PCB time domain simulation technique and PCB EMS simulation technique

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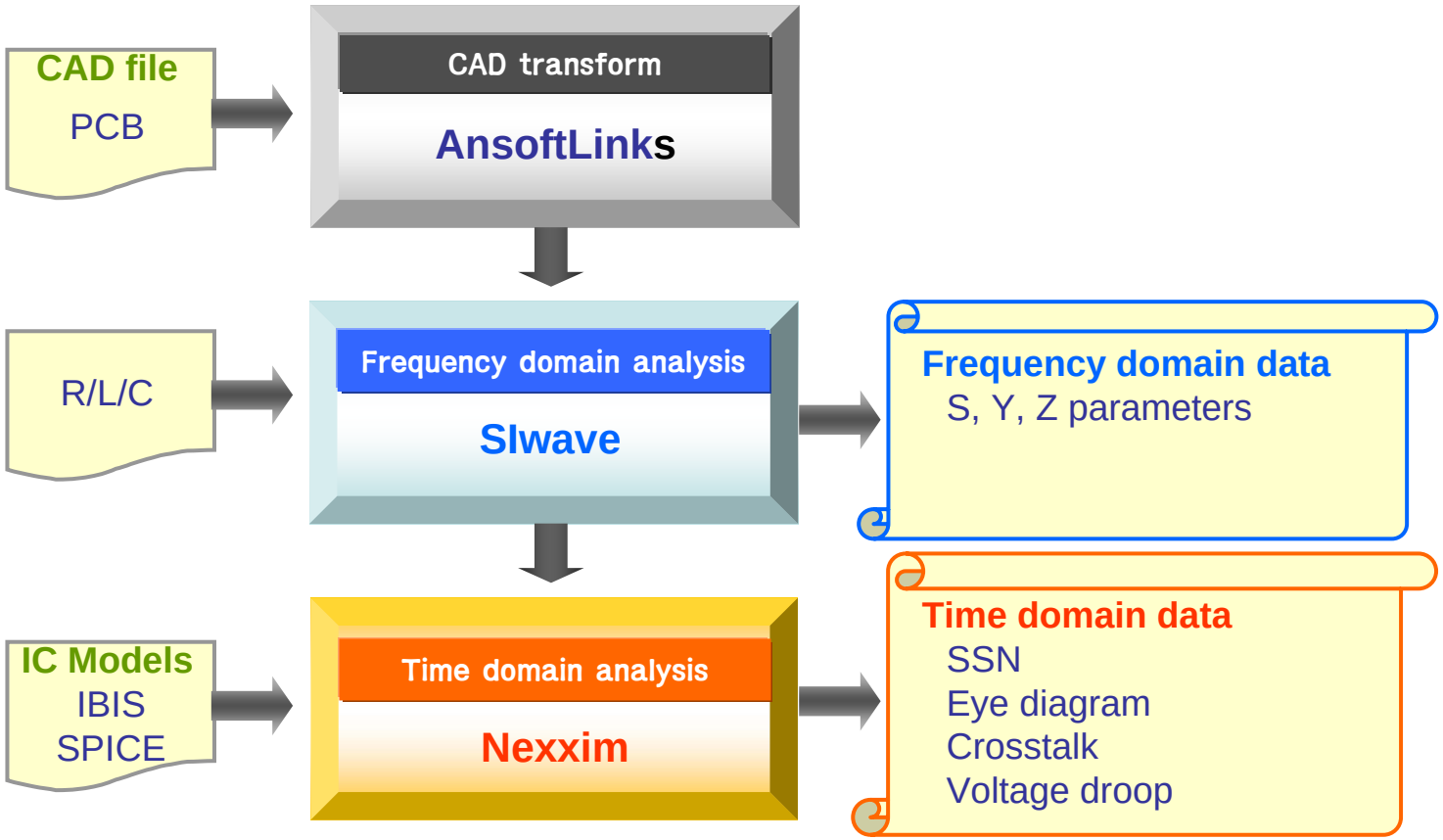
Contents

PCB time domain simulation technique

PCB simulation flow



Time domain simulation Idea

PCB model
Touchstone file format

Logic Board

PCB

PCB

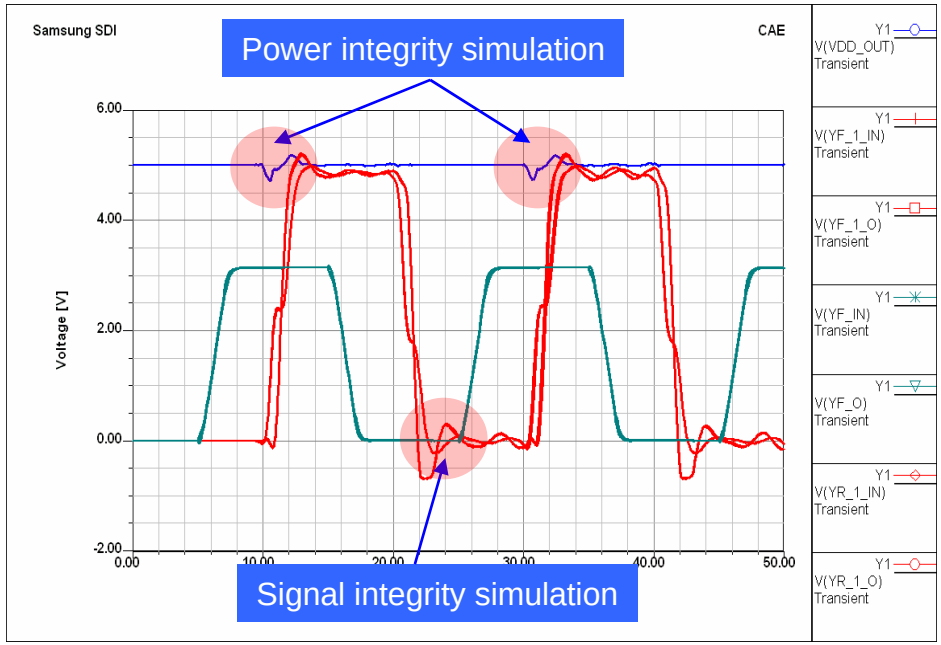
74VHCT541ATTR

IR2106S

Passive device
SPICE model

IC model
IBIS model

IC model
SPICE model



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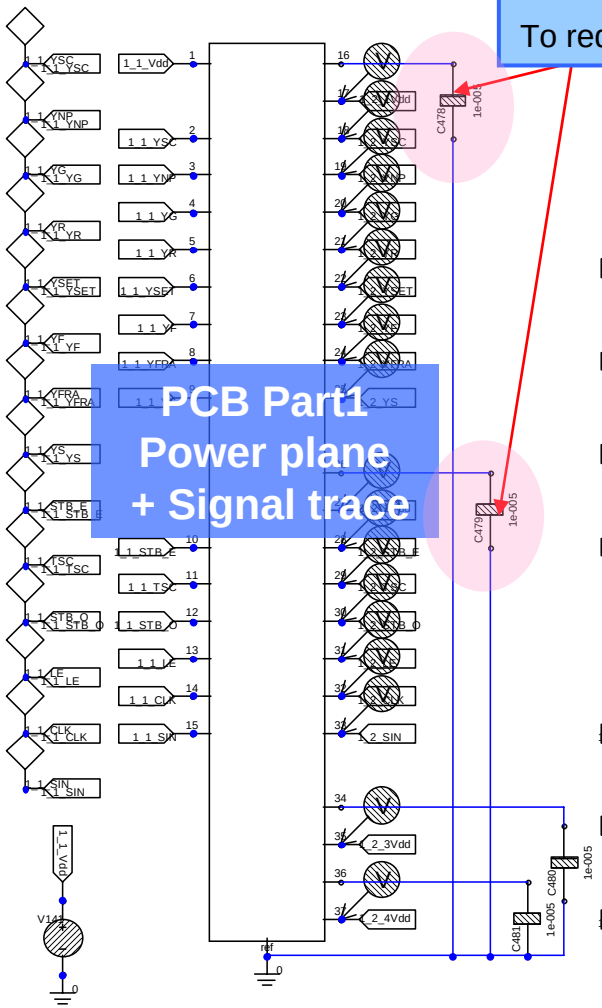
Time domain simulation set up

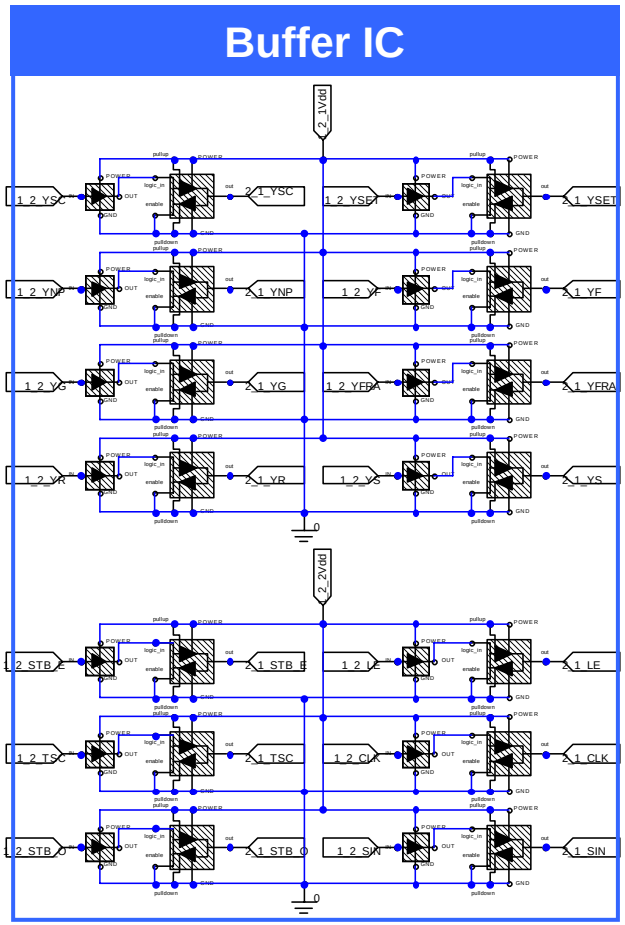
Simulation tip :

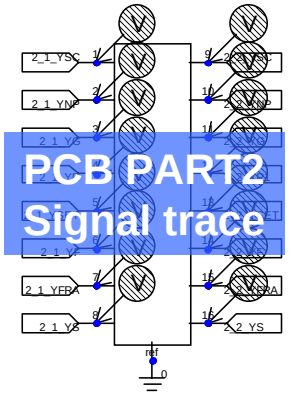
- A port should be assigned to the node of decoupling capacitor
- Initial condition voltage should be set

To reduce unnecessary initial charging time of decoupling capacitor and avoid conversance error

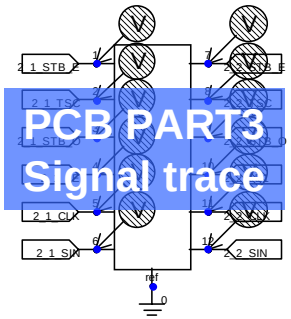


PCB Part1
Power plane
+ Signal trace

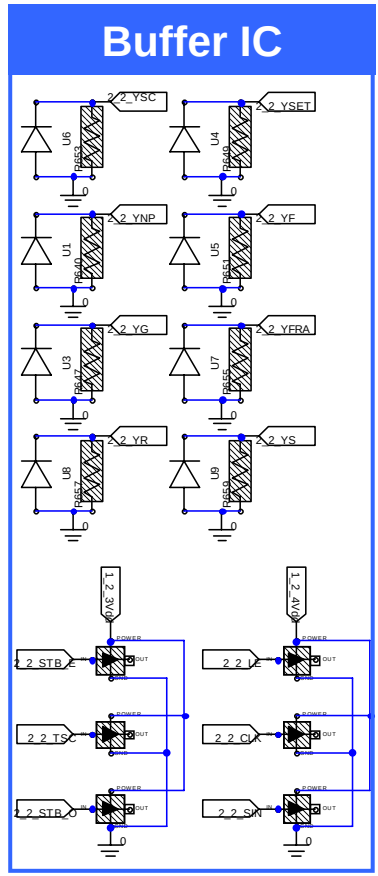




PCB PART2
Signal trace

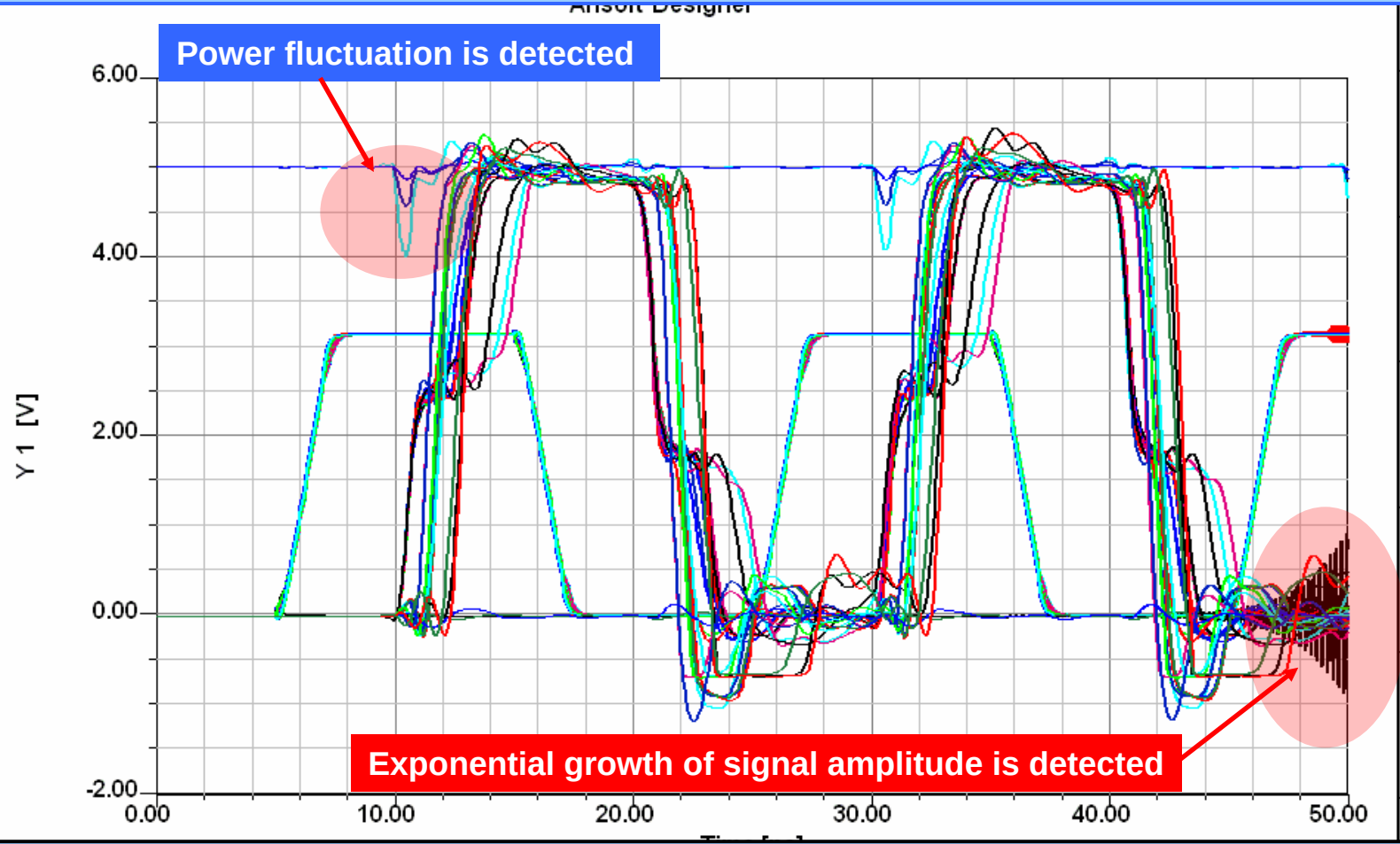


PCB PART3
Signal trace



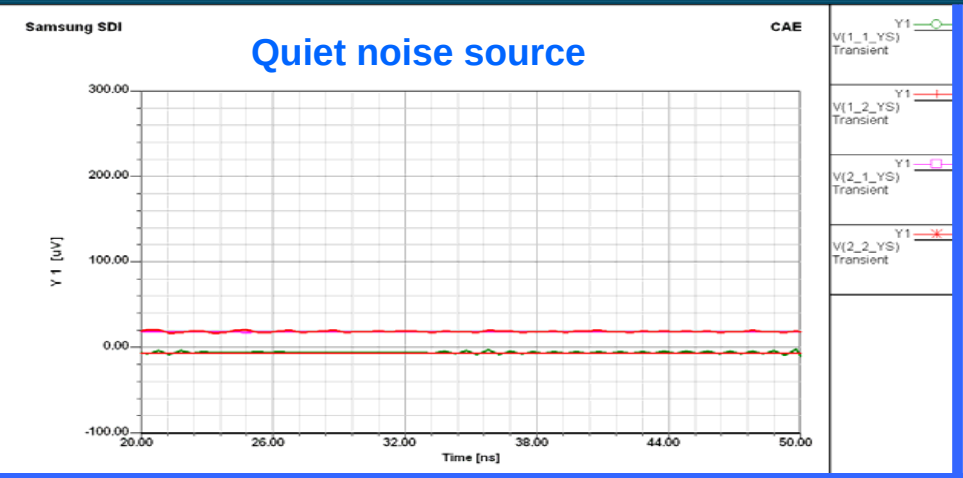
Exponential growth issue of signal

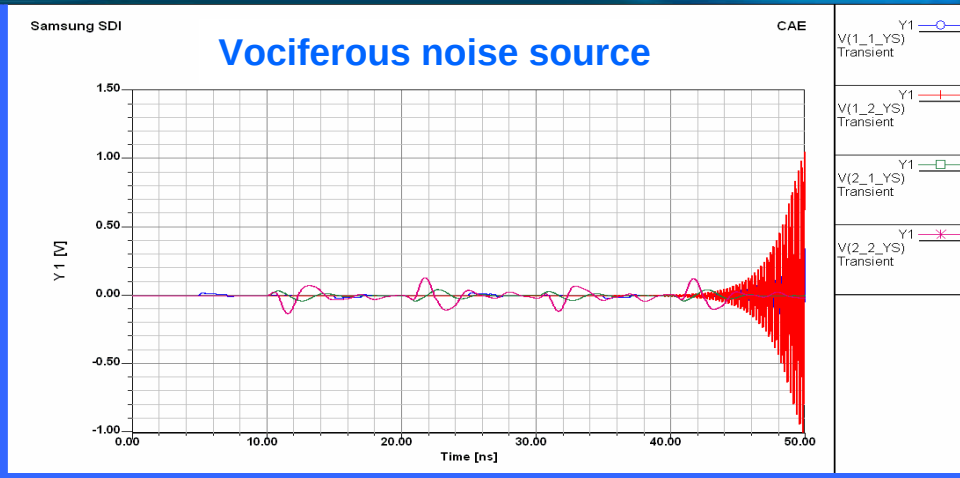
1. SSO (Simultaneous Switching Output) simulation
2. 50MHz frequency switching signal



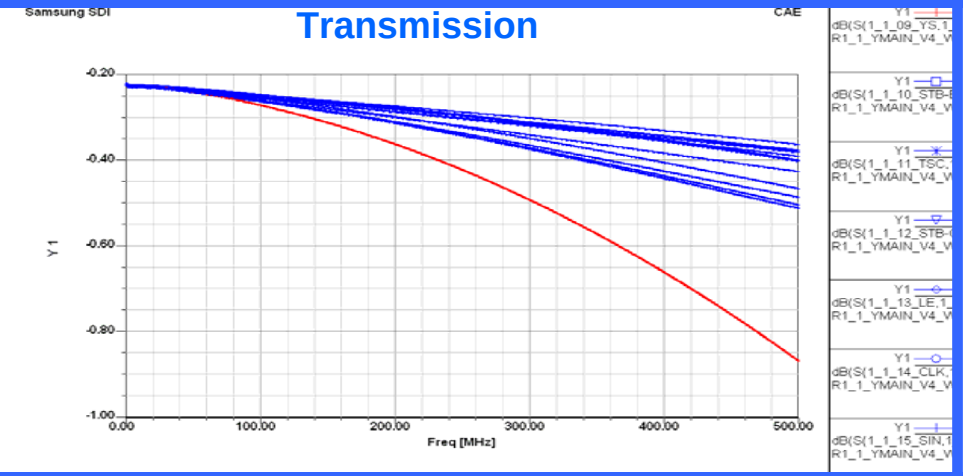
- Impossible to proceed to simulate many cycles (such as eye diagram)
- This is uncontrollable even though we change PCB modeling option
- The results is valid before the exponential growth

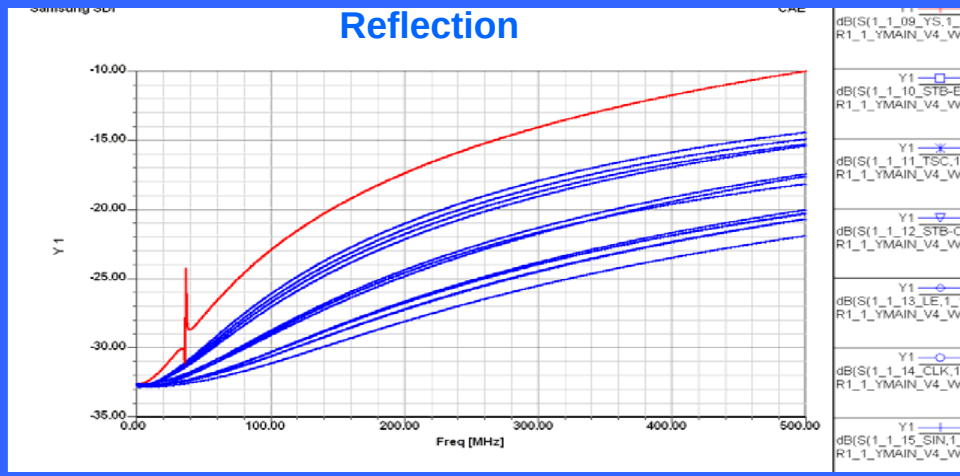
Analysis of exponential growth





If the signal in the vicinity is quiet, the victim line is also quiet





The worse signal integrity characteristic is, the higher possibility of exponential growth in time domain is

We have assumed some part of frequency range in PCB modeling is not passive and induced exponential growth in time domain simulation

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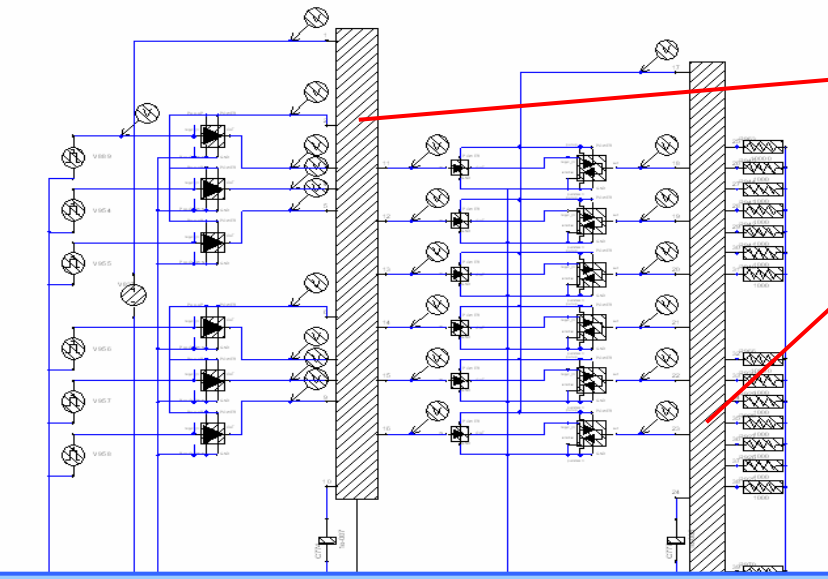
The effort to avoid exponential growth

CASE 1

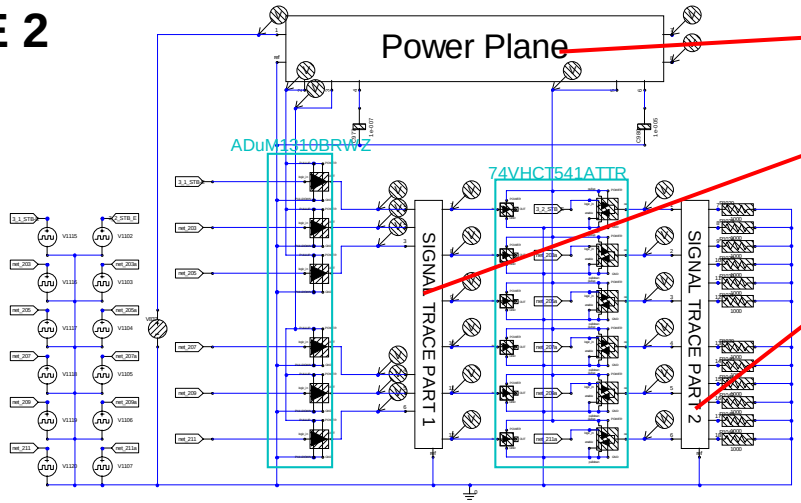


ONE touchstone file for the whole PCB

발진 발생

To succeed in time domain simulation without any exponential growth the PCB modeling size should be minimized.

CASE 2



Separate touchstone file for each part

발진 현상 없음

Simulation guide

1. Exponential growth in time domain is intrinsic characteristic of S-parameter

2. Must apply passivity compensation algorithms

   - apply ".option s_element.enforce_passivity=1" in Nexxim
   - enforce passivity during FWS transformation in SIwave
   - use third part software to perform passivity compensation

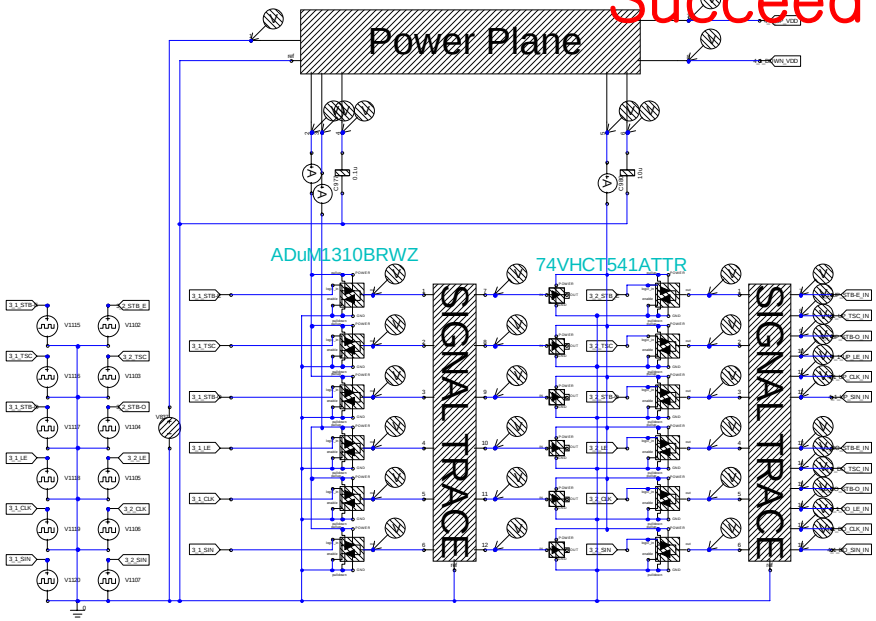
3. Minimize the size of one block
   - passivity compensation algorithms is feasible under 20 ports

4. Simulation methodology using Siwave and Nexxim was fast to simulate and pertinent to analyze crosstalk in PCB.

The effort to avoid exponential growth

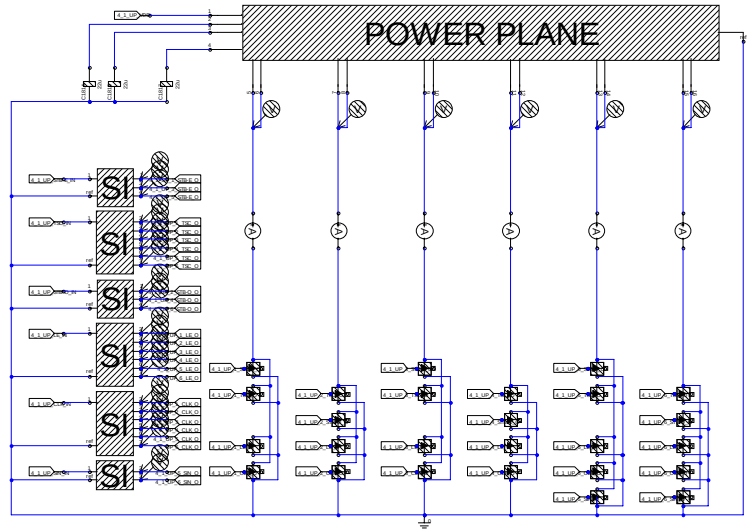
The first PCB

Succeed



The second PCB

Succeed



Separate touchstone file for each part

After interconnect two PCB → FAIL

After interconnect two PCB and perform passivity compensation → Succeed

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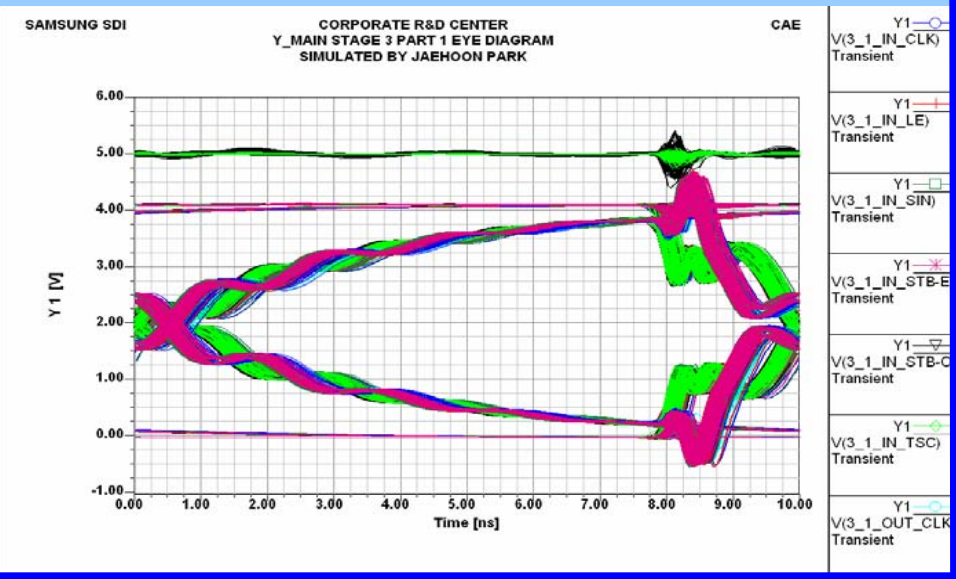
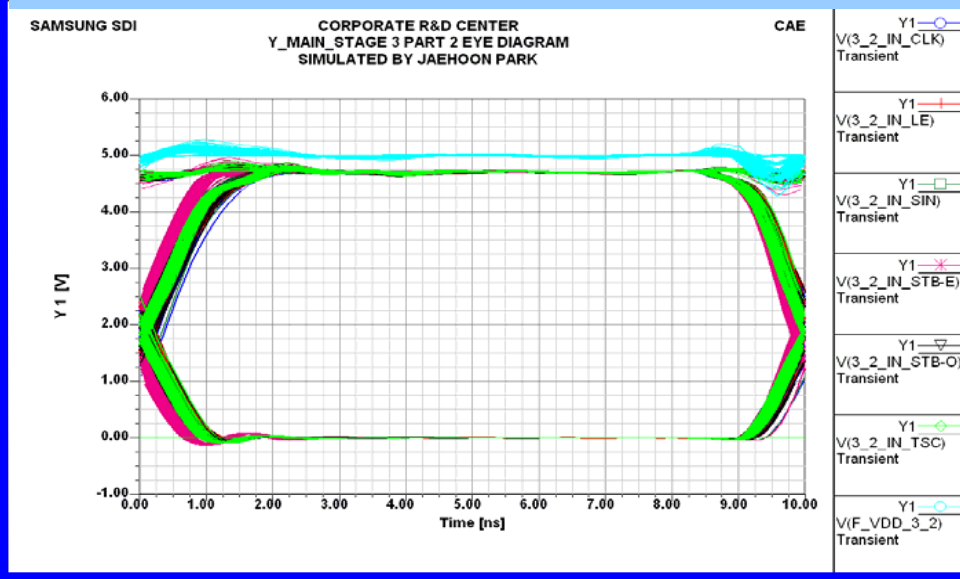
Time domain results (after passivity compensation)

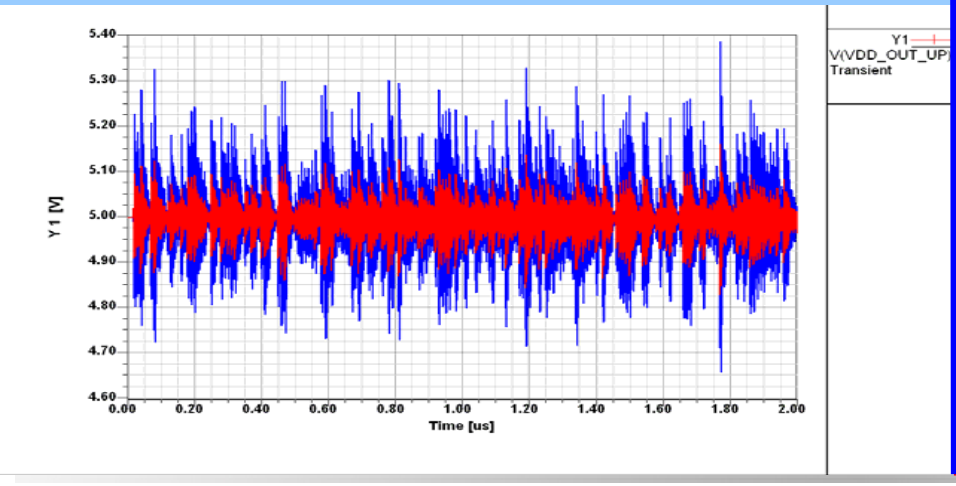
Eye diagram



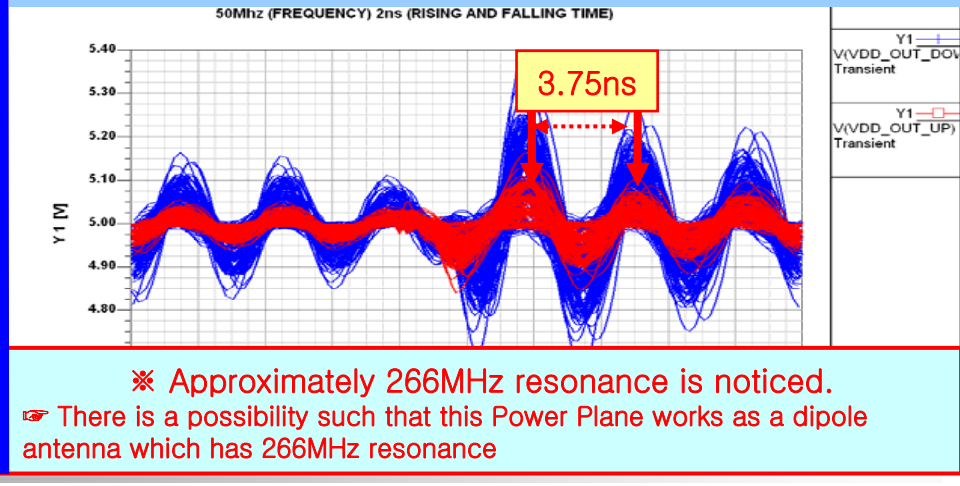
Eye diagram



Transient response of the power



Eye diagram of the power



※ Approximately 266MHz resonance is noticed.

☞ There is a possibility such that this Power Plane works as a dipole antenna which has 266MHz resonance

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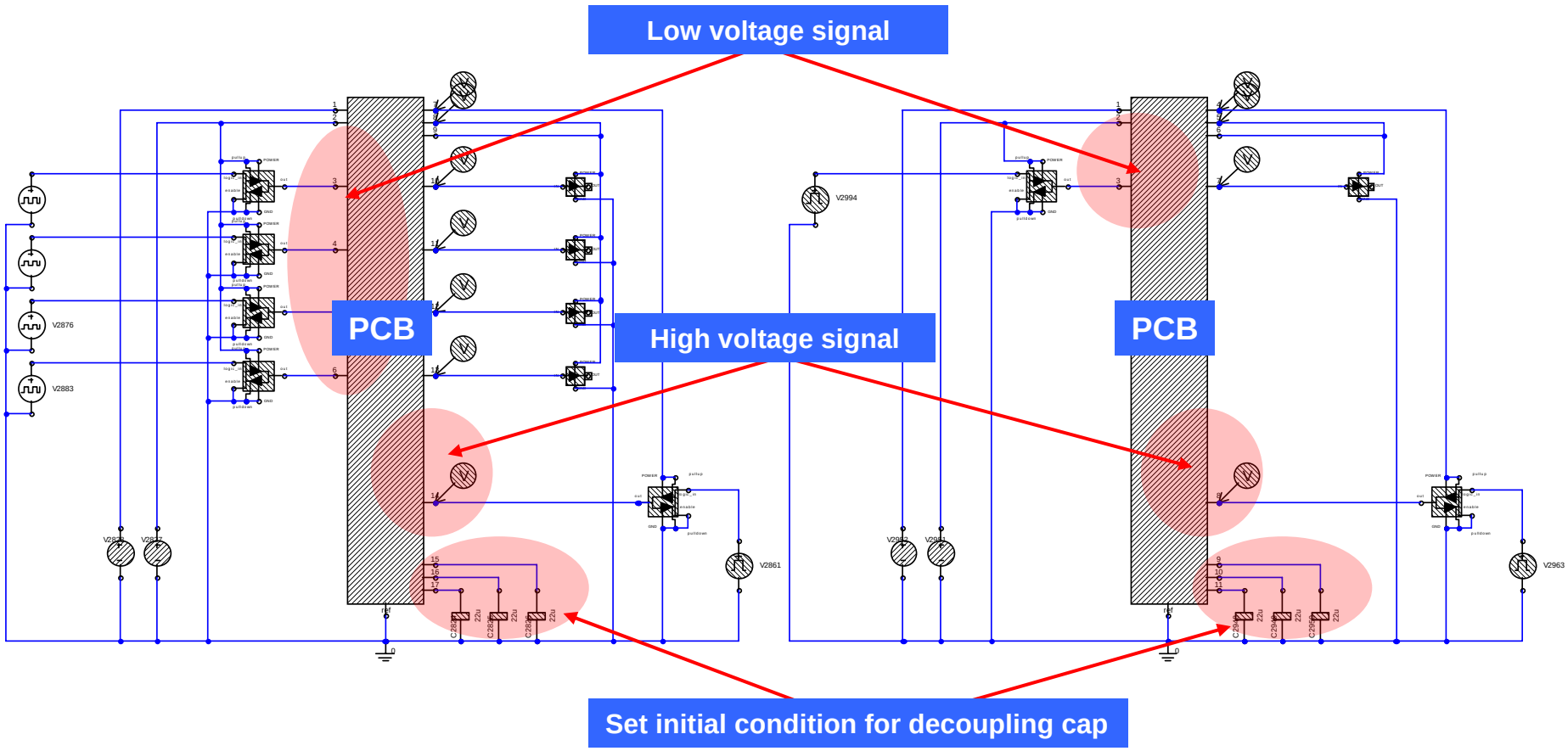
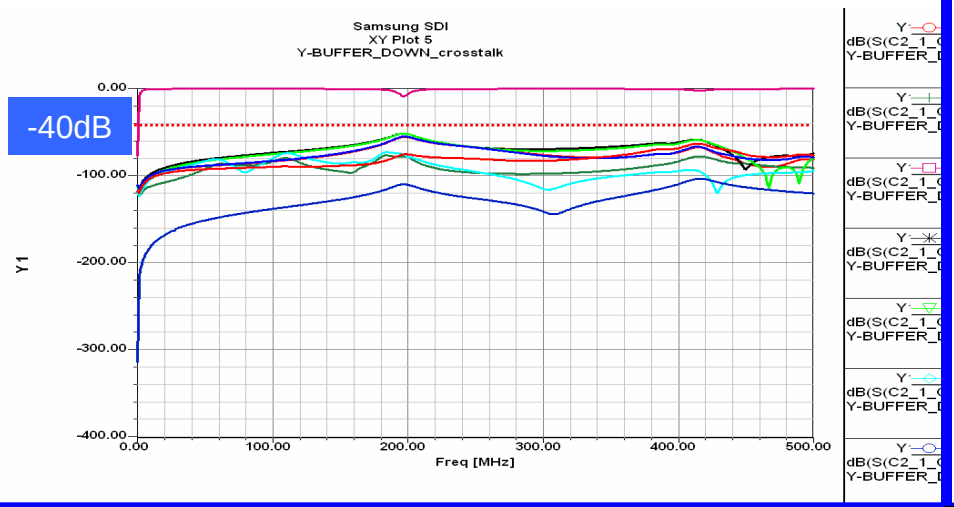
Crosstalk simulation in time domain

Crosstalk simulation should be handled with considering port limitation in passivity compensation

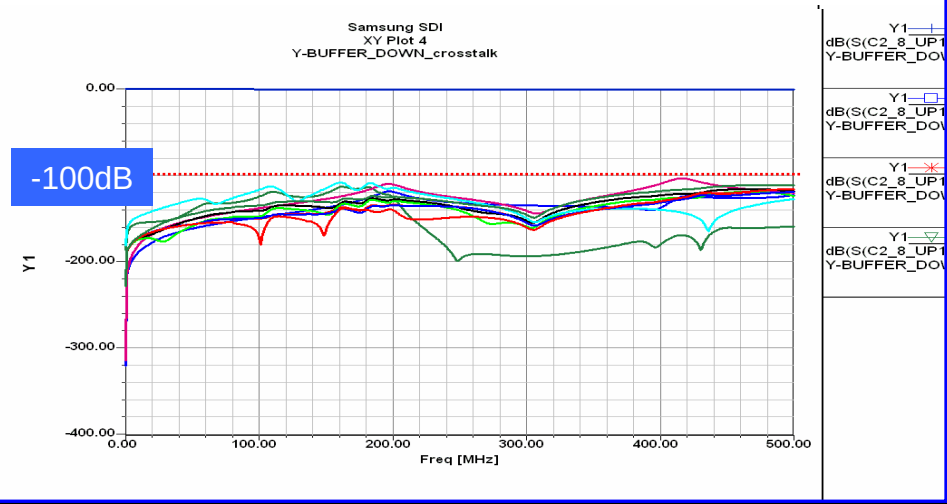


Crosstalk simulation (after passivity compensation)

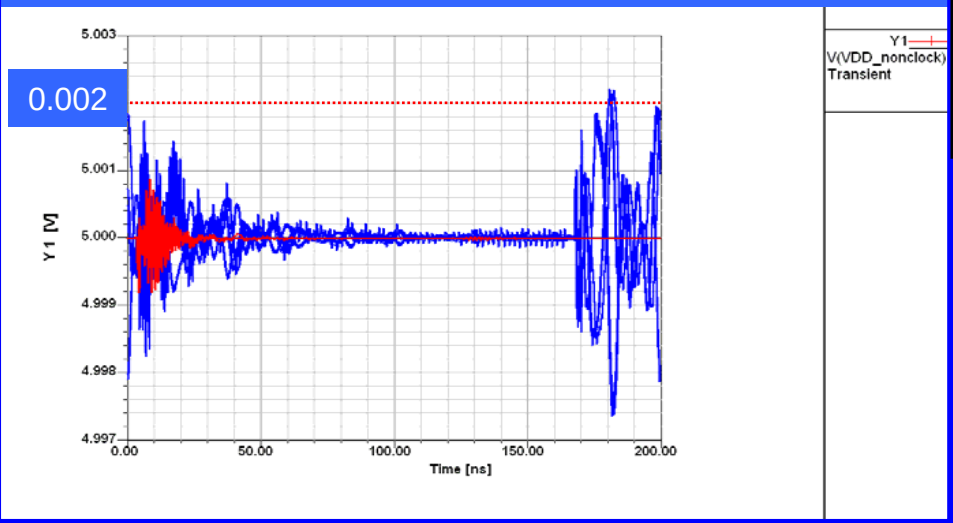
Crosstalk in frequency domain
High voltage power → Low voltage



Crosstalk in frequency domain
High voltage signal → Low voltage



Crosstalk in time domain
High voltage → Low voltage power

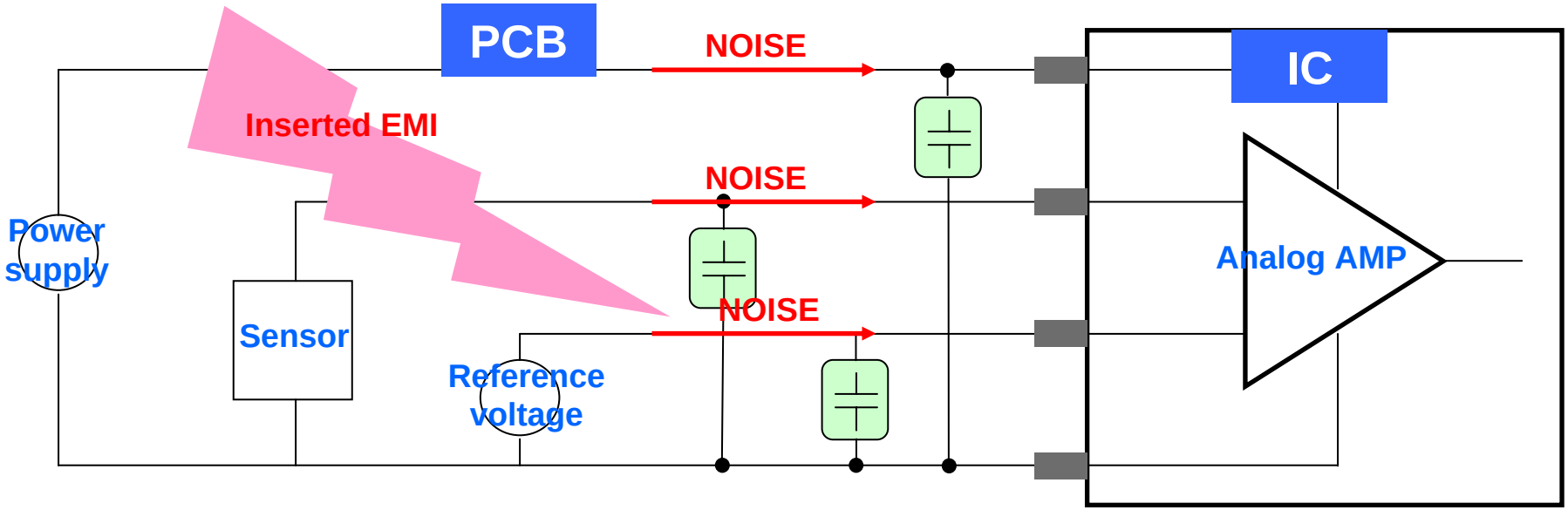


From frequency domain results has correlation to time domain results

→ Frequency domain expectation 0.005 V
→ Time domain 0.002V

PCB EMS simulation technique

The Basic Idea

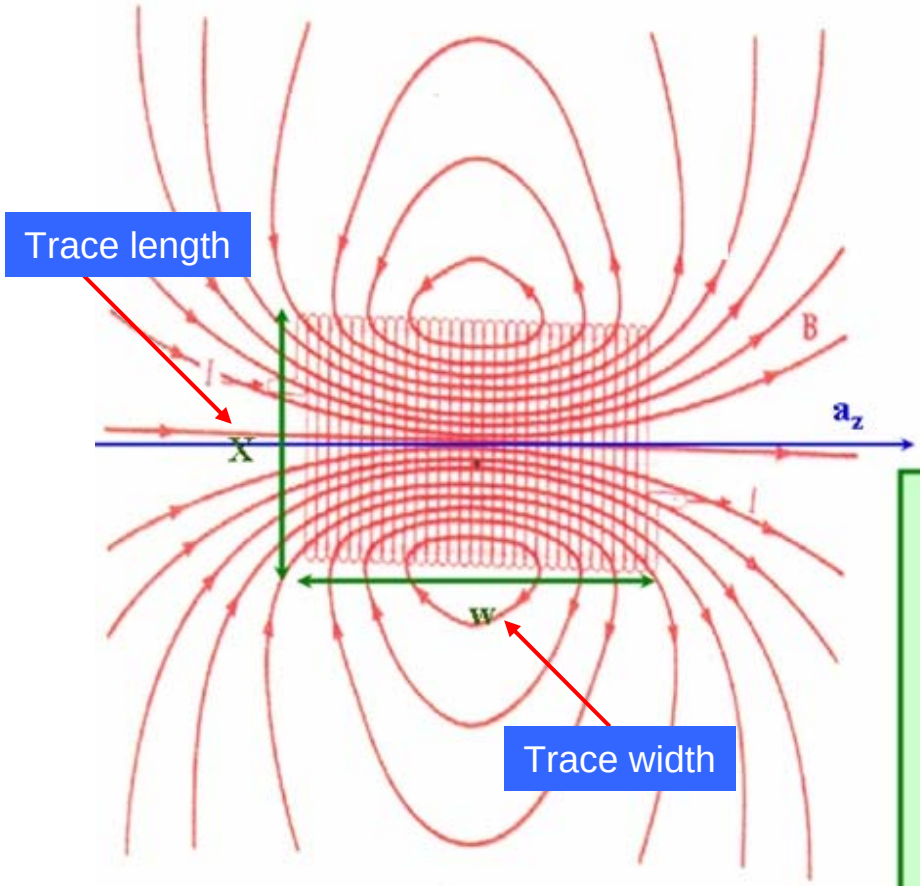


About low speed input (such as power, reference voltage, sensing signal)

1. Extraneous EMI is transformed to noise in low speed signal trace to IC

2. High frequency noise is transformed to DC offset inside IC

Basic Idea



$$L = \frac{\Phi}{I}$$

$$H = \frac{NI}{w} a_z$$

$$\therefore \Phi = S \bullet B$$

$$= X \times d \times \mu \times \frac{\left(\frac{w}{dw}\right) \times \left(\frac{I}{w} \times dw\right)}{w} = \frac{X\, d\mu I}{w}$$

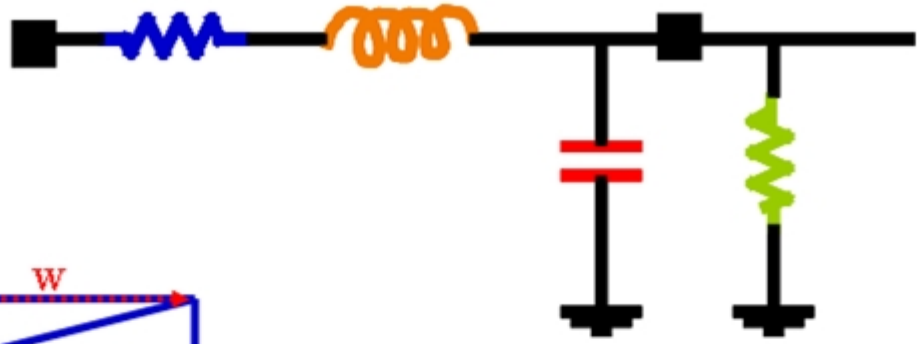
$$\therefore \frac{L}{X} = \frac{\mu \times d}{w}$$

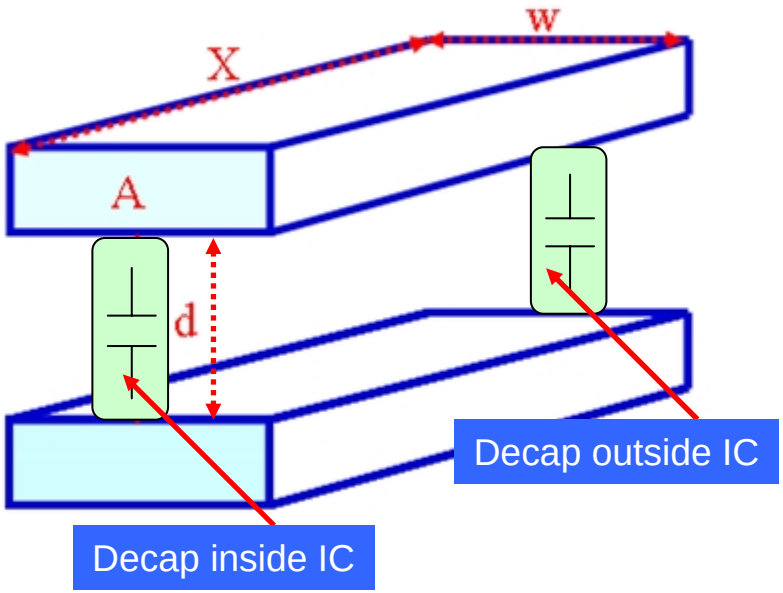
1. Any trace loop in PCB can be assumed as solenoid in infinitesimal point of view
2. Extraneous EM field induce electromotive force in this solenoid

Basic Idea

ε : permitivity 유전율

μ : permeability 투자율





$$\frac{R}{X} = \rho \frac{l}{A}$$

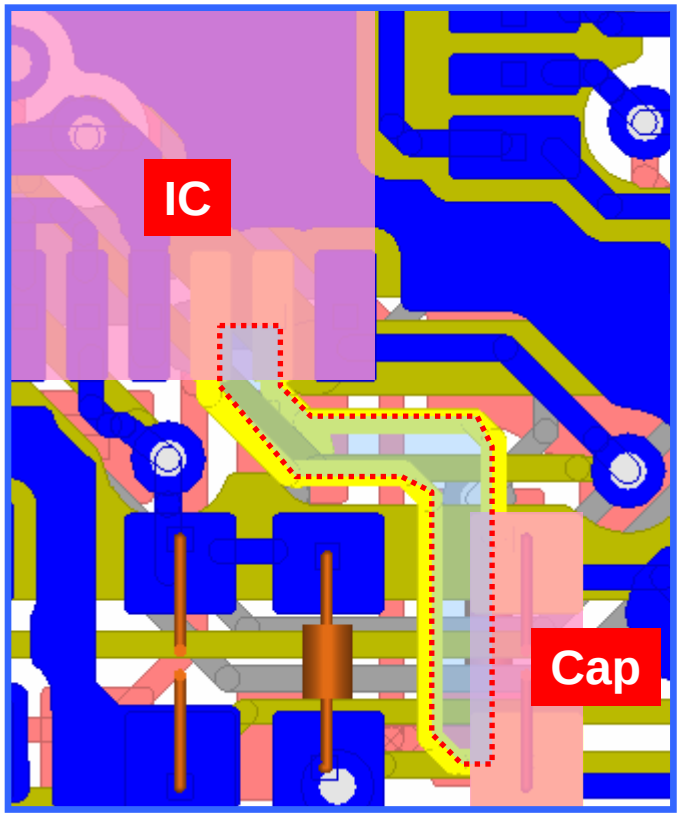
Make Return Pass just beside to reduce L

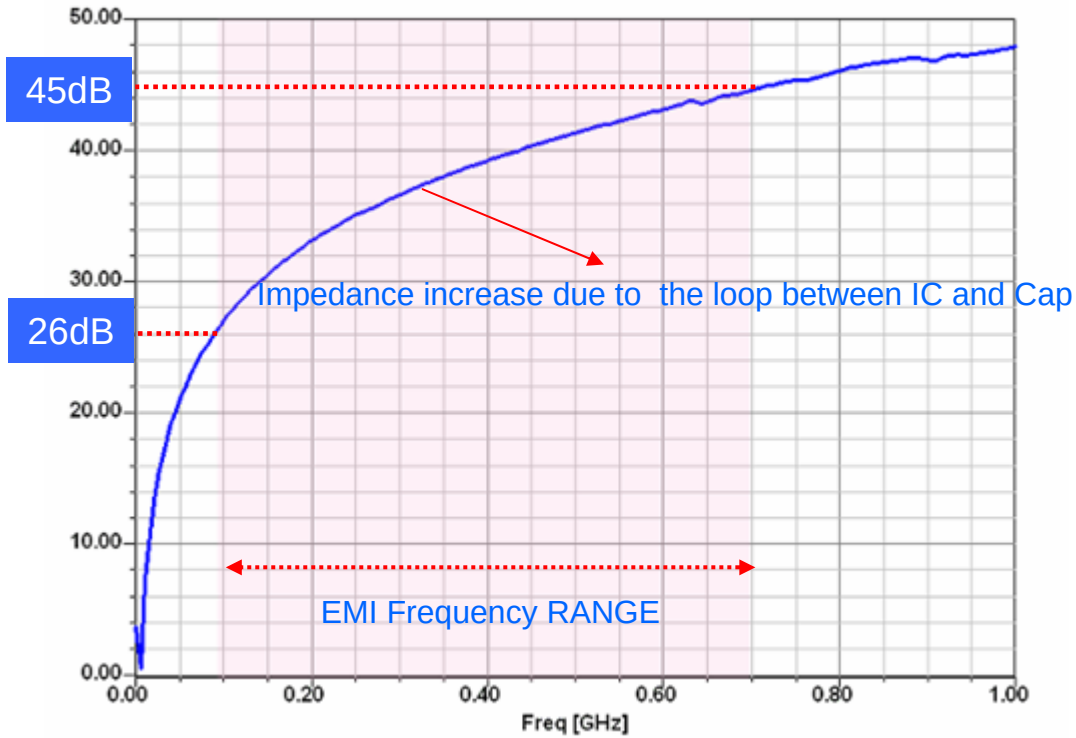
$$\frac{L}{X} = \mu_0 \frac{d}{w}$$

$$\frac{C}{X} = \varepsilon \frac{w}{d}$$

$$L = \frac{\Phi}{I} \qquad C = \frac{Q}{V}$$

Real case 1



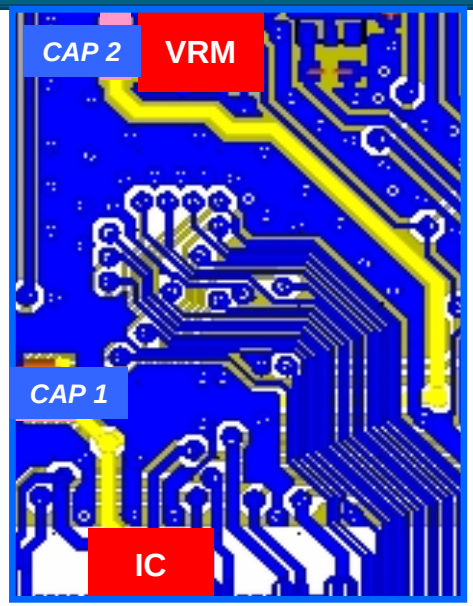


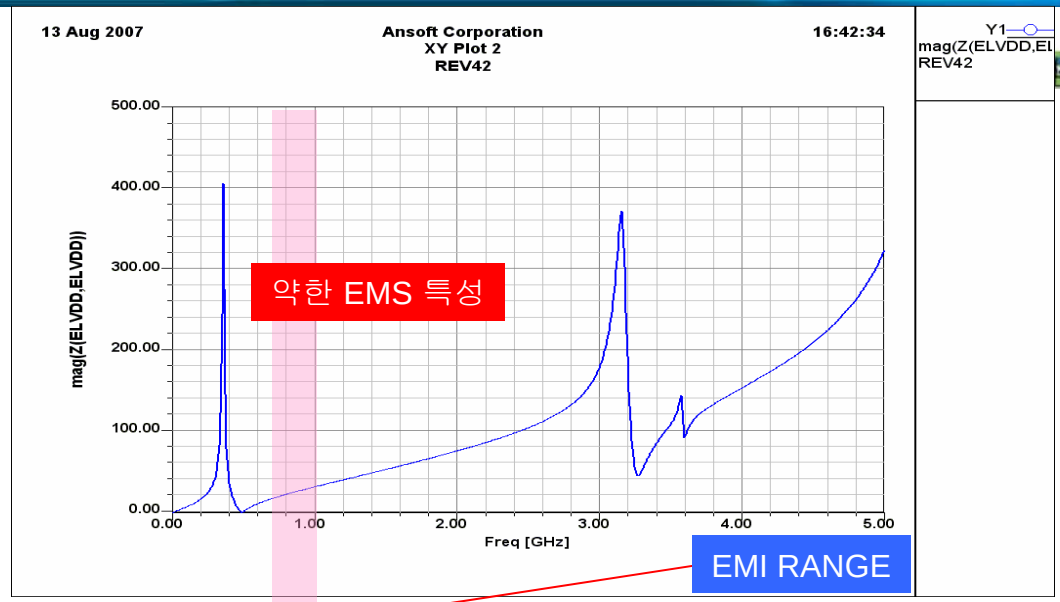
1. Trace loop is detected
2. There is no shield effect or eddy current effect

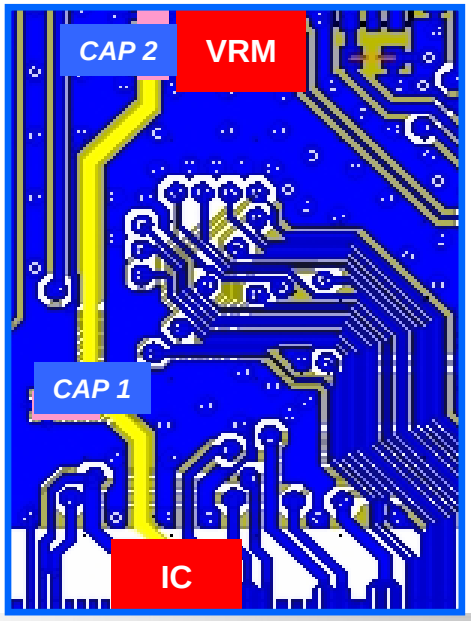
→ The loop between IC and Cap works as a solenoid and generate electromotive force with responding to extraneous EM field

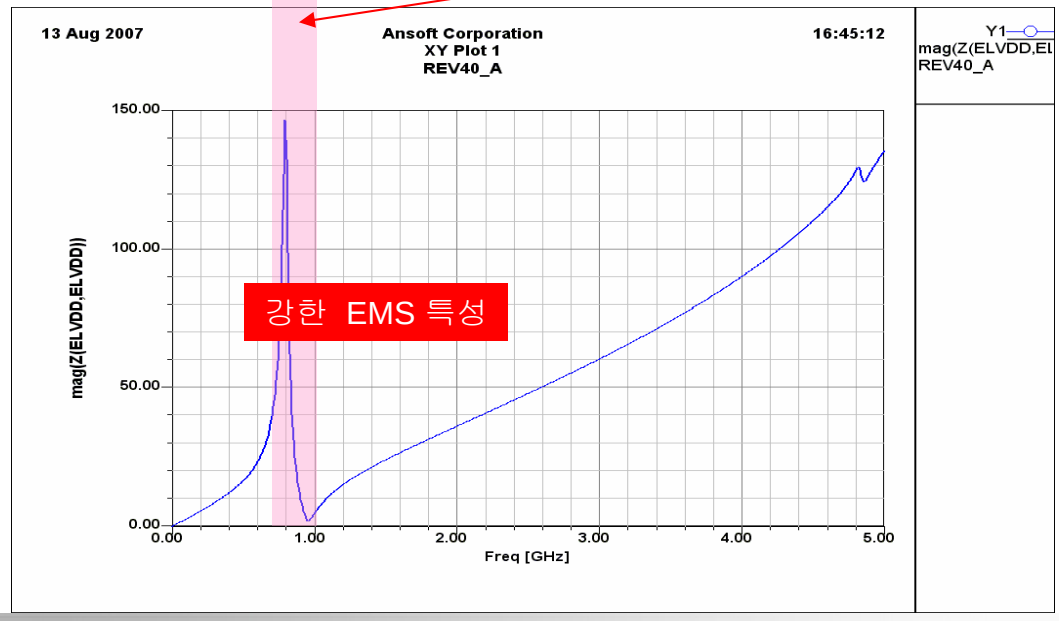
→ After place small plane just between IC and CAP, EMS characteristic disappeared

Real case 2









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Conclusion

Conclusion

1. This EMS analysis technique is only applicable to low speed signal that is connected to OP AMP

2. EMS is critically related to inductance characteristic of PCB Trace

3. Z-parameter analysis using SIwave was handy and speedy to approach EMS issue