S-Parameter:

What You Can Read, What You Have to Read

Asian IBIS Summit
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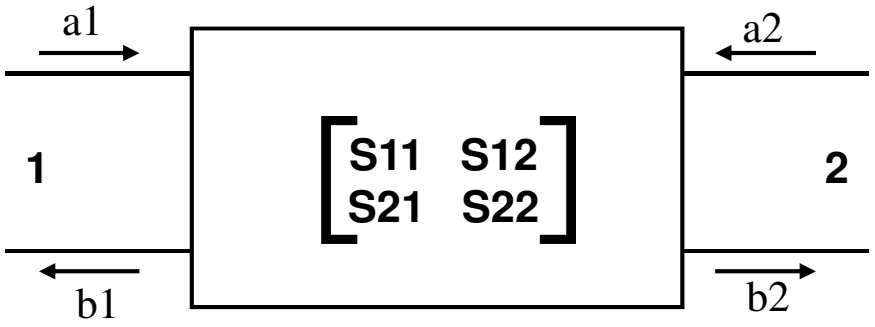
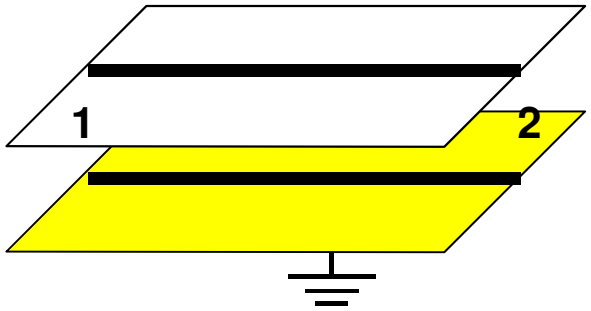
KEI Systems
Shinichi Maeda

Contents

S-Parameter

Definition





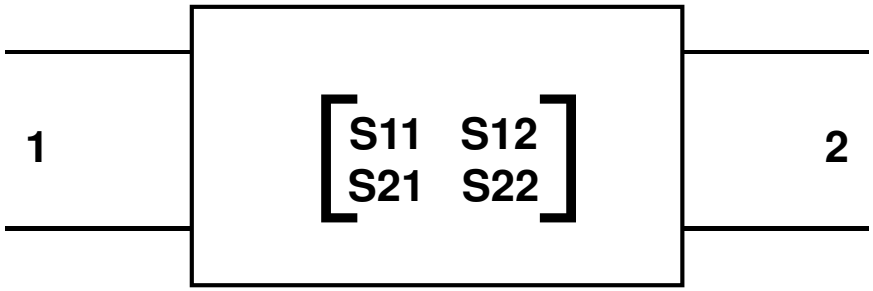
$$\begin{bmatrix} b1 \\ b2 \end{bmatrix} = \begin{bmatrix} S11 & S12 \\ S21 & S22 \end{bmatrix} \begin{bmatrix} a1 \\ a2 \end{bmatrix}$$

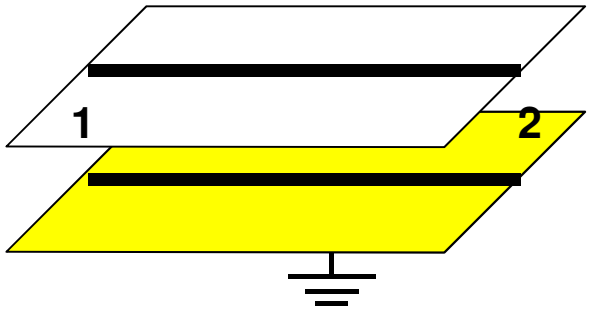
$b1 = S11\ a1 + S12\ a2$

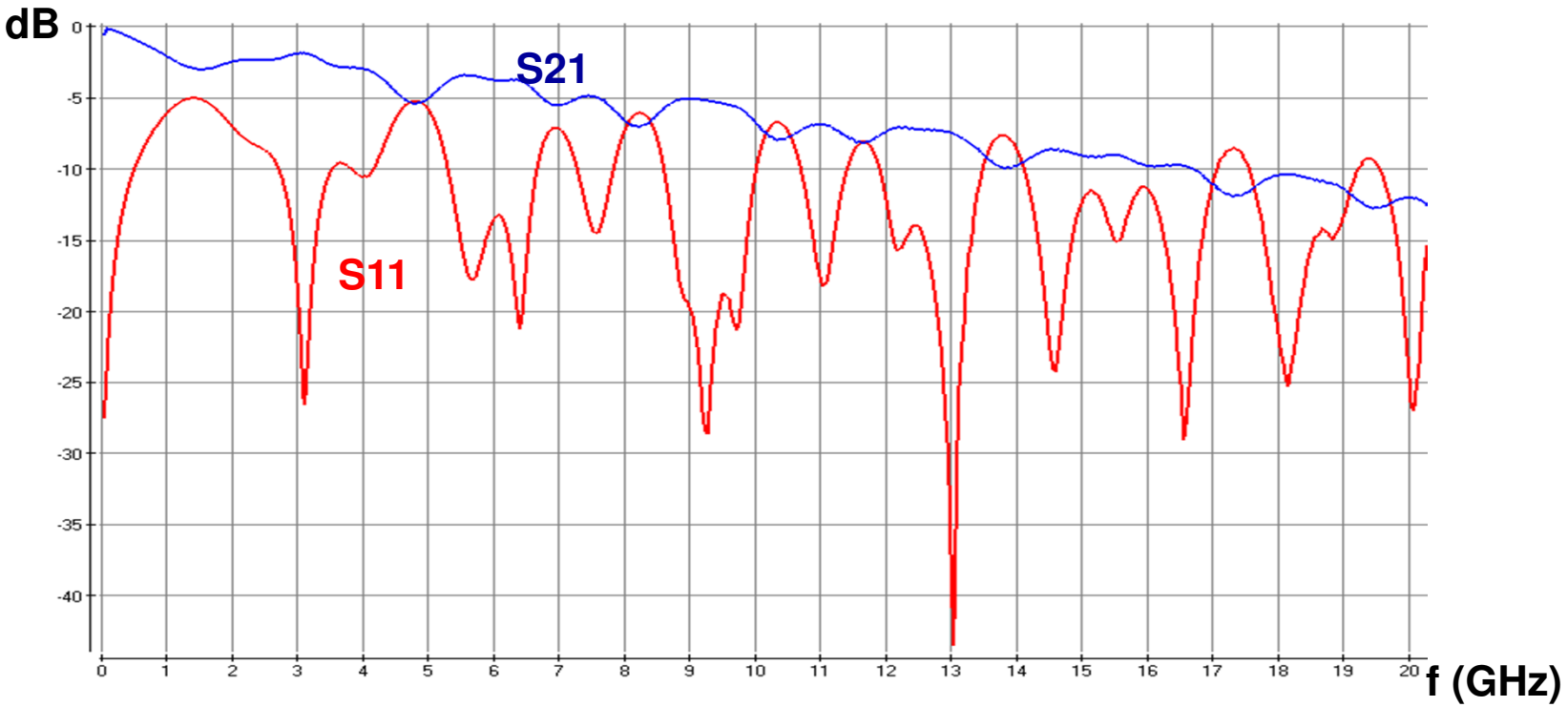
$b2 = S21\ a1 + S22\ a2$

S-Parameter

f-Gain S11, S21

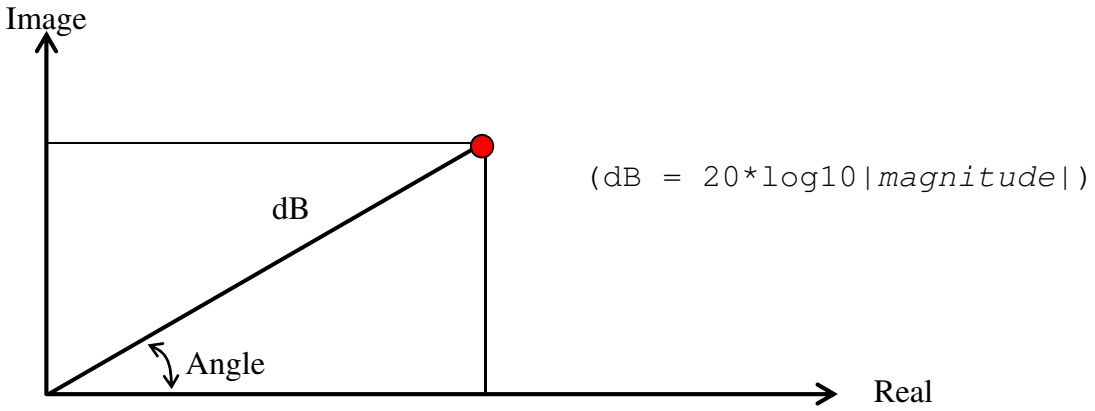






Touchstone Format

S-Parameter has not only Gain but also Phase Information



#Hz S RI R 50

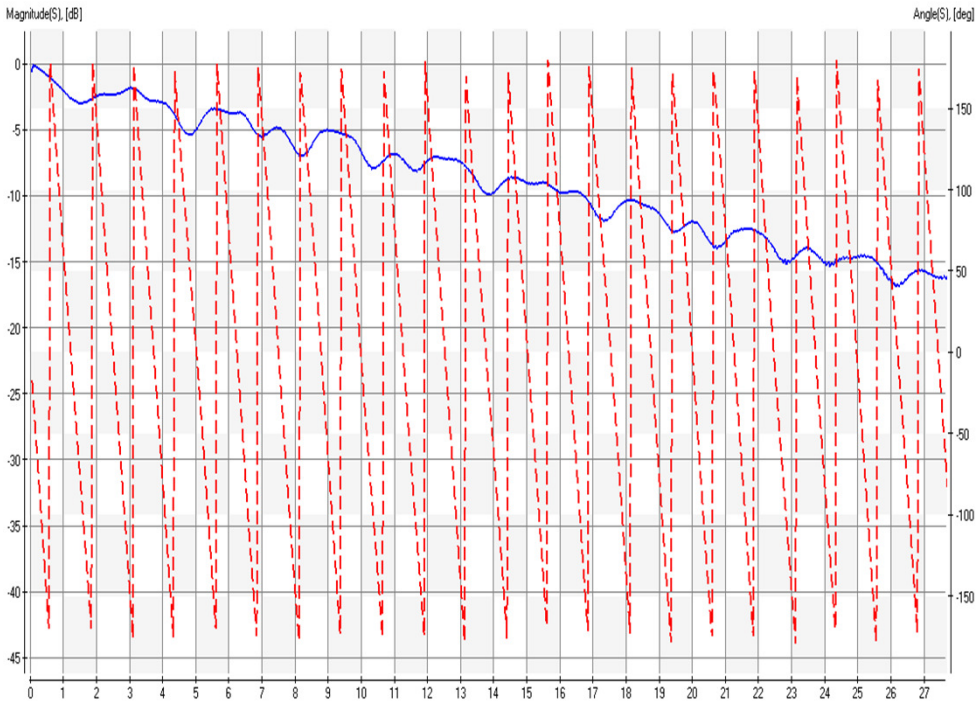
!Freq.(Hz)	S 11(Real)	S 11(Image)	S 21(Real)	S 21(Image)	S 12(Real)	S 12(Image)	S 22(Real)	S 22(Image)
100	0.9963976	-0.0592837	0.0036024	0.0592837	0.0036024	0.0592837	0.9963976	-0.0592837
105	0.9960653	-0.0619751	0.0039347	0.0619751	0.0039347	0.0619751	0.9960653	-0.0619751
109	0.9957023	-0.0647868	0.0042977	0.0647868	0.0042977	0.0647868	0.9957023	-0.0647868
114	0.9953058	-0.0677237	0.0046942	0.0677237	0.0046942	0.0677237	0.9953058	-0.0677237

Hz S dB R 50

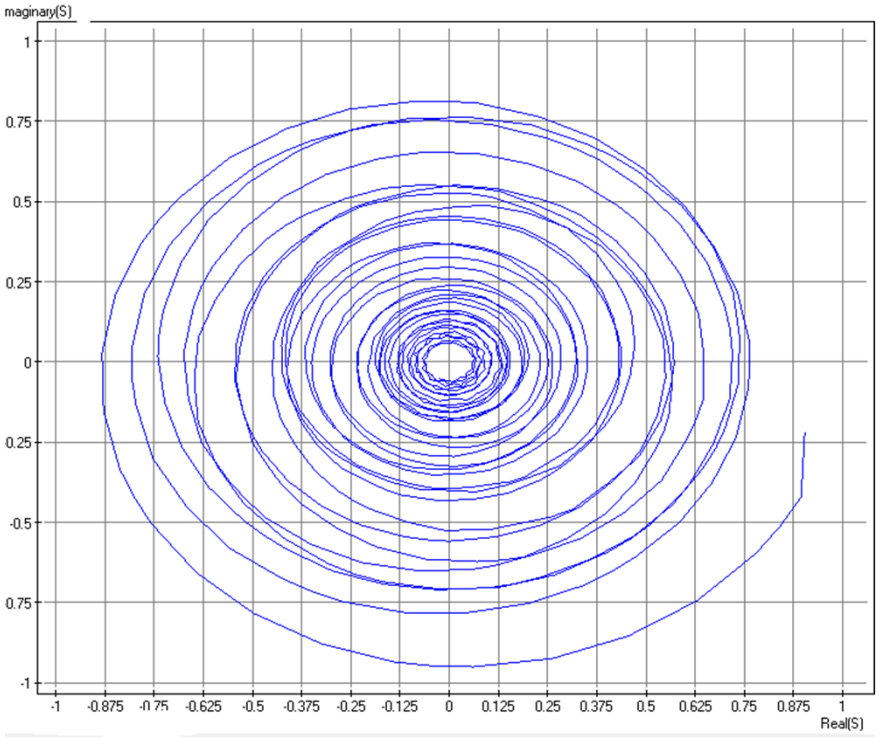
!Freq.(Hz)	S 11(dB)	S 11(Angle)	S 21(dB)	S 21(Angle)	S 12(dB)	S 12(Angle)	S 22(dB)	S 22(Angle)
0	-47.086	0	-0.030729	0	0.0030349	0	-45.89	0
20000000	-42.074	33.99	-0.036255	-2.4168	-0.0040052	-2.4173	-40.855	36.75
40000000	-37.675	27.089	-0.050993	-4.7962	-0.021603	-4.7816	-36.52	32.053
60000000	-35.21	11.904	-0.070329	-7.117	-0.042006	-7.0758	-34.168	18.639
80000000	-33.905	-4.606	-0.089164	-9.3816	-0.059283	-9.3243	-32.984	3.3062

Phase

Show both Gain and Phase



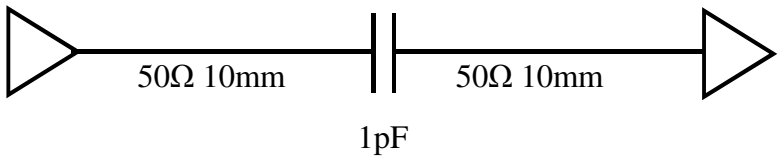
dB/Angle

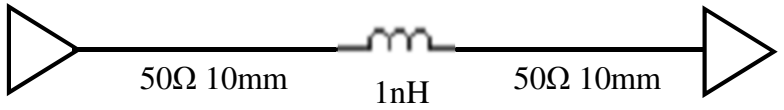


Real/Imaginary

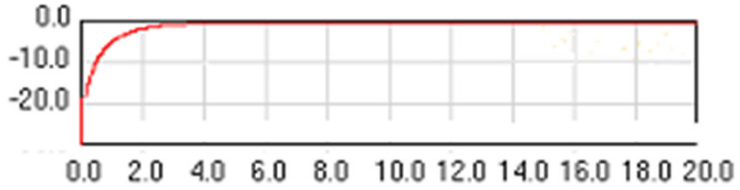
Phase Information (Sample 1)

C/L Insertion Loss / Phase: Start Value / Cycle

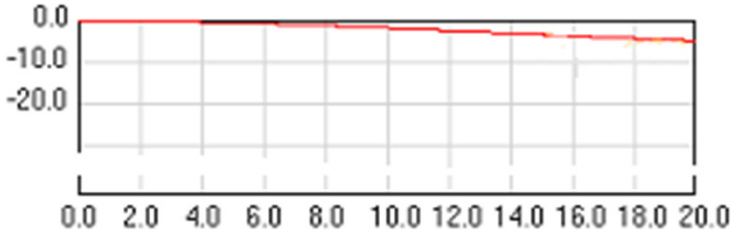




Gain (dB)

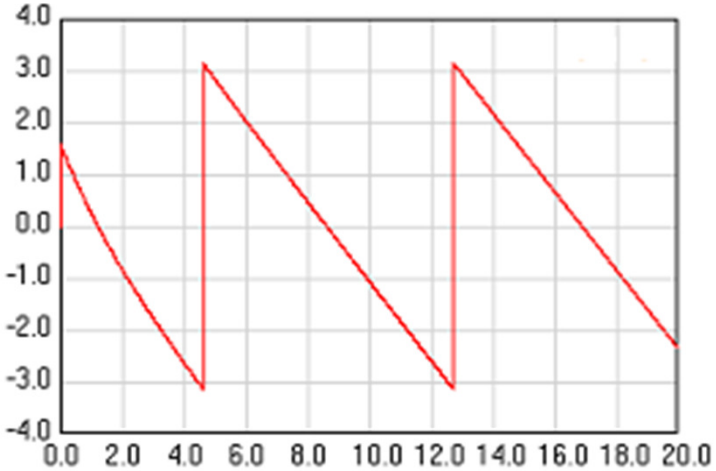


f (GHz)

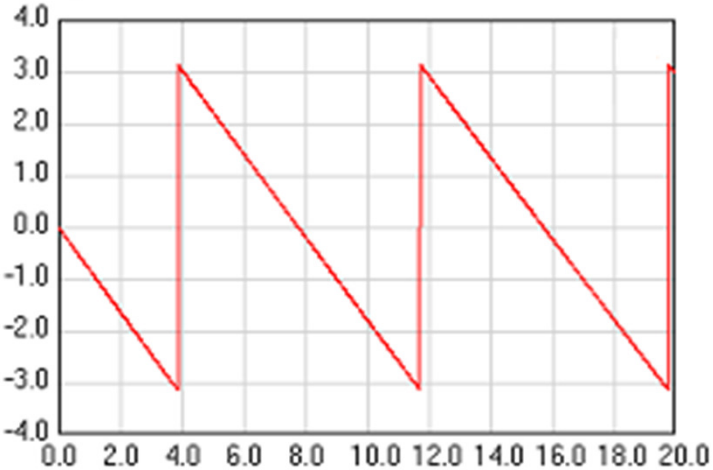


f (GHz)

Phase (rad)



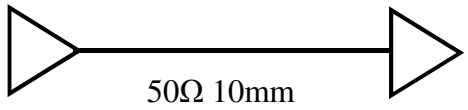
f (GHz)

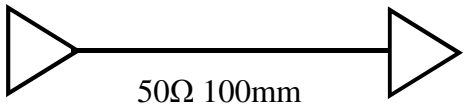


f (GHz)

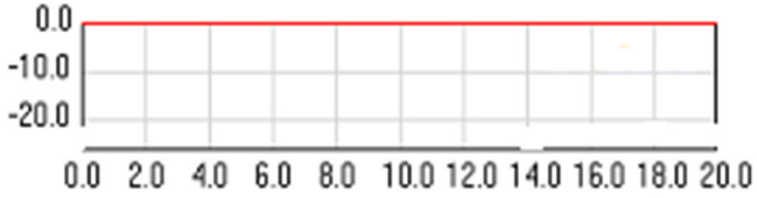
Phase Information (Sample 2)

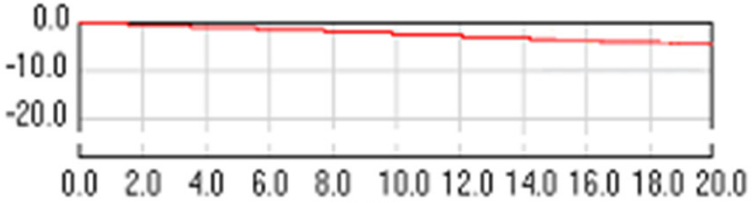
- Line Length Insertion Loss / Phase: Start Value / Cycle



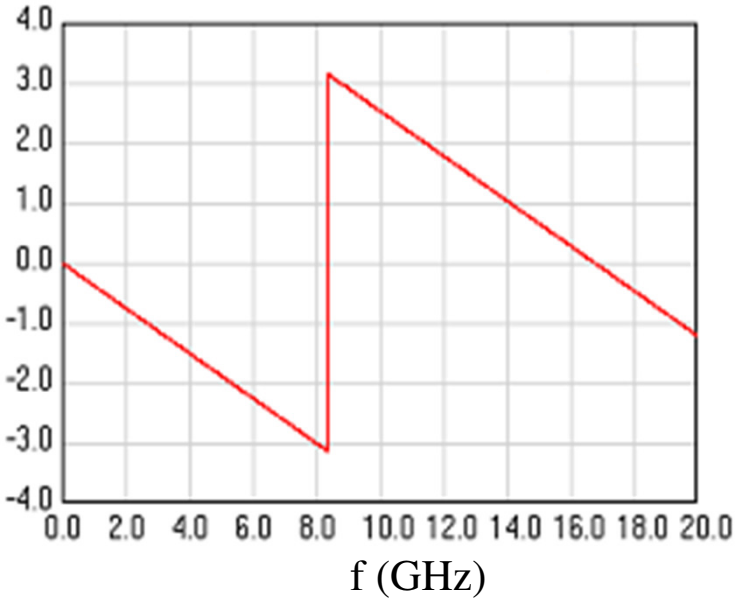


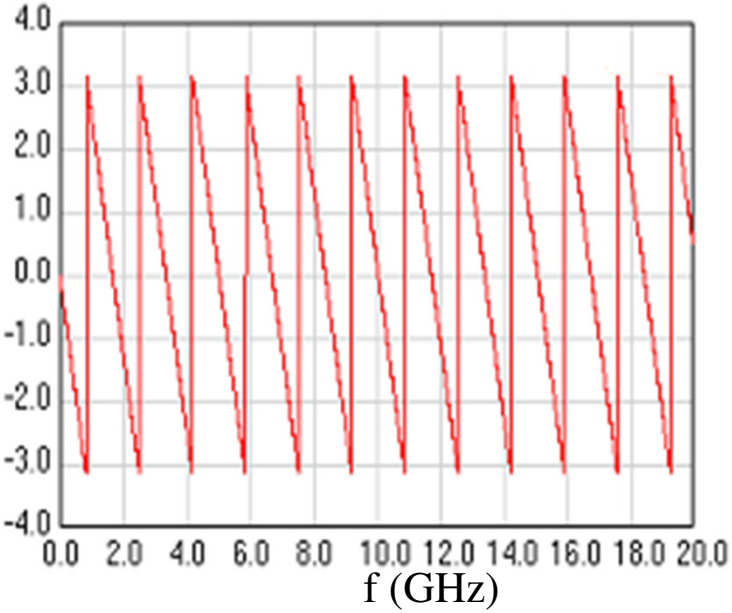
Gain (dB)





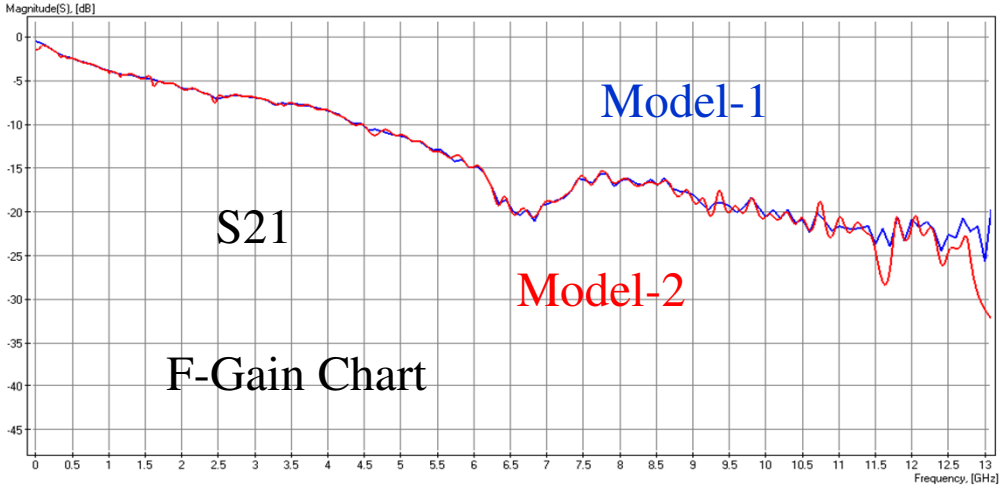
Phase (rad)

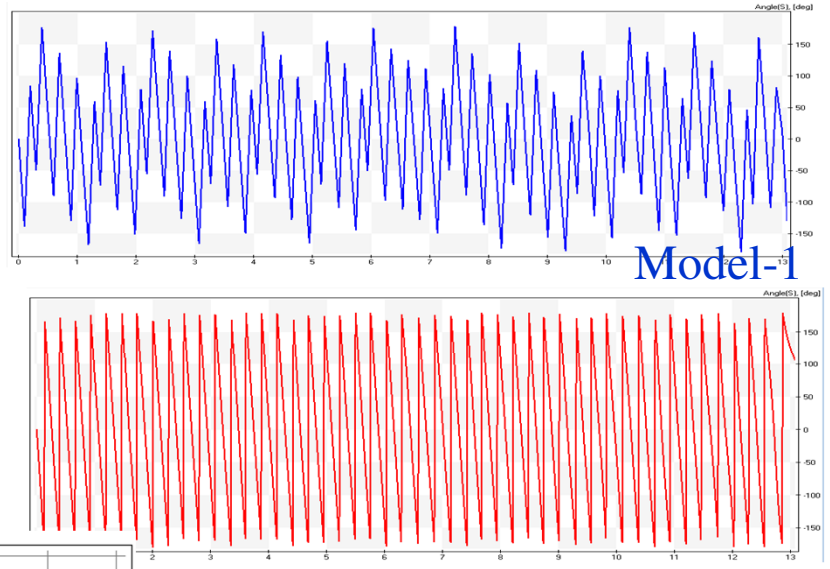


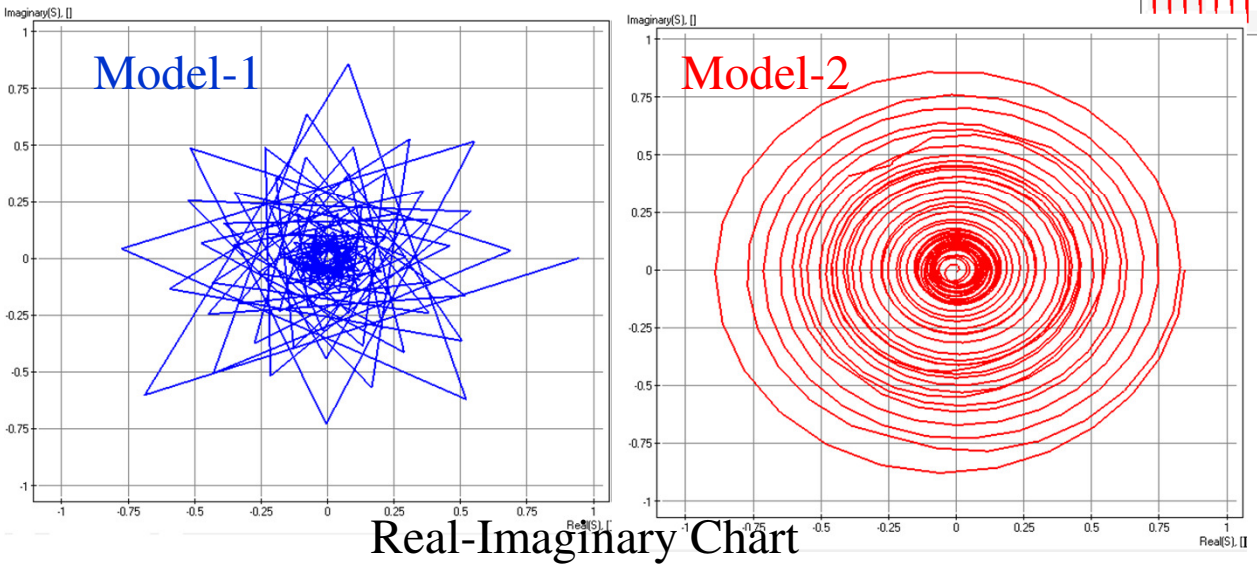


Why Phase ?

- Same Gain/Different Phase Data



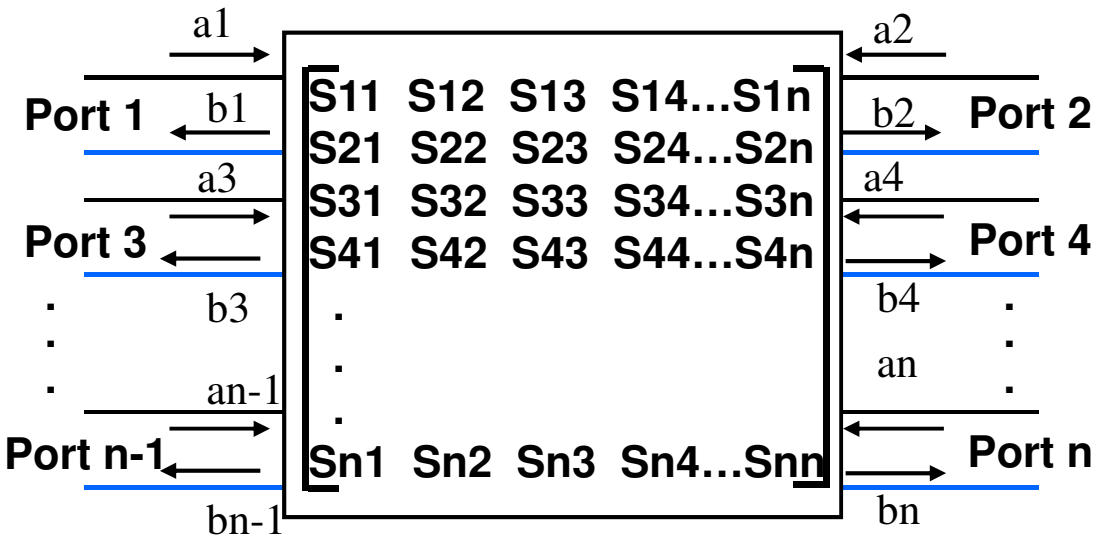




Real-Imaginary Chart

Multi-Port S-Parameter

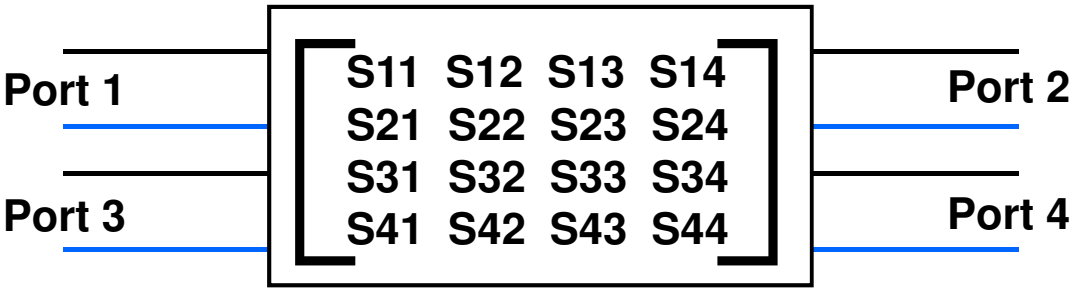
- Not only 2-Port but also n-Port

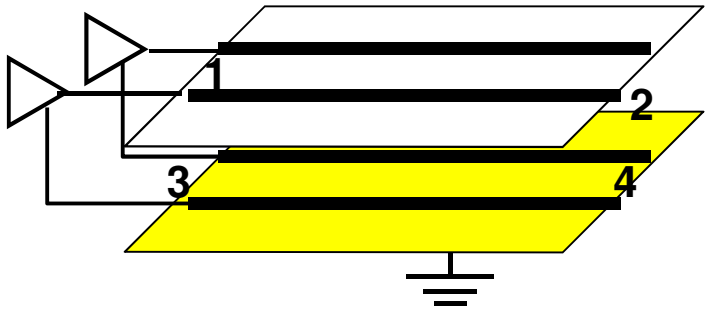


$$\begin{bmatrix} b1 \\ b2 \\ b3 \\ b4 \\ . \\ . \\ bn \end{bmatrix} = \begin{bmatrix} S11 & S12 & S13 & S14 & . & . & S1n \\ S21 & S22 & S23 & S23 & . & . & S2n \\ S31 & S32 & S33 & S34 & . & . & S3n \\ S41 & S42 & S43 & S44 & . & . & S4n \\ & & & & . & . & \\ & & & & . & . & \\ Sn1 & Sn2 & Sn3 & Sn4 & . & . & Snn \end{bmatrix} \begin{bmatrix} a1 \\ a2 \\ a3 \\ a4 \\ \\ \\ an \end{bmatrix}$$

Example: 4 Port (Two Single Lines)

- Two Single Ended Lines



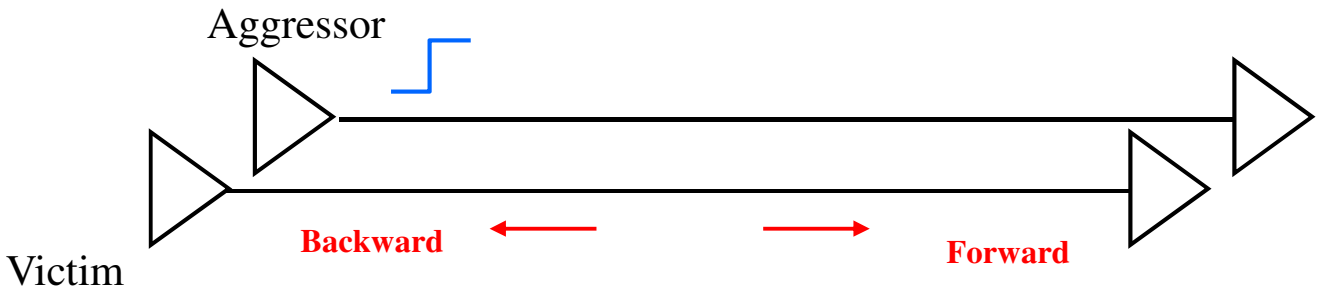


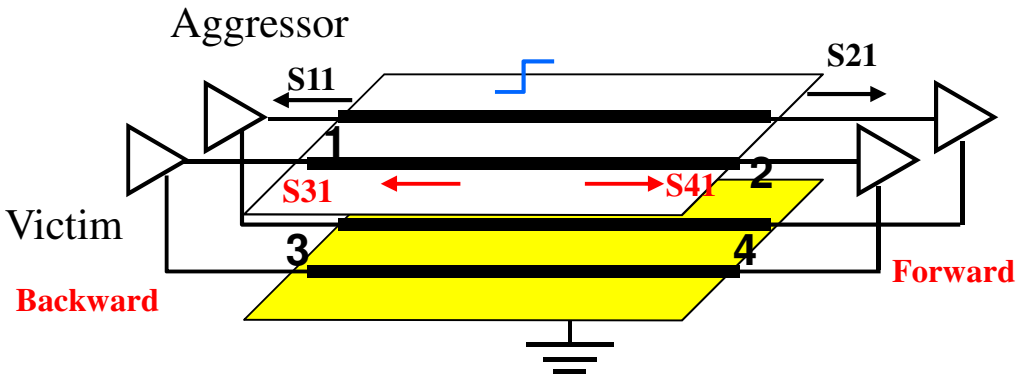
$$\begin{bmatrix} b1 \\ b2 \\ b3 \\ b4 \end{bmatrix} = \begin{bmatrix} S11 & S12 & S13 & S14 \\ S21 & S22 & S23 & S23 \\ S31 & S32 & S33 & S34 \\ S41 & S42 & S43 & S44 \end{bmatrix} \begin{bmatrix} a1 \\ a2 \\ a3 \\ a4 \end{bmatrix}$$

$$b1 = S11\ a1 + S12\ a2 + S13\ a3 + S14\ a4$$
$$b2 = S21\ a1 + S22\ a2 + S23\ a3 + S24\ a4$$
$$b3 = S31\ a1 + S32\ a2 + S33\ a3 + S34\ a4$$
$$b4 = S41\ a1 + S42\ a2 + S43\ a3 + S44\ a4$$

Cross-talk Definition

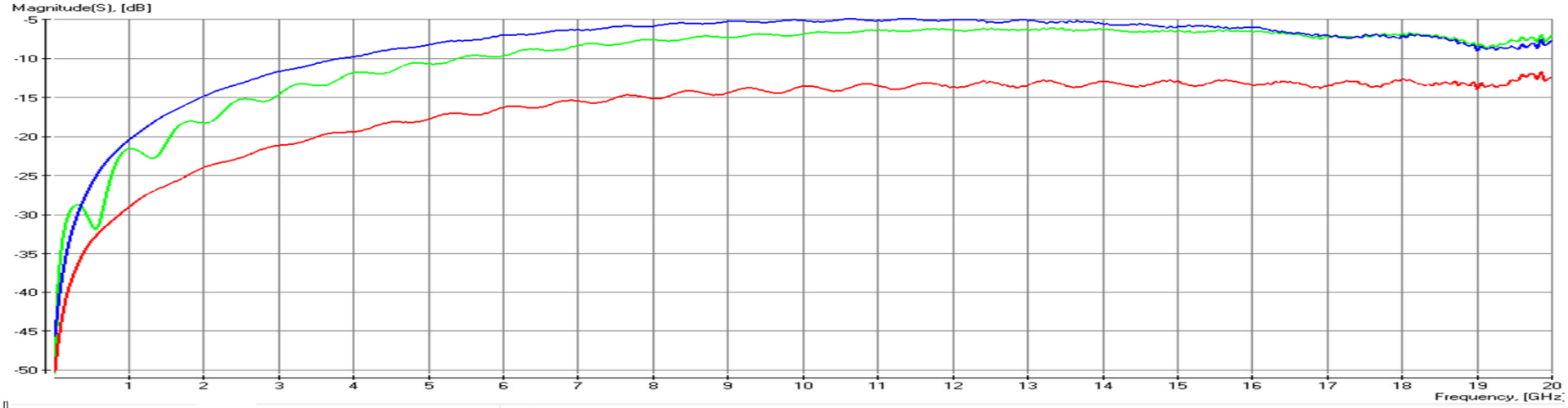
- Cross-talk: Forward / Backward

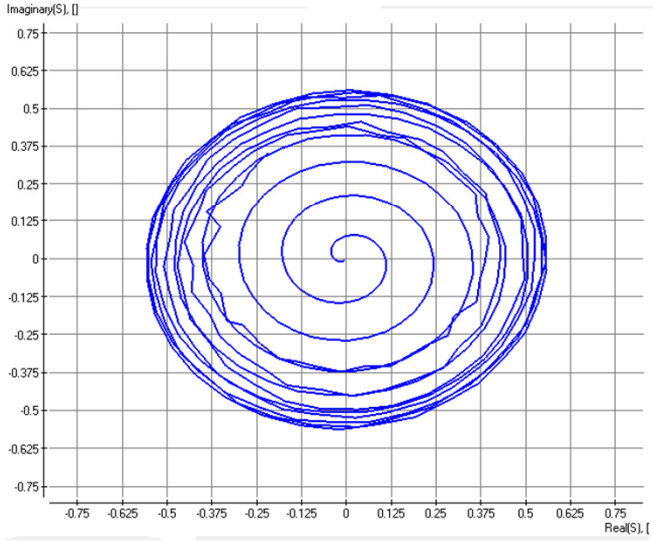




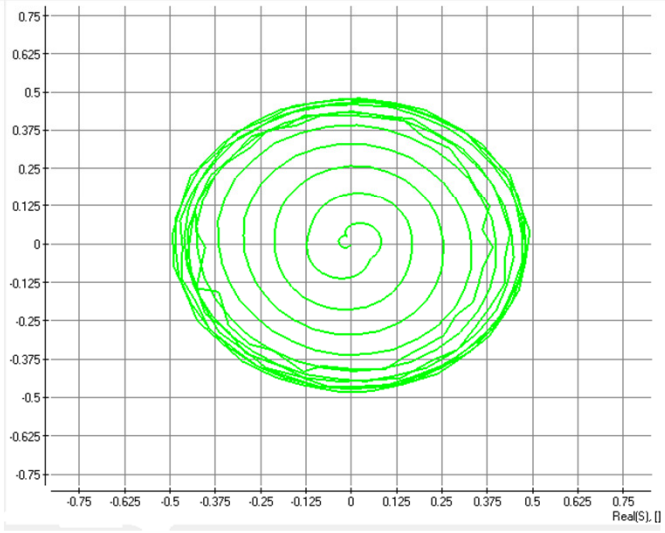
Read Maximum Aggressor from S

- Cross-talk between 2 Lines

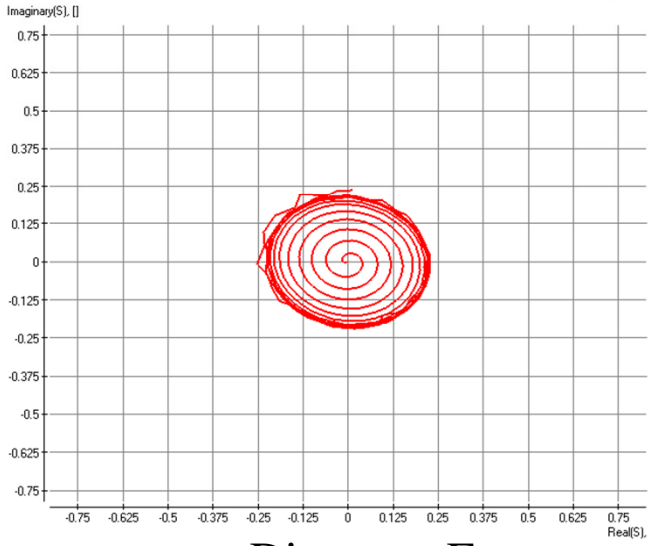




Distance: Close



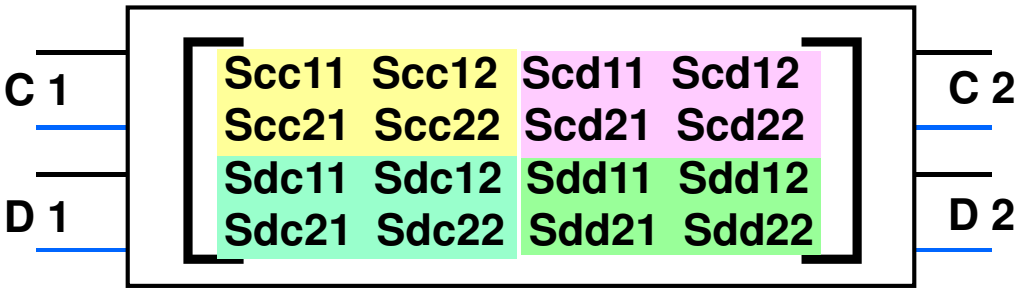
Distance: Medium

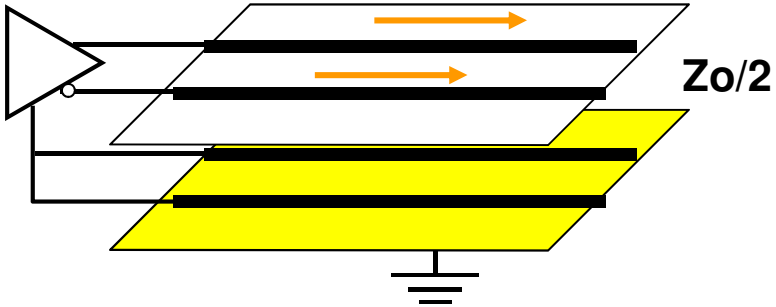


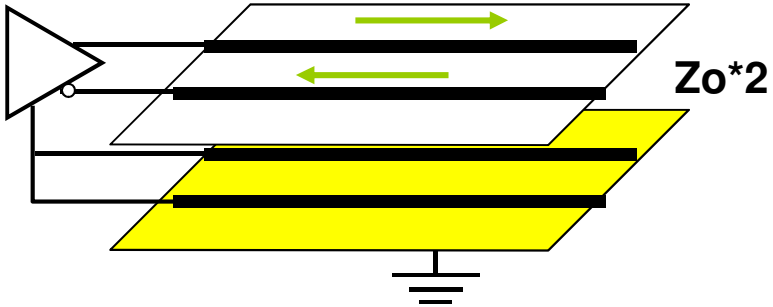
Distance: Far

Differential Line

- Differential Line Model







Scc: Common Mode

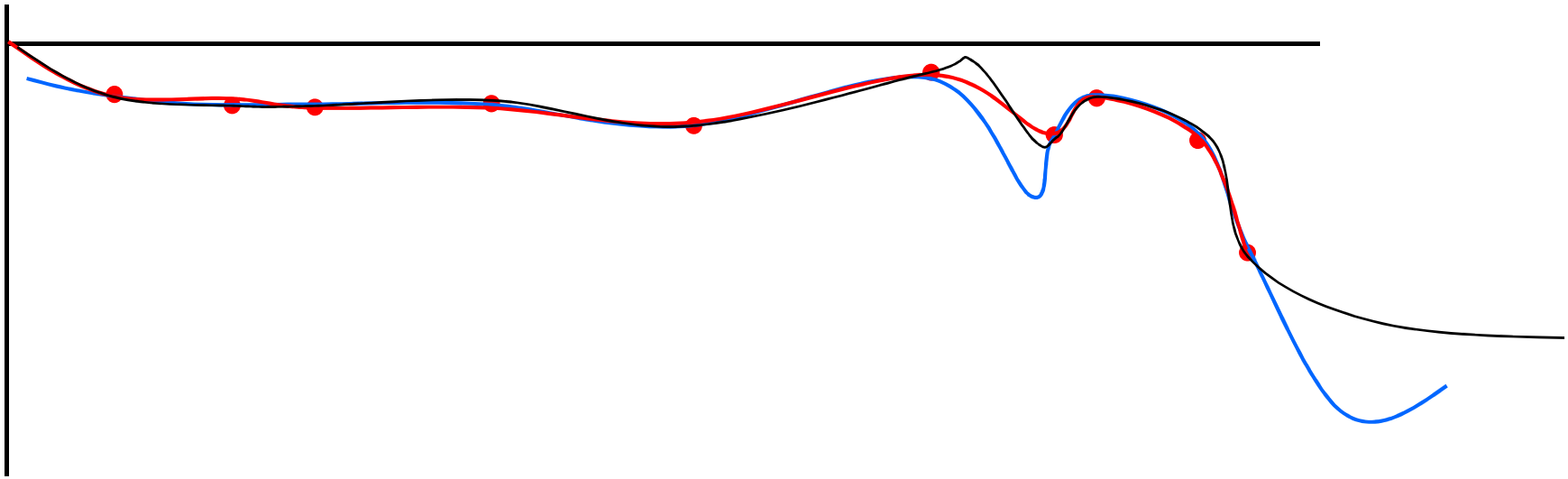
Sdd: Differential Mode

Scd: Common to Differential

Sdc: Differential to Common

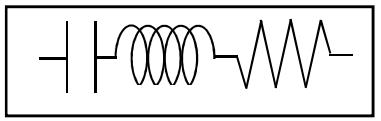
Outrange (DC/Higher Frequency)

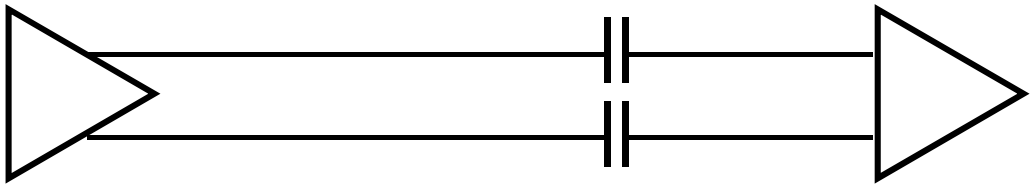
- S-Parameter does not define DC
- Simulator Needs DC data
  - Guidance of Passive EDA models, Hiroaki Ikeda, Japan Aviation Electronics Industry ,Ltd, 2009 IBIS Summit Japan
- How to Simulate Higher Frequency
- Extrapolation

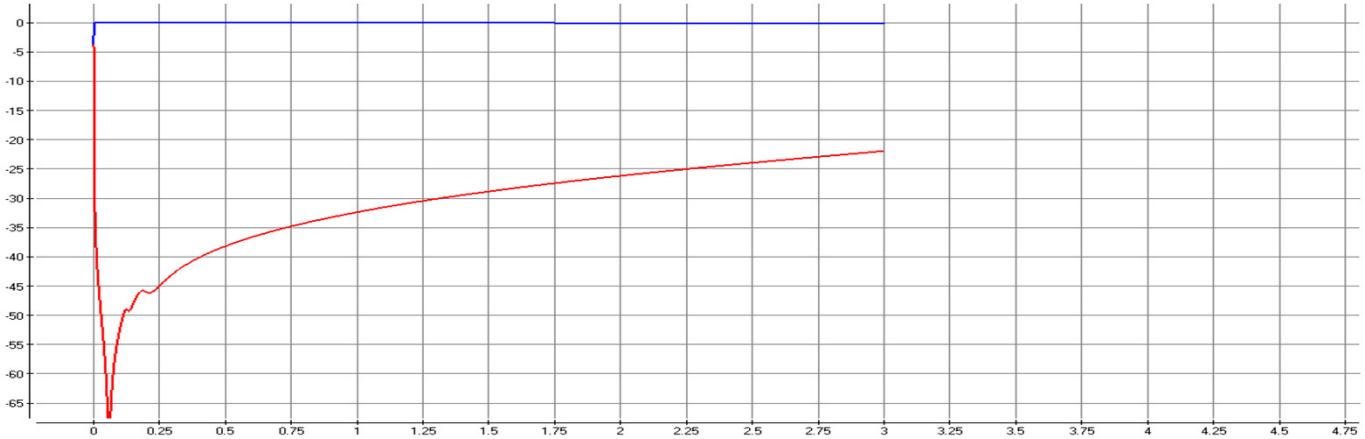


Example: AC Coupling C Model

- Most S Models of C are for PI
  - Up to 3-8 GHz model
  - PCIe Simulation needs 12 - 20 GHz (x3 - x5)
- Use Fitted Equivalent Model







Reference

1. Quality of S-Parameter, S.Maeda, KEI Systems, 2011 ANSYS Japan Conference

2. Guidance of Passive EDA models, Hiroaki Ikeda, Japan Aviation Electronics Industry ,Ltd, 2009 IBIS Summit Japan

KEI-Systems

- Knowledge Based Electronics Intellectual Systems
- High-Speed SI/PI Consulting
- New Hampshire, USA
- E-mail: KEI-Systems@comcast.net