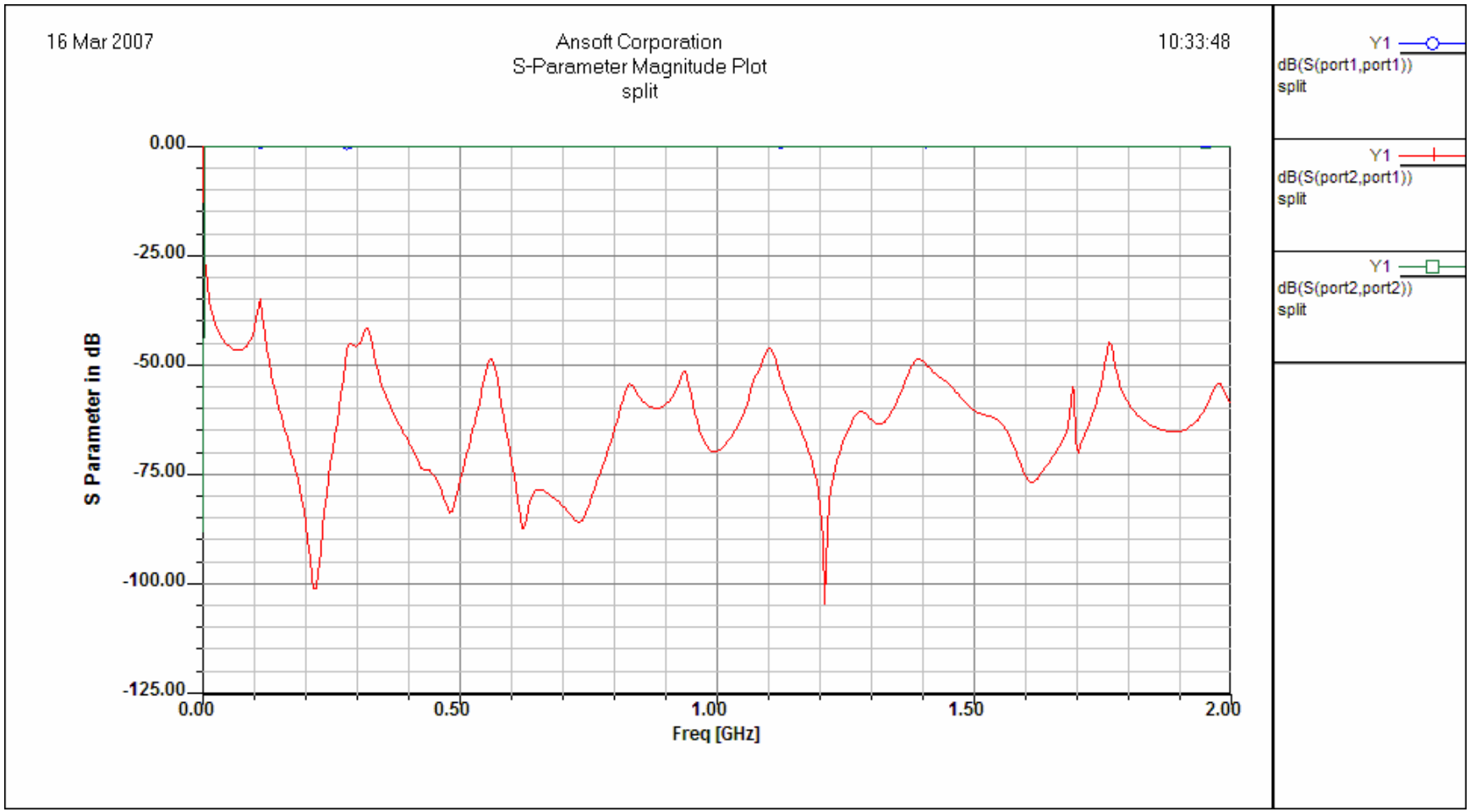

16 Mar 2007
Ansoft Corporation
S-Parameter Magnitude Plot
split
10:29:05
0.00
-100.00
-200.00
-300.00
S Parameter in dB
0.00
0.50
1.00
1.50
2.00
Freq [GHz]
Y1
dB(S(port1,port1)) [db]
split
Y1
dB(S(port2,port1)) [db]
split
Y1
dB(S(port2,port2)) [db]
split

Isolation analysis

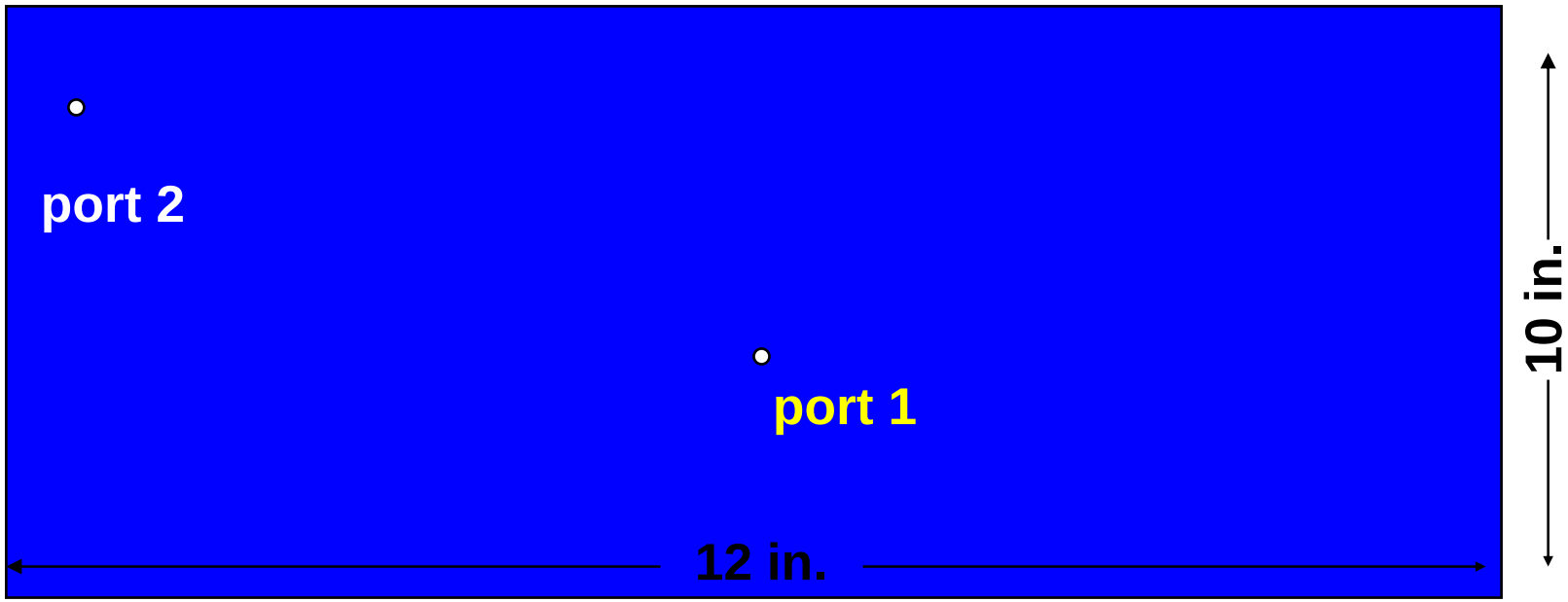


One point connect

Result

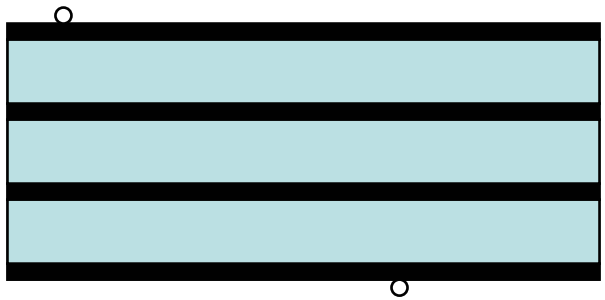

16 Mar 2007
Ansoft Corporation
S-Parameter Magnitude Plot
split
10:33:48
0.00
-25.00
-50.00
-75.00
-100.00
-125.00
S Parameter in dB
0.00
0.50
1.00
1.50
2.00
Freq [GHz]
Y1
dB(S(port1,port1))
split
Y1
dB(S(port2,port1))
split
Y1
dB(S(port2,port2))
split

Isolation analysis



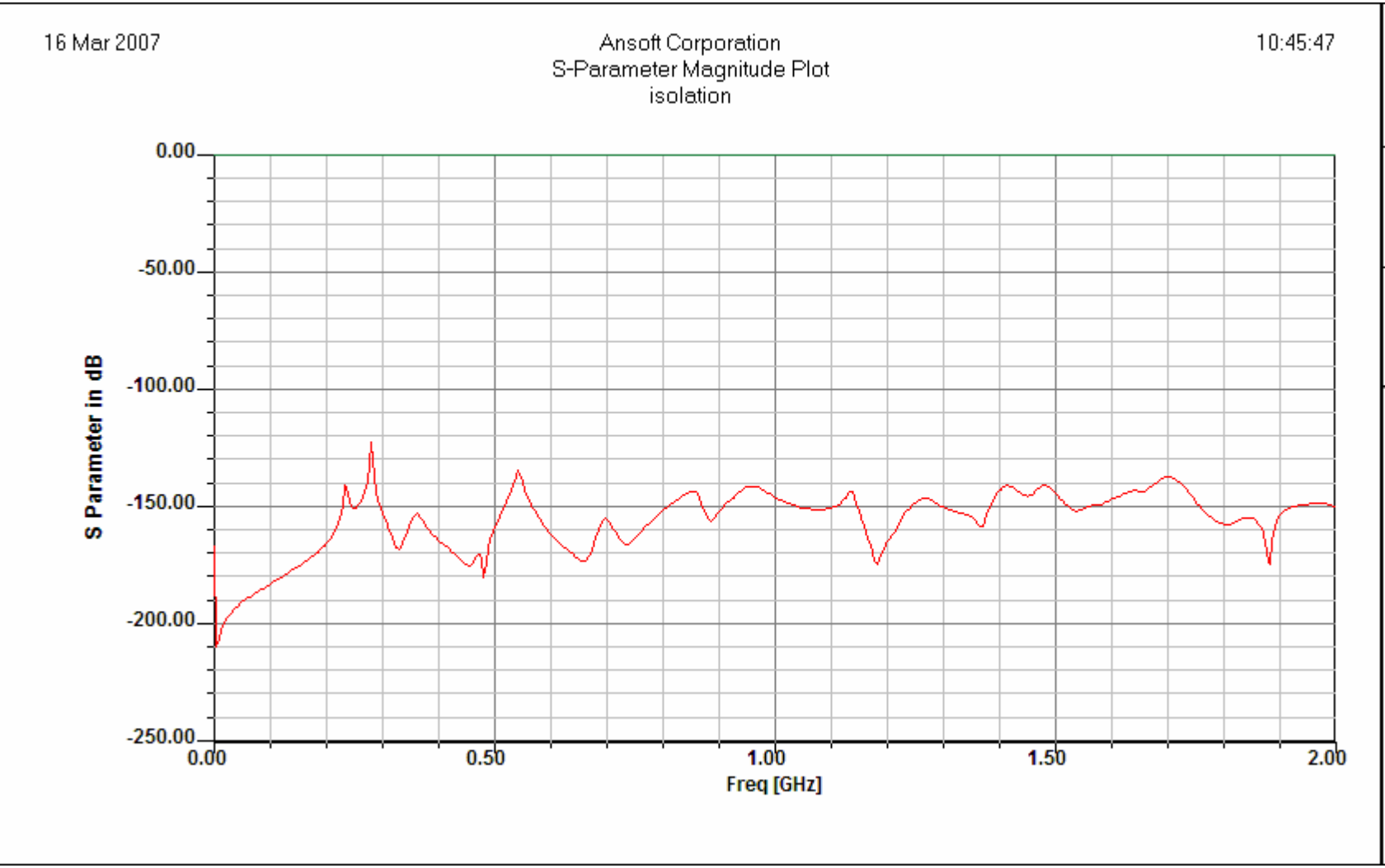
port 2

Change layer



port 1

Result


16 Mar 2007
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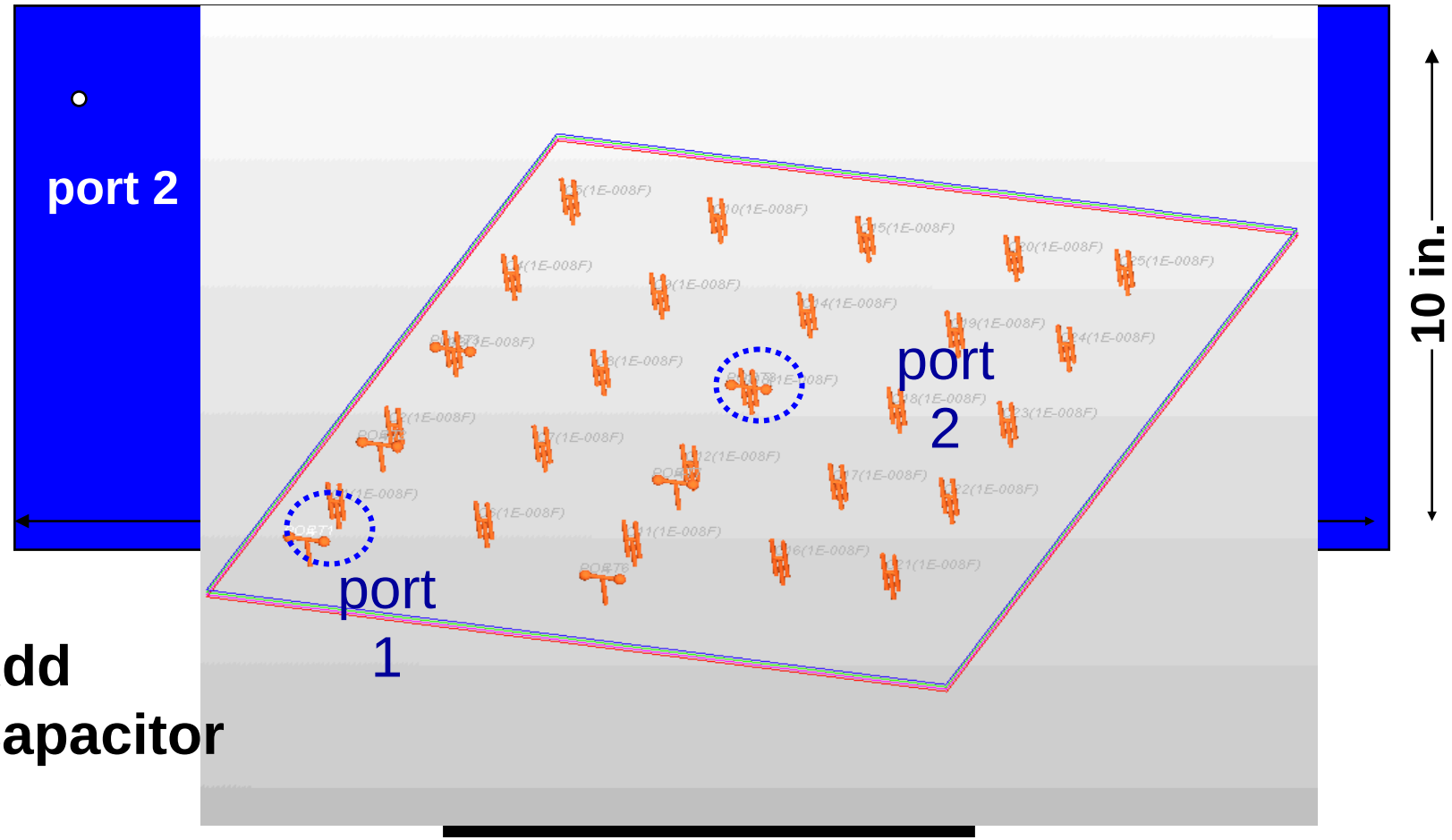
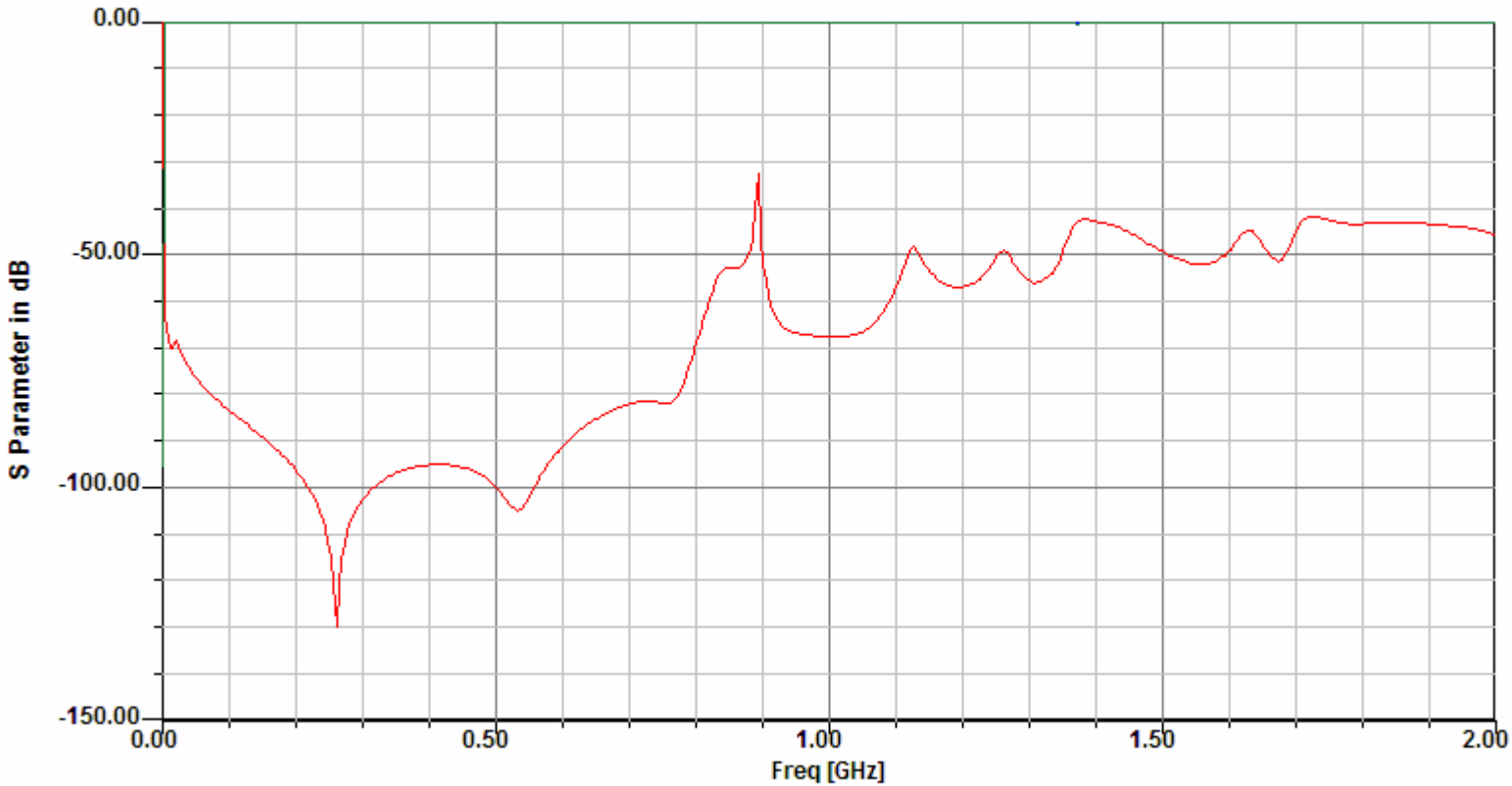
S-Parameter Magnitude Plot
isolation
10:45:47
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
S Parameter in dB
0.00
0.50
1.00
1.50
2.00
Freq [GHz]
Y1
dB(S(port1,port1))
isolation
Y1
dB(S(port2,port1))
isolation
Y1
dB(S(port2,port2))
isolation

Isolation analysis

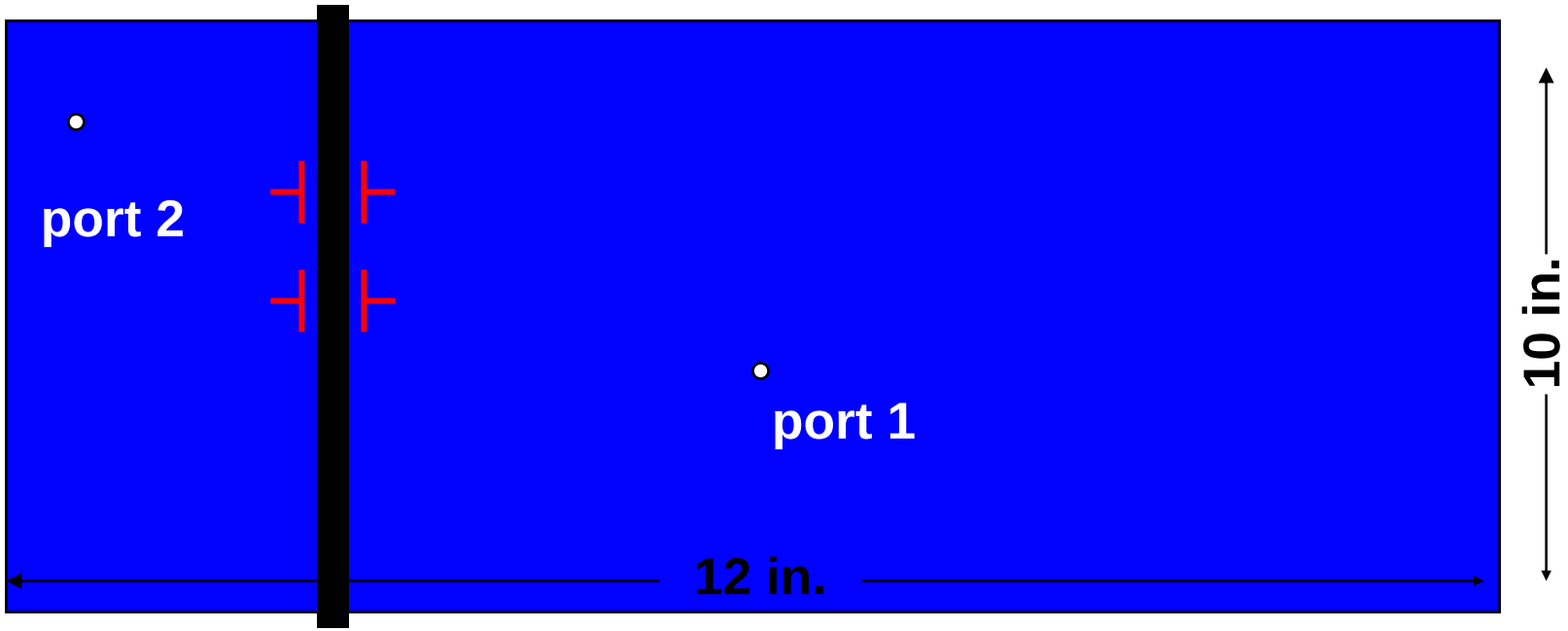


Add Capacitor

Result

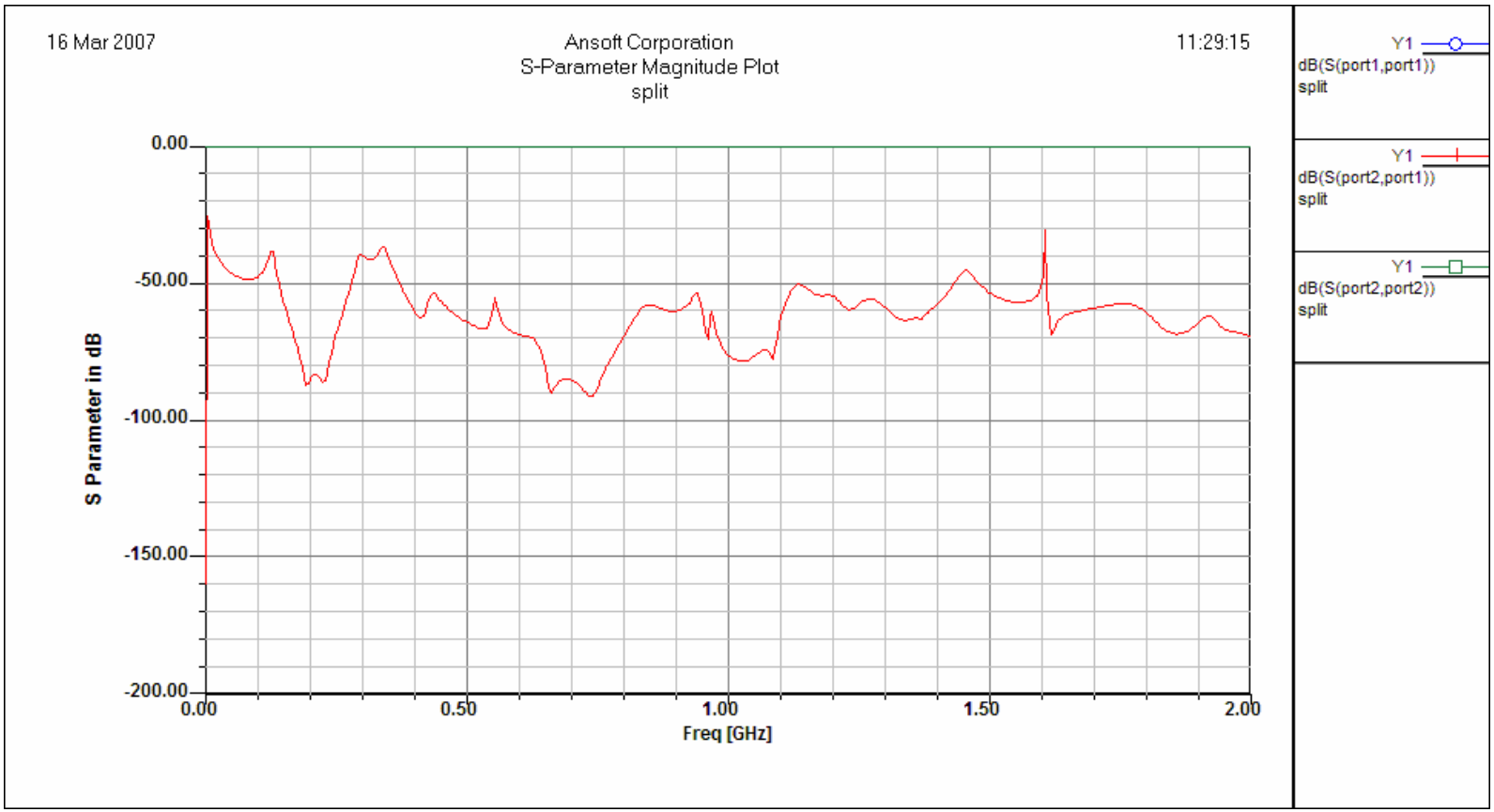

16 Mar 2007
Ansoft Corporation
S-Parameter Magnitude Plot
isolation
11:25:57
0.00
-50.00
-100.00
-150.00
S Parameter in dB
0.00
0.50
1.00
1.50
2.00
Freq [GHz]
Y1
dB(S(port1,port1))
isolation
Y1
dB(S(port2,port1))
isolation
Y1
dB(S(port2,port2))
isolation

Isolation analysis

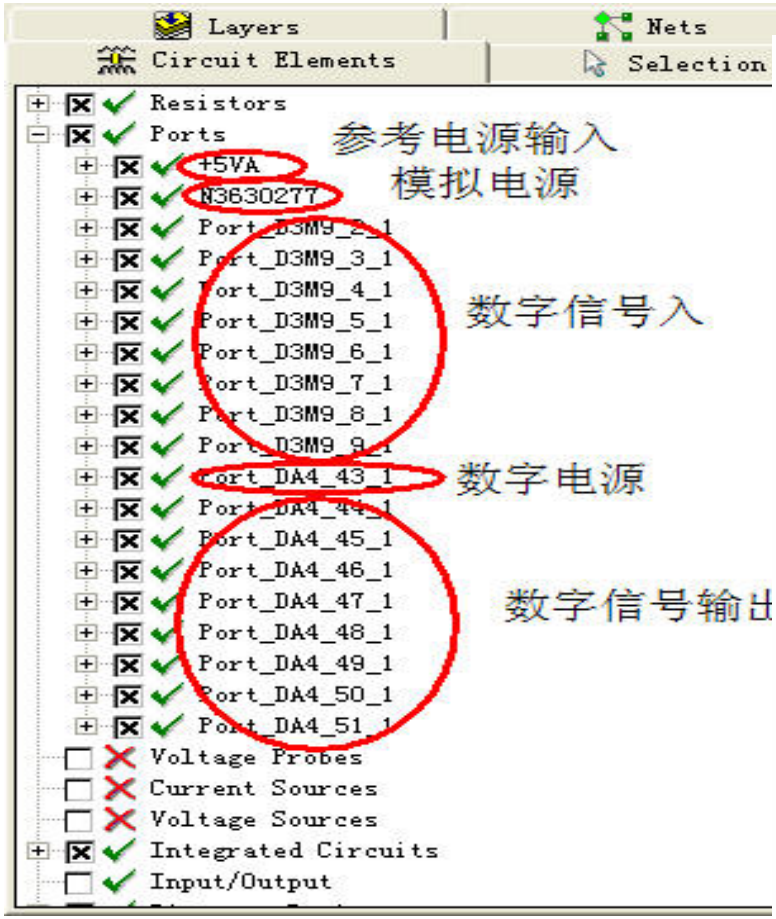


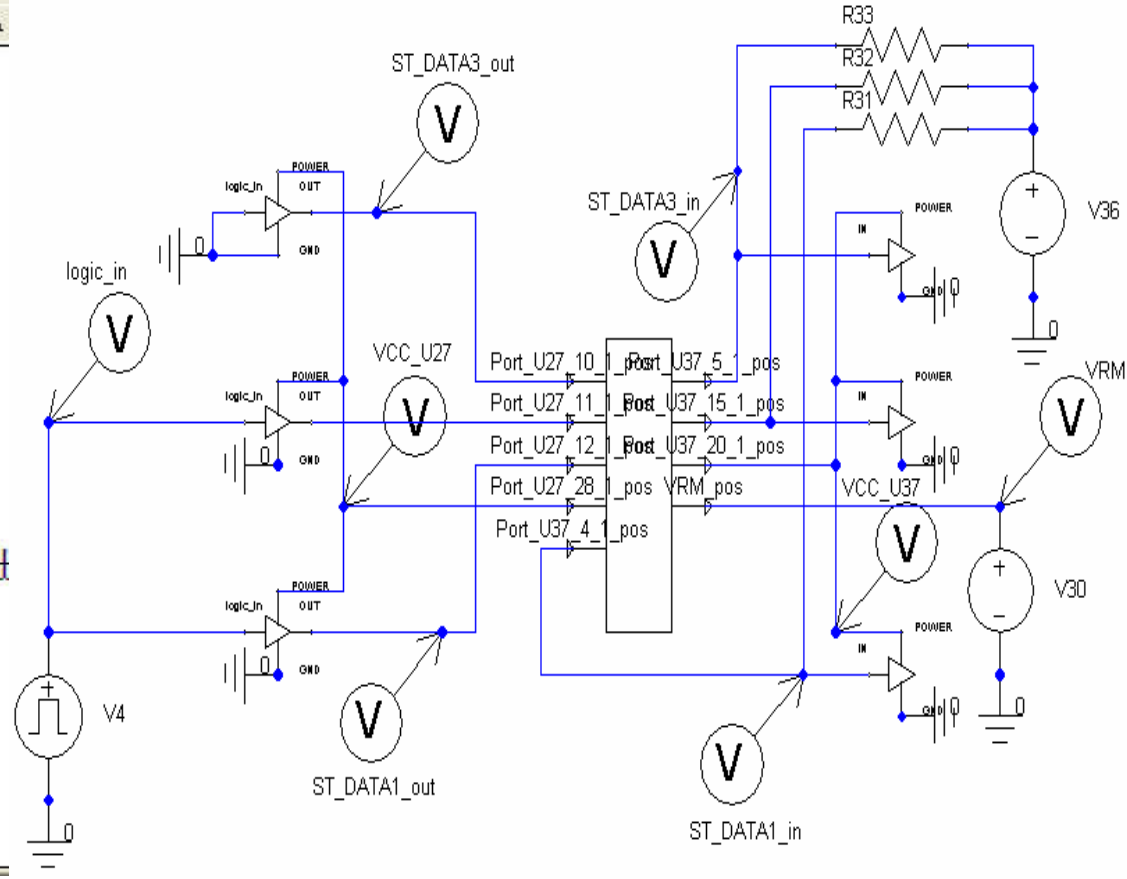
Add Xgap Capacitor

Result


16 Mar 2007
Ansoft Corporation
S-Parameter Magnitude Plot
split
11:29:15
0.00
-50.00
-100.00
-150.00
-200.00
S Parameter in dB
0.00
0.50
1.00
1.50
2.00
Freq [GHz]
Y1
dB(S(port1,port1))
split
Y1
dB(S(port2,port1))
split
Y1
dB(S(port2,port2))
split

SSO analysis using N-port S-Parameter





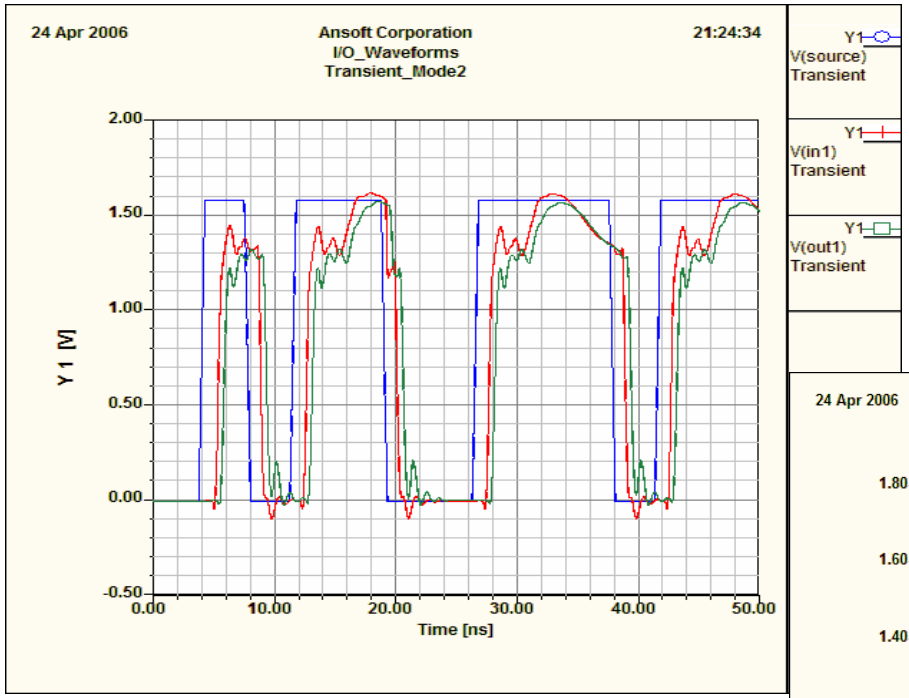
Problem in using S-Parameter for Transient analysis

- Non-convergence
  - Most Timing domain simulator using IFFT to solve the S-parameter (because it's Frequency domain)
  - Mostly happen in multi-port S-parameter(>10) or long delay
  - S-parameter Convolution
    - Do not Consider causality/passivity problems
- Non-Causal or Non-Passive
  - State-space with rational functions or Enforce Passivity option

Ensuring accuracy across simulation domains

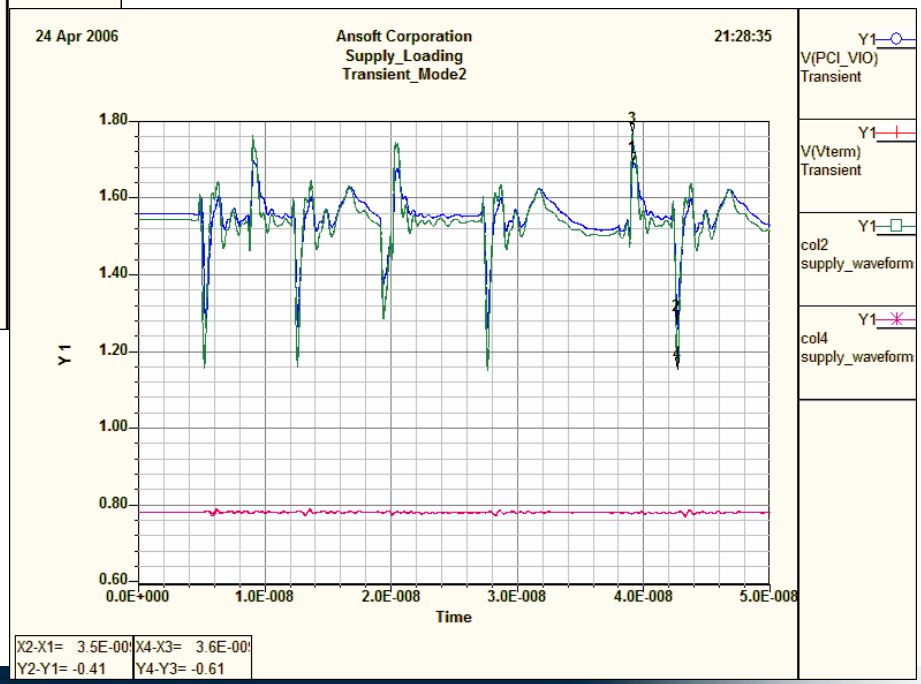
- State Space
  - Pole-residue fit to frequency-domain data
  - Only stable poles used: causal
  - Very efficient transient simulation
    - Simple first-order differential equation
  - Passivity not guaranteed
    - But can be enforced for moderate-sized problems

Transient analysis results using State Space



18 IBIS Drivers
57 Port S-parameter model

Transient simulation time: 366s



Reuse of state-space model

Run simulation for the 1st time

State-space fitting

Generation of a .sss file with the state space model details

Used in subsequent runs with unchanging S-parameter data

Save simulation time!
No need to regenerate the state space model

Conclusion

- S-Parameter Model for High Speed Interconnection
  - Wideband, Accuracy
  - Full Wave Simulation or Measurement
- Time Domain Simulation for S-Parameter Model
  - Convergence, Causal and Passive
  - State Space and Convolution