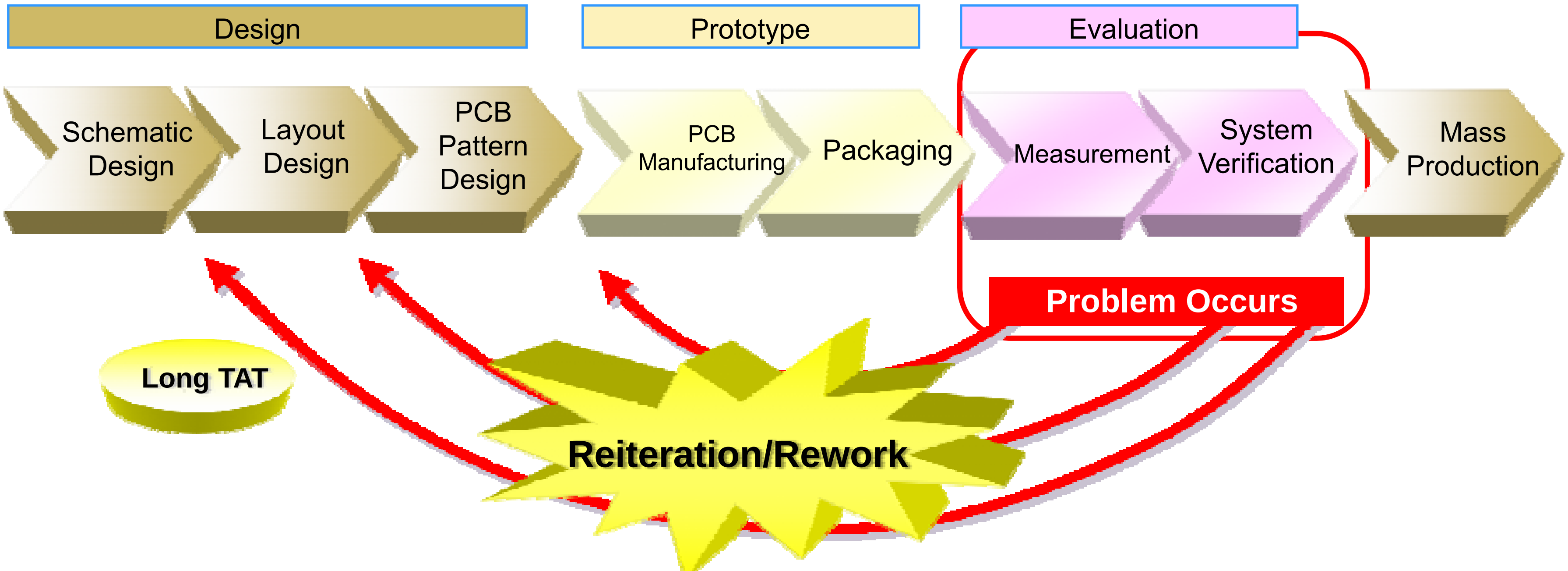
Reduce the Noise - Optimize Design

Using EMIStream to Suppress EMI

11/15-17/2010 : EMC Seminar Series in California
TechDream, Inc. President and Founder Yoshi Fukawa

Advantages of EMIStream



- **Eliminate EMI issues at an early design stage**
  - **reduce design rework**
- **Reduce time and cost spent on evaluation/testing process**
  - **rapid time-to-market**
- **Speedy analysis**
  - **20 times faster than conventional spice engine**
- **Educate new engineers on “Good Design”**

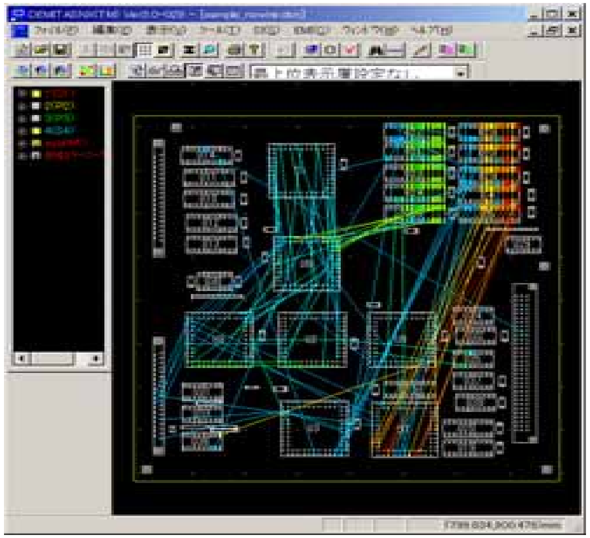
EMIStream Background

NEC Products

EMIStream was created by engineers at NEC facing real world EMI problems.

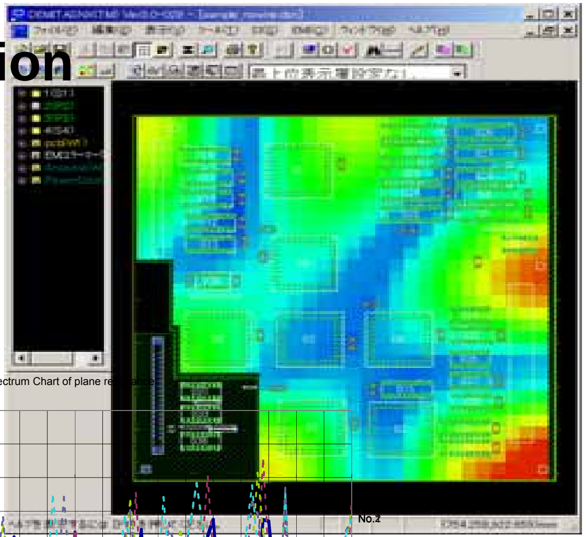
<u>NEC is part of EMC Consortium Member of MST and creating new EMC rules.</u>

EMIStream Features



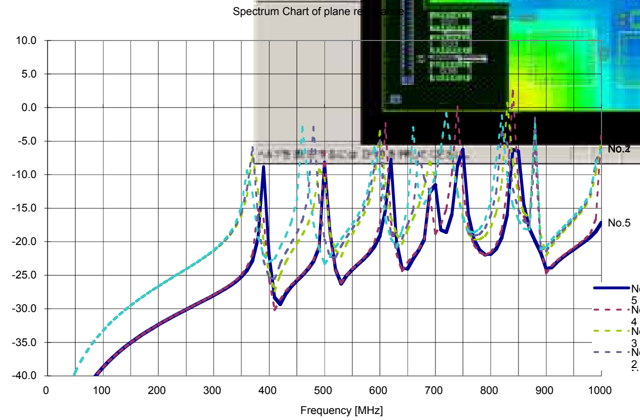
13 EMI Design Rule Check

- Return Current Path Discontinuity
- Reference Change
- Estimated Radiation



Power/Ground Plane Resonance Analysis

- Auto capacitor placement
- See “hot points” at a glance
- Frequency characteristics display



13 EMI Design Rule Check

Over 150 rules were investigated and boiled down to 13 key design rules

Return Path Check

1. Reference Change
2. Return Current Path Discontinuity

Signal Check

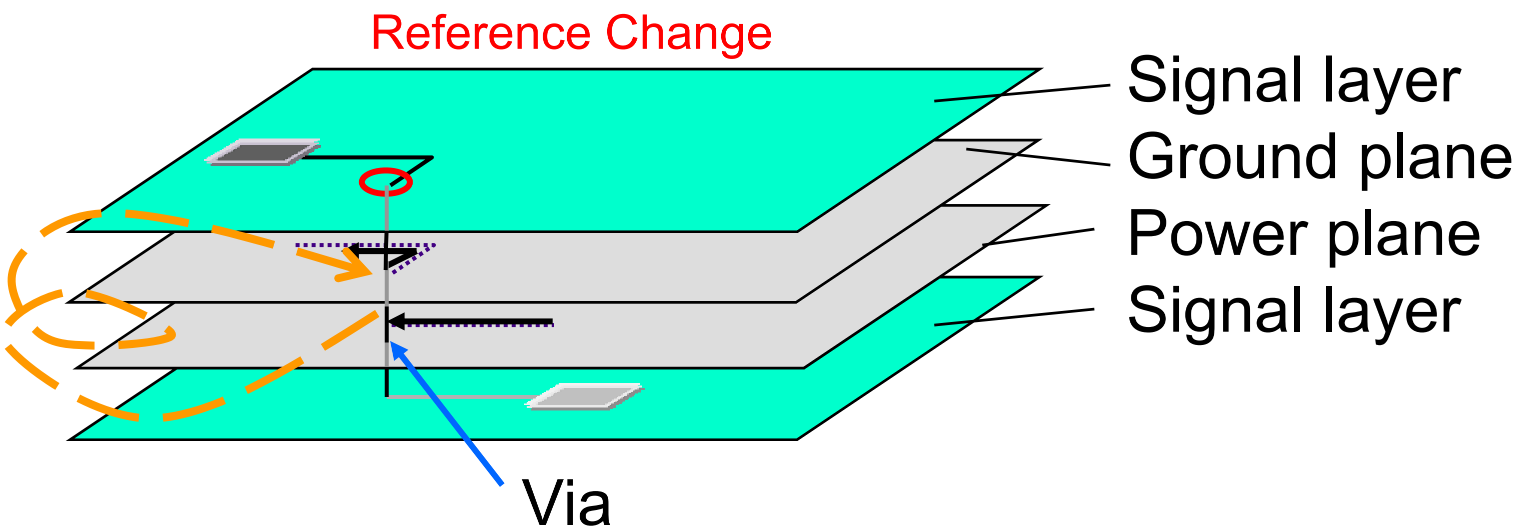
3. Trace Length
4. Via Count
5. Traces Near Plane Edge
6. Estimated Radiation
7. Signal Guard Trace
8. Filter
9. Differential Signal
10. Crosstalk

Power Plane Check

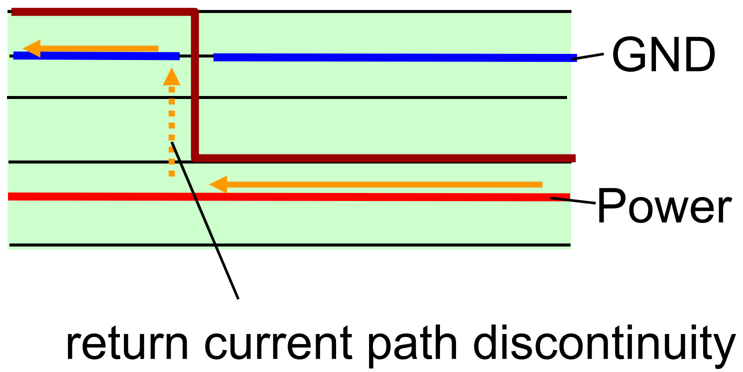
11. Signal Guard Via Spacing
12. Grounding Vias Along Plane Outline
13. Decoupling Capacitor

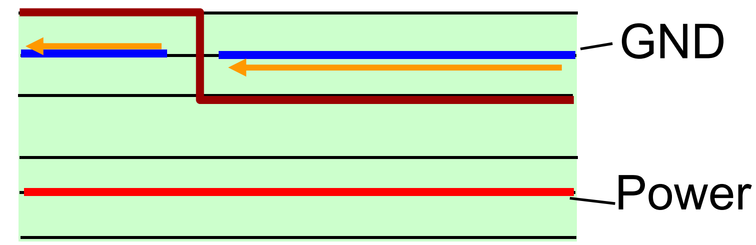
(1) Reference Change

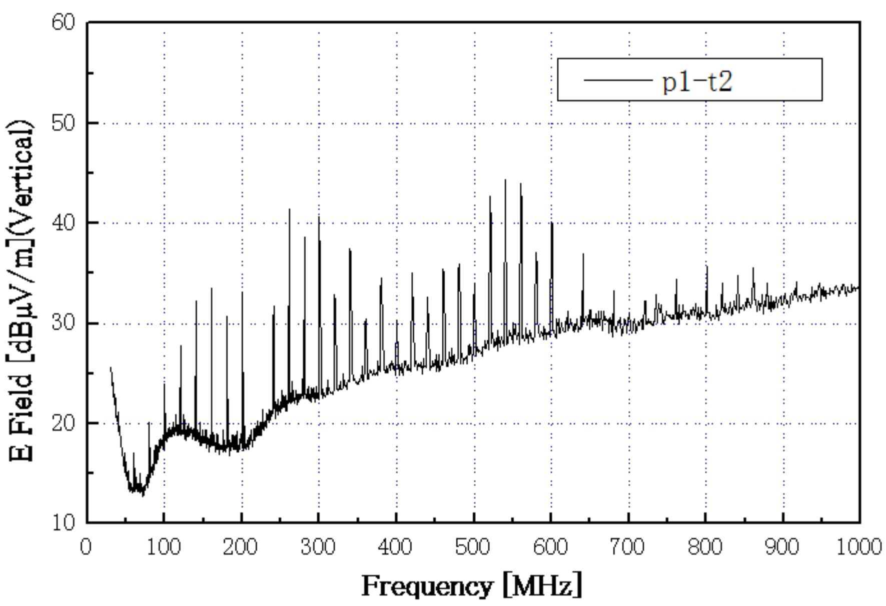
Traces crossing over power and ground plane
→discontinuity of return current path

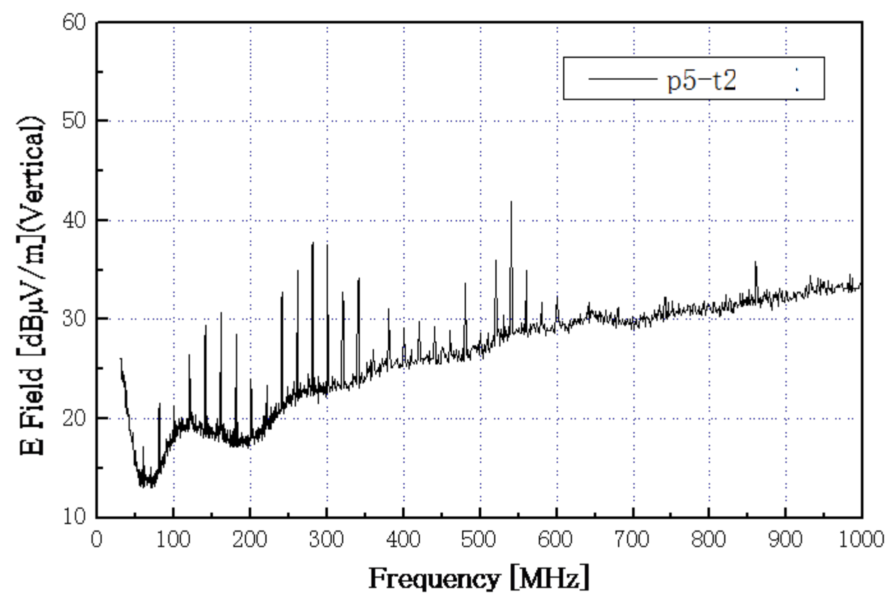


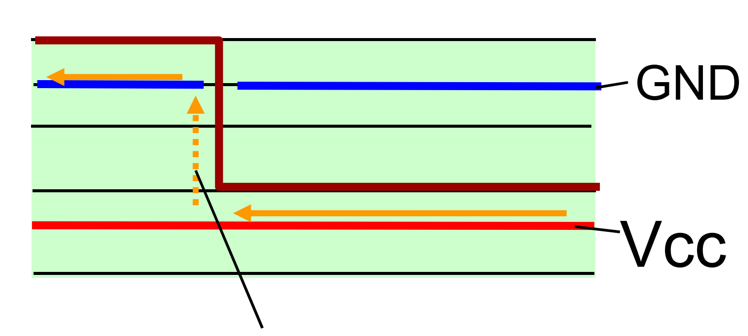
<u>Distance from return path route (capacitor, SG trace) to the via≦ Threshold value</u>

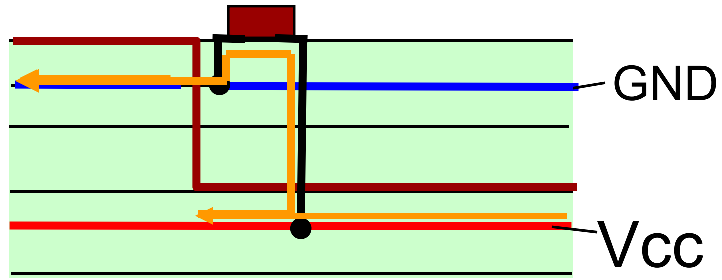

GND
Power
return current path discontinuity


GND
Power

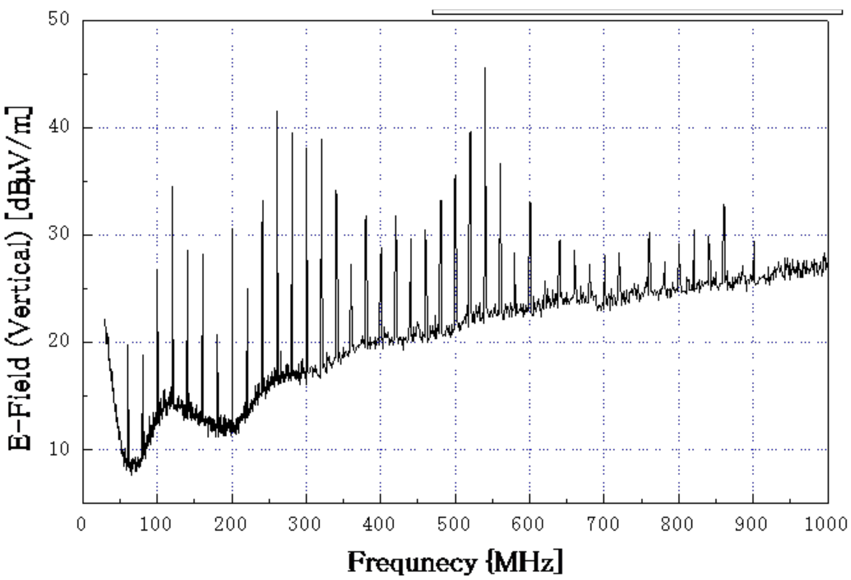

p1-t2
E Field [dBμV/m](Vertical)
Frequency [MHz]

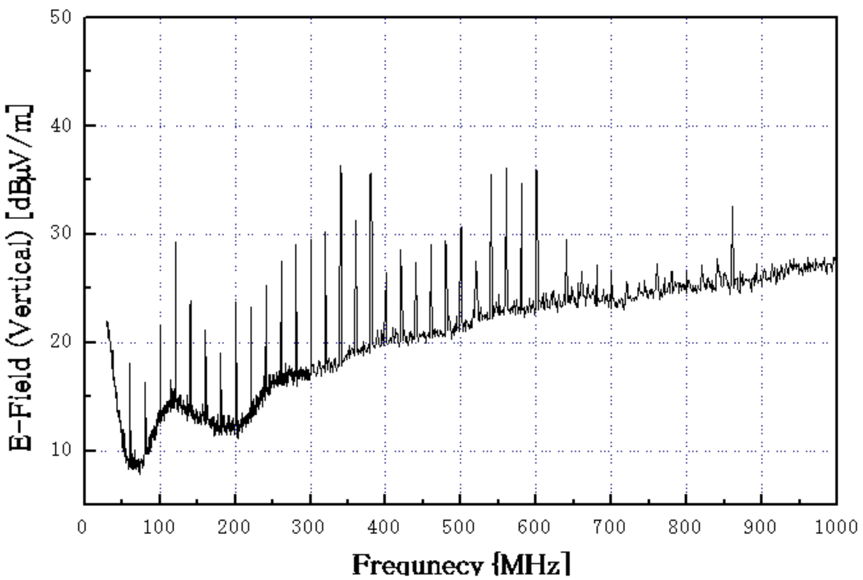

p5-t2
E Field [dBμV/m](Vertical)
Frequency [MHz]





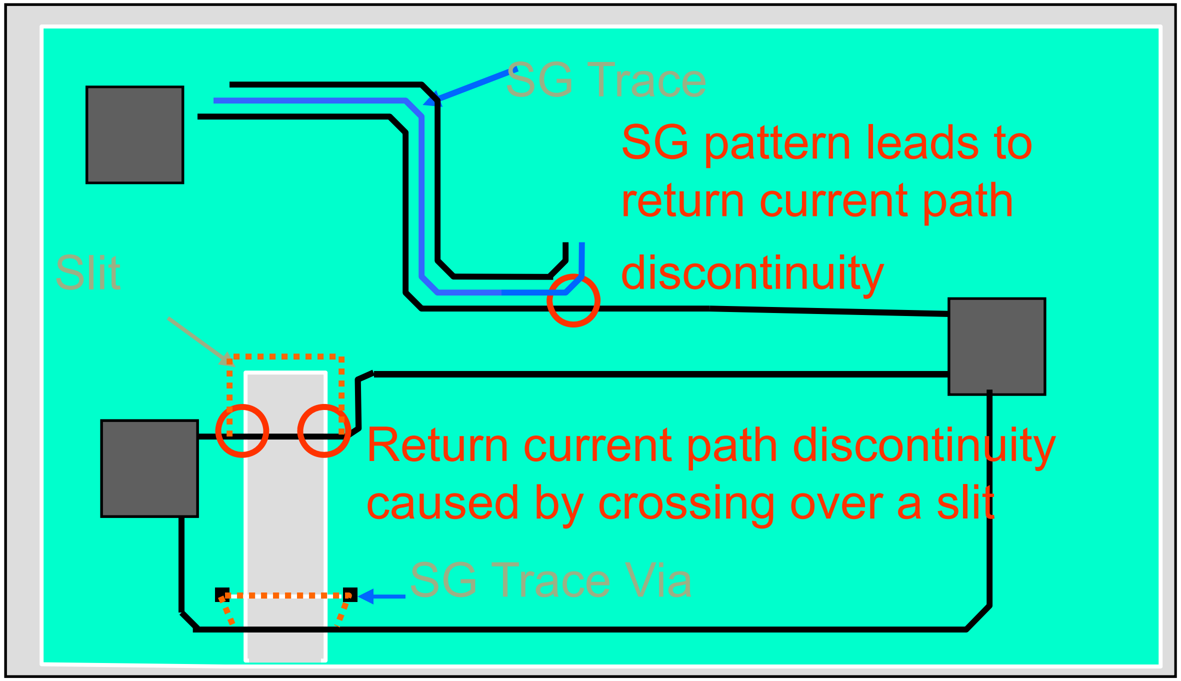
Add capacitor near the Via





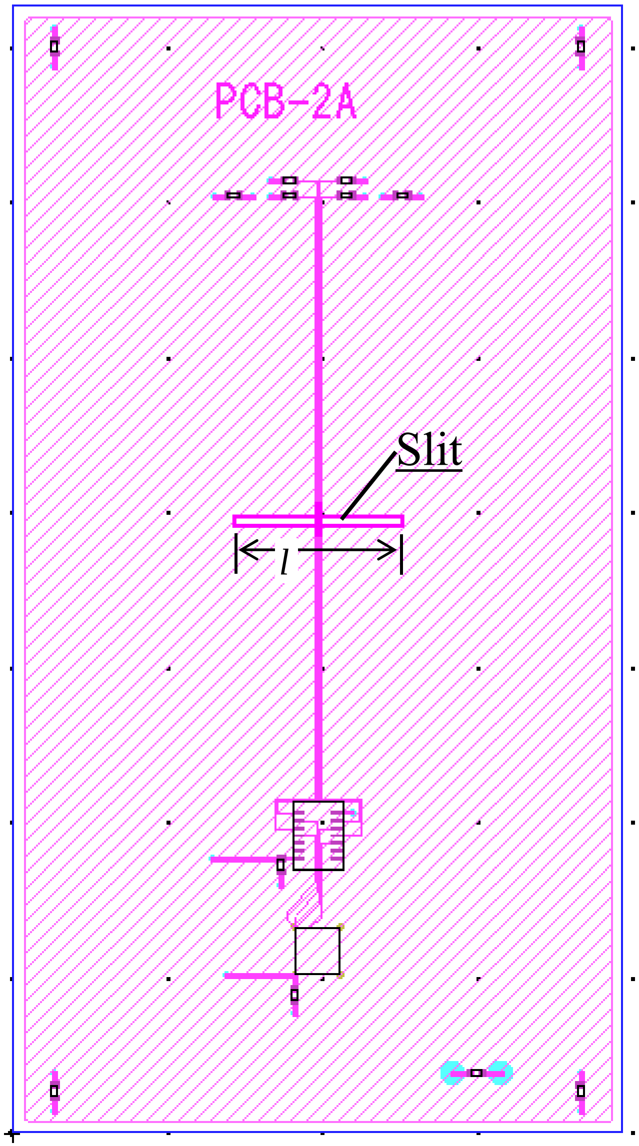
(2) Return Current Path Discontinuity

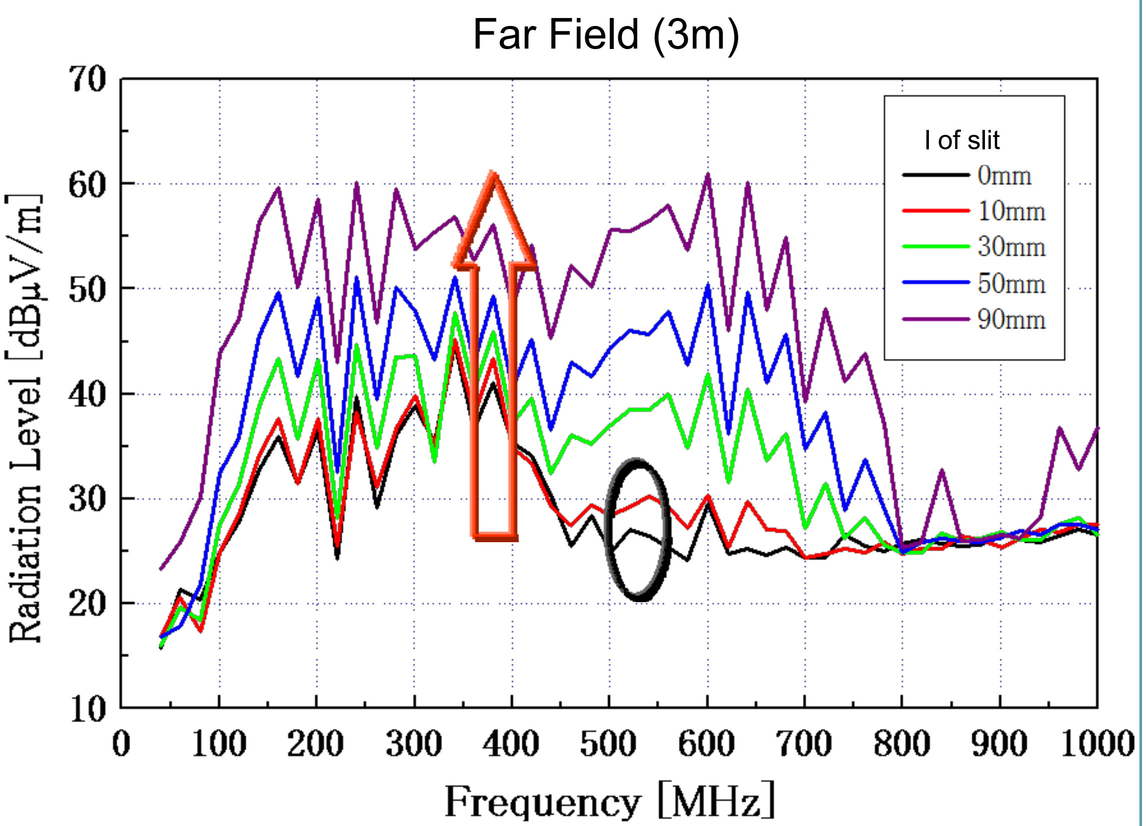
Return current path discontinuity →increases current loop area



Distance to hold return current path (Capacitor, Via) ≦Threshold value

The Amount of Radiation with Slit （Measurement Result）

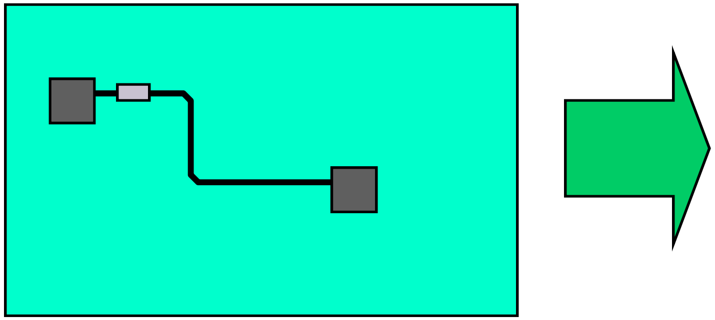


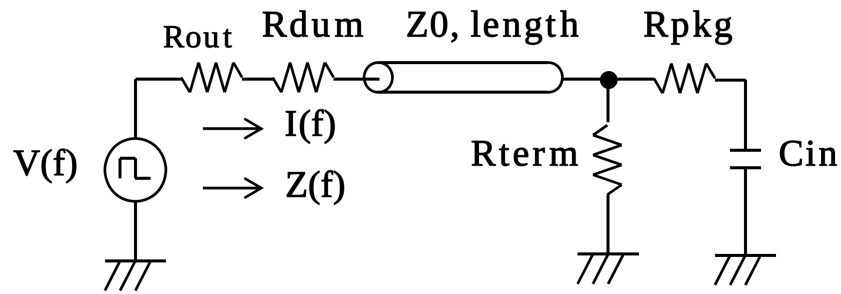


Amount of radiation is bigger if the slit length is longer.

(3) Estimated Radiation

(i) Differential-mode radiation is calculated using equivalent circuit





$$V(n\,f_0) = \left| 2\,V_{swing} \cdot duty \frac{\sin(n\pi \cdot duty)}{n\pi \cdot duty} \frac{\sin(n\pi\, t_r\, f_0)}{n\pi\, t_r\, f_0} \right| \qquad (n = 1, 2, 3, 4, \cdots)$$

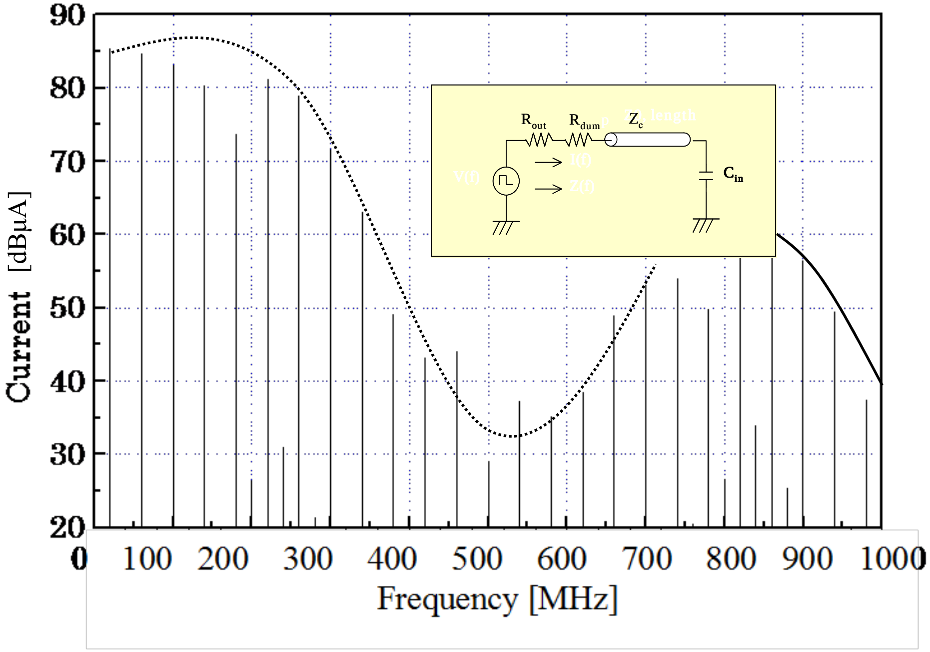
$$Z_{load}(f) = R_{term} \,||\, \left(R_{pkg} + \frac{1}{j\,2\pi\, f\, C_{in}} \right)$$

$$\beta(f) = 2\pi\, f \frac{\sqrt{\varepsilon_r}}{LightSpeed}$$

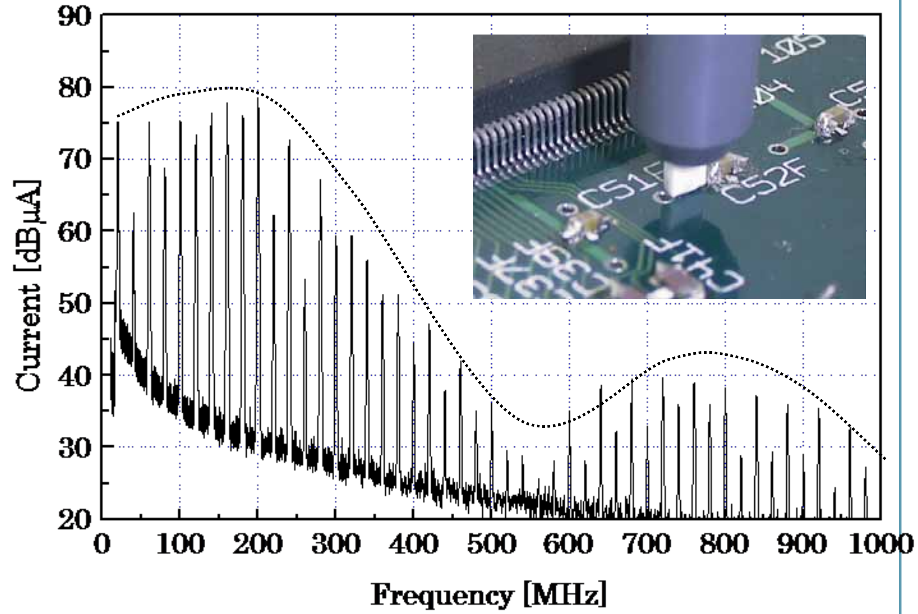
$$Z(f) = R_{out} + R_{dump} + Z_c \frac{Z_{load}(f) + j\,Zc \cdot \tan(\beta(f) \cdot length)}{Z_c + j\,Z_{load}(f) \cdot \tan(\beta(f) \cdot length)}$$

$$I(f) = \frac{V(f)}{Z(f)}$$

$$E(f) = 1.316858\mathrm{E}\text{-}14 \left(\frac{\mathrm{length} \cdot 2\,\mathrm{height} \cdot \mathrm{I(f)} \cdot \mathrm{f}^2}{dis\tan ce} \right)$$

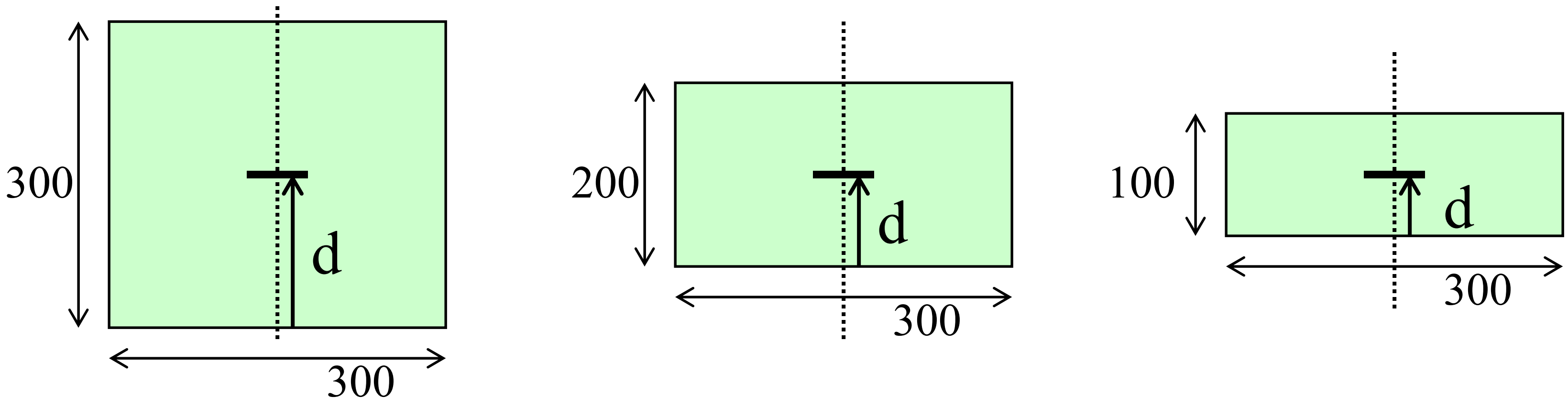


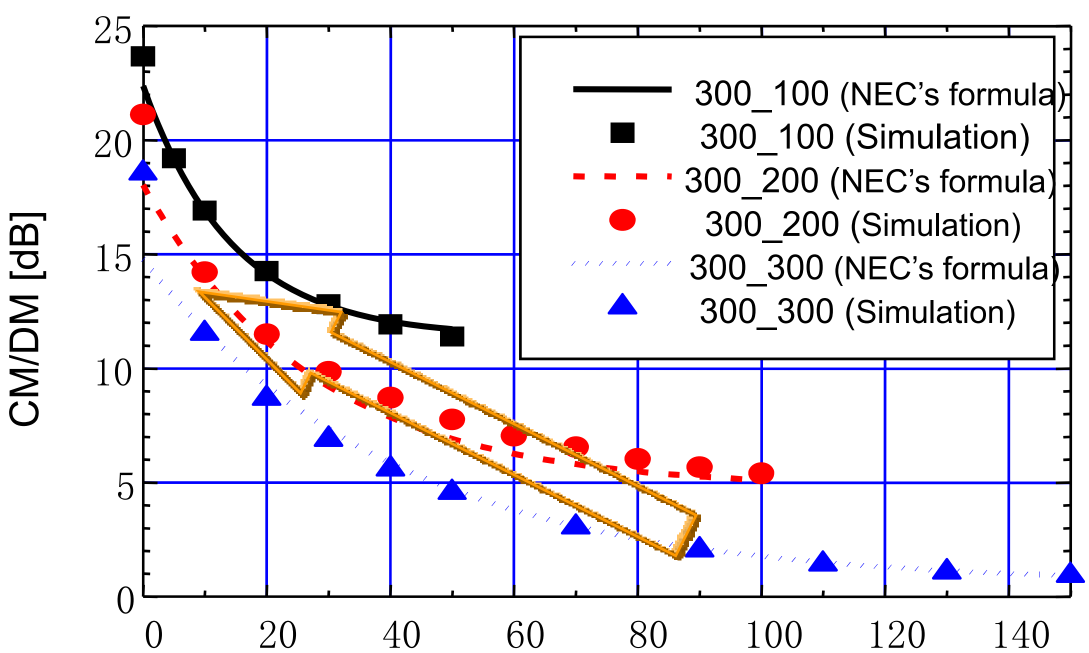
Simulation result with EMIStream



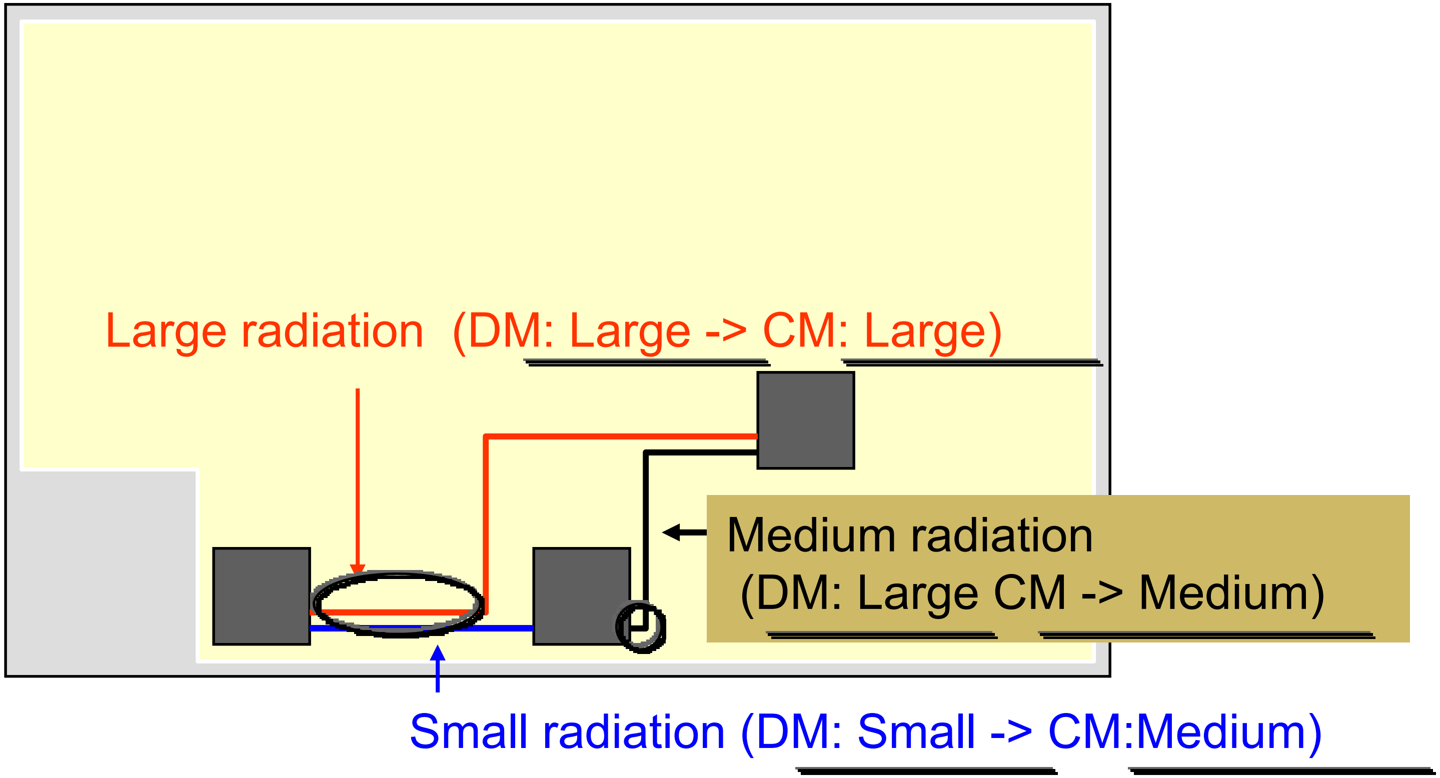
Measurement result using magnetic probe

CM/DM ratio: Dependent on trace position and board size





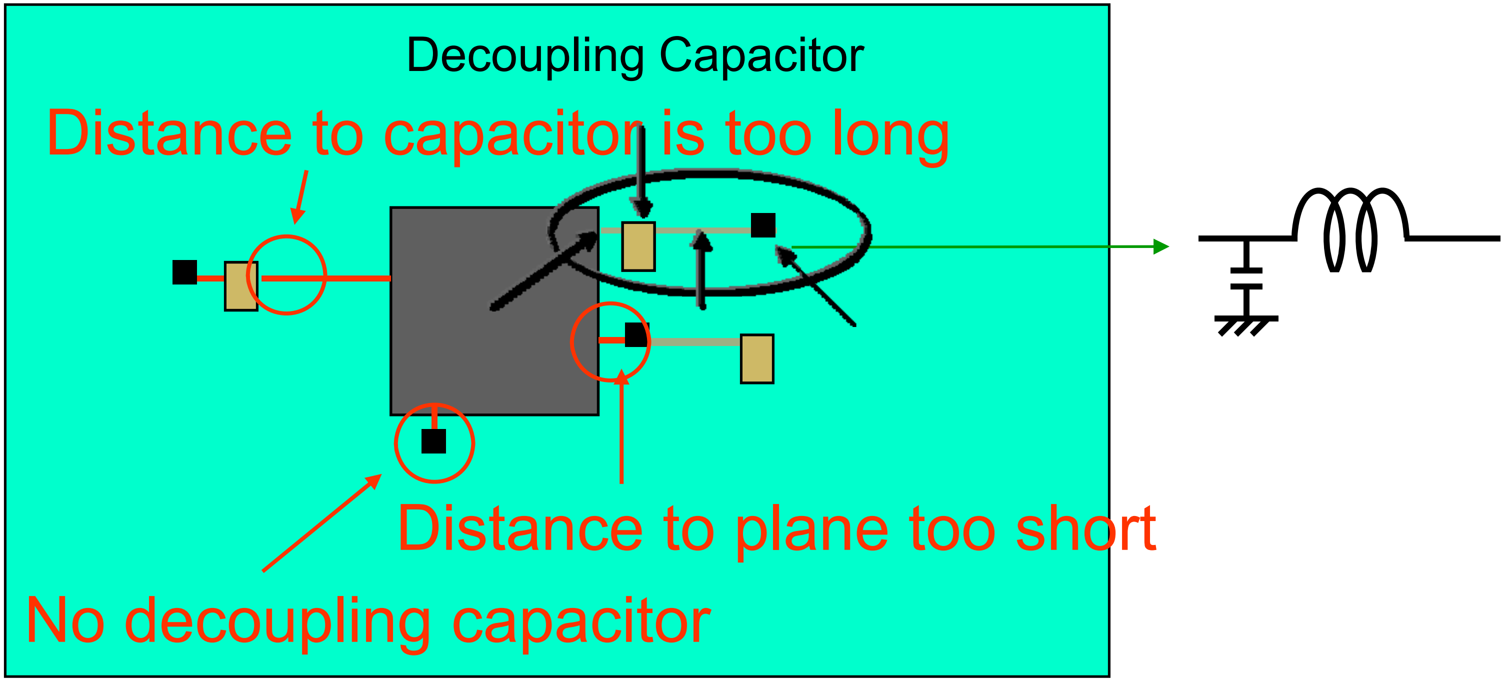
(ii) Estimated radiation of common mode based on differential mode



Total radiation =Differential mode radiation
+ Common mode radiation

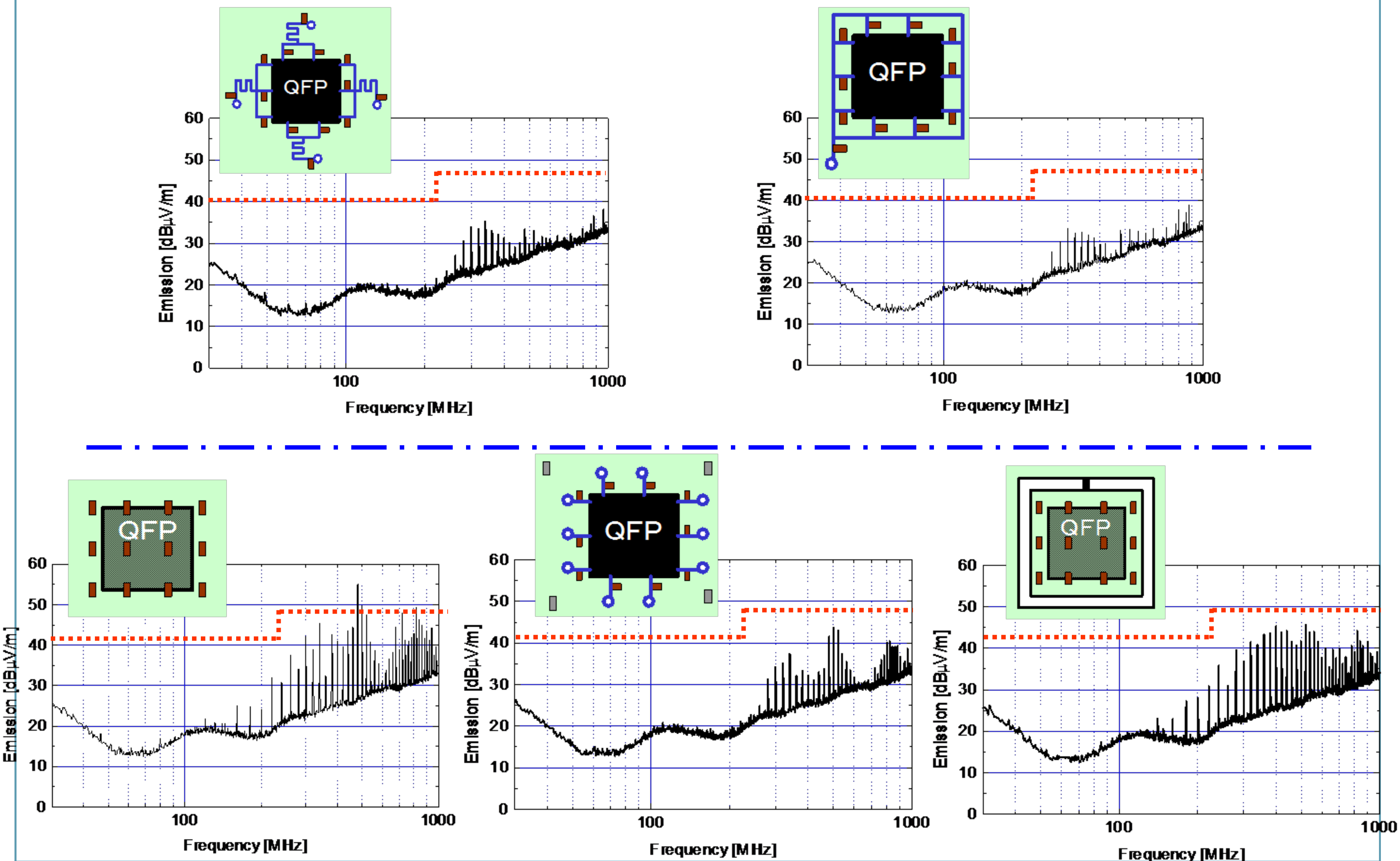
(4) Decoupling Capacitor

Incomplete Decoupling Capacitor →Excitation Point on Plane



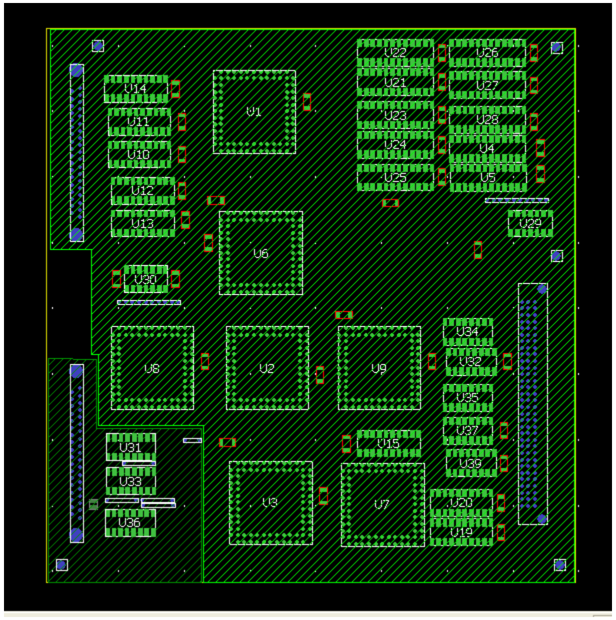
<u>IC power pin- decoupling capacitor ≦Threshold Value</u>

<u>Minimum≦ IC power pin – PWR plane ≦Maximum distance</u>

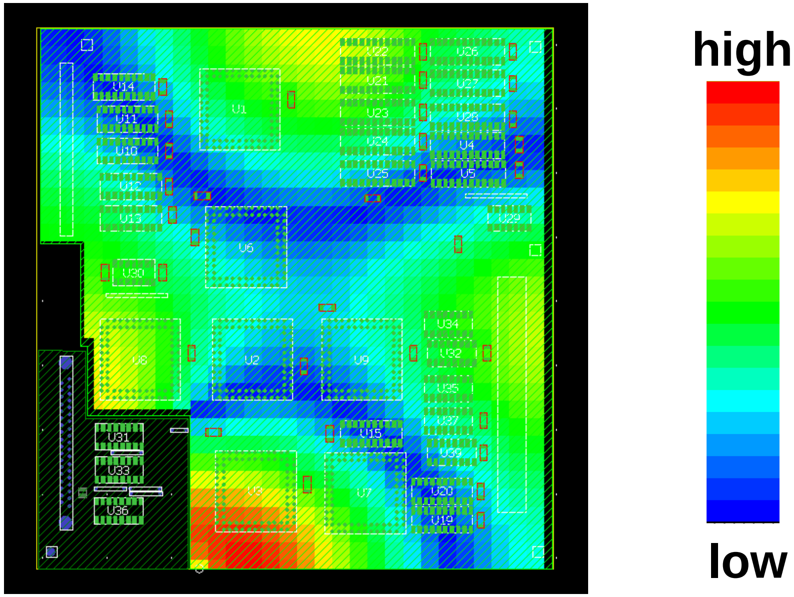

QFP
Emission [dBµV/m]
Frequency [MHz]
60
50
40
30
20
10
0
100
1000

Plane Resonance Analysis

Amount of EMI increases if resonance occurs between power and ground planes. EMIStream takes into account plane shapes, plane distance, and capacitors to analyze resonance based on the PEEC (Partial Element Equivalent Circuit) method.



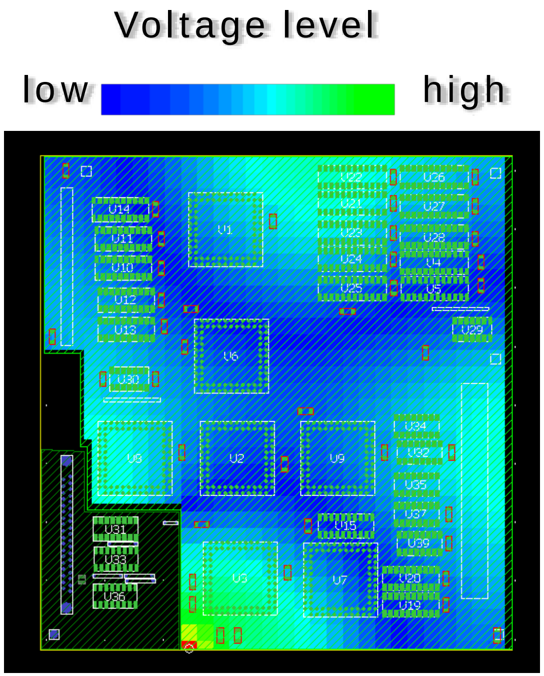
Board configuration

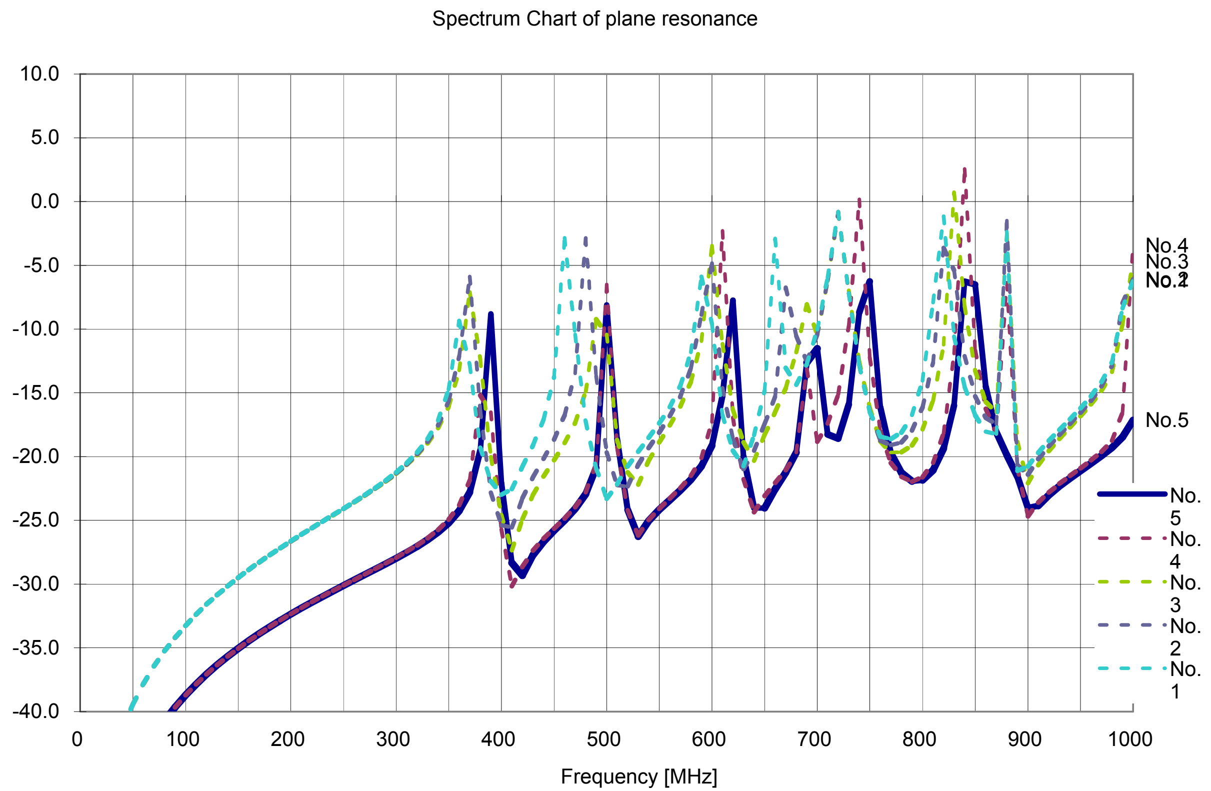


Voltage distribution

Plane Resonance Analysis

Reduce resonance using auto capacitor placement.
EMIStream **will automatically add capacitors until the resonance falls under the set maximum voltage.**



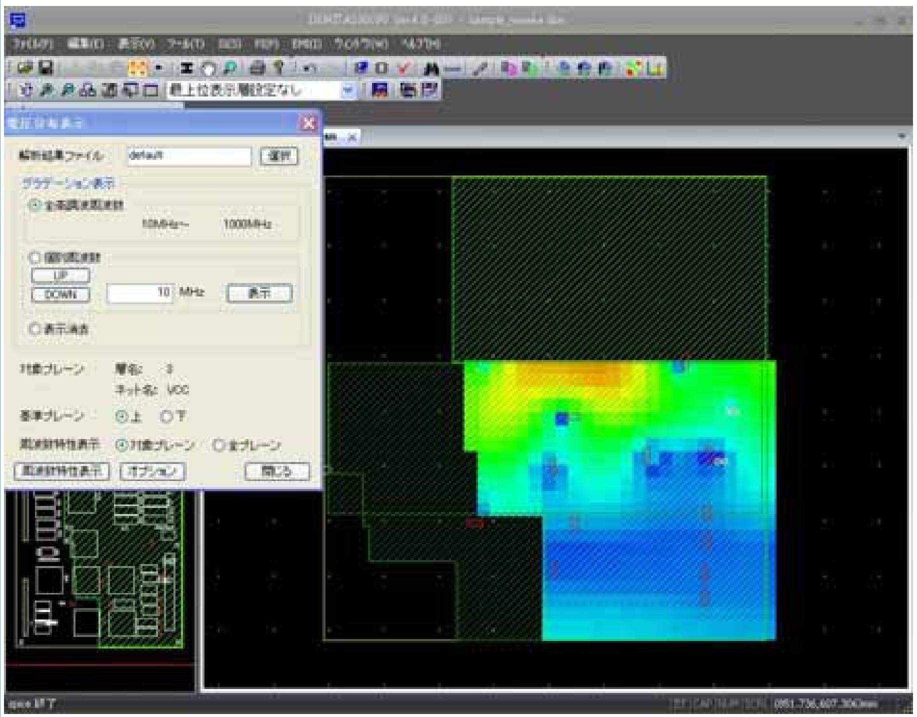


Expert Version Features

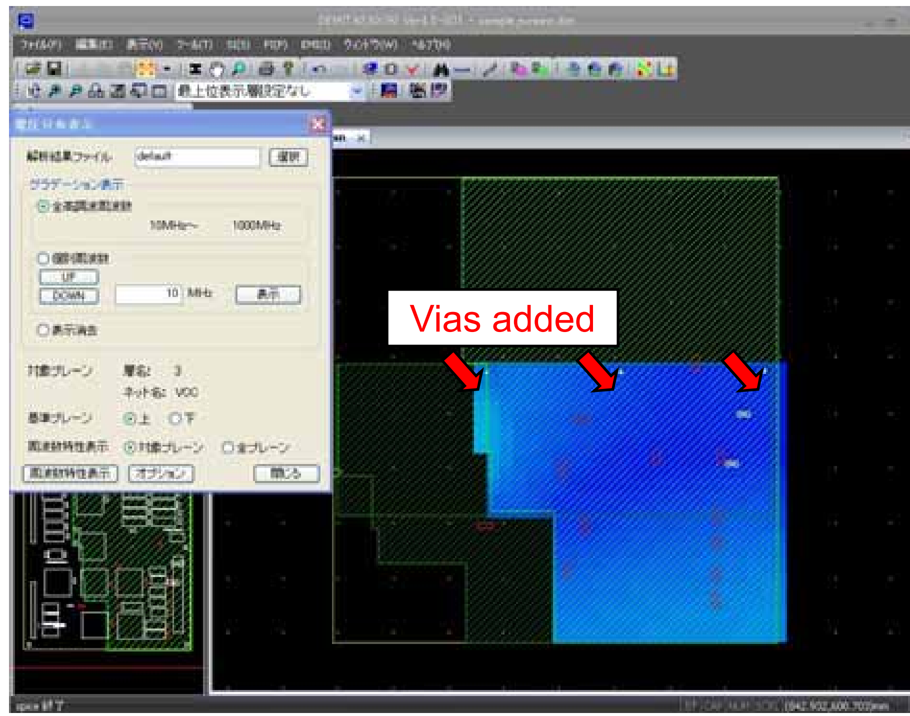
Multiple Layer Resonance Analysis

You can analyze multiple layers (G/V/G) at a time. Not only will you be able to reduce resonance by changing capacitor placement, but now *EMIStream* will also allow you take via placement into account and change/add location as needed.

Before



After

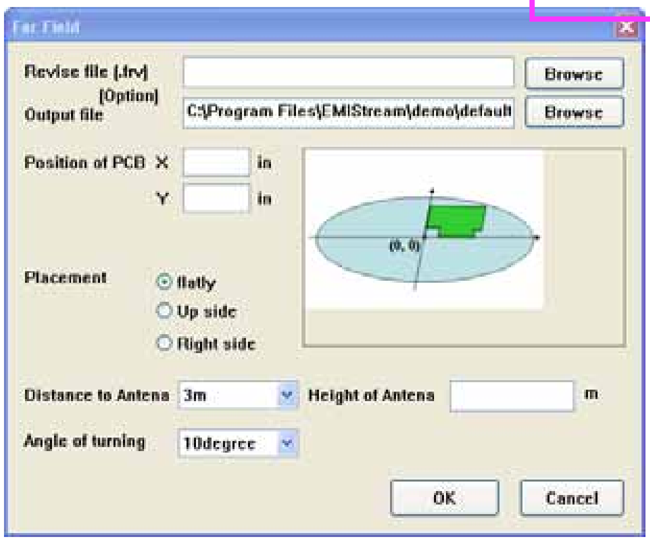


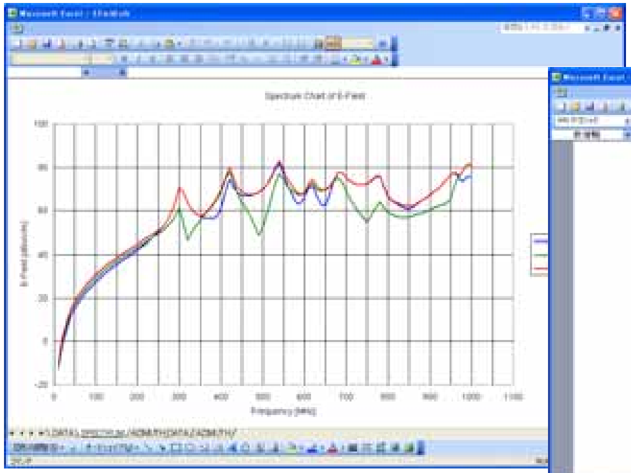
Expert Version Features

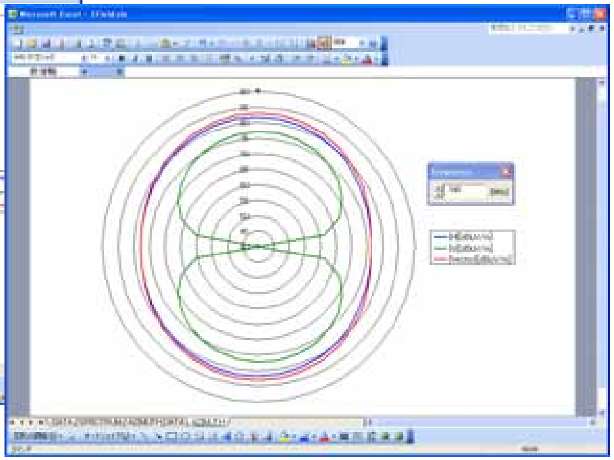
Power/Ground Resonance Analysis - Far Field EMI Calculation

Far field EMI is calculated by plane edge voltage (one pair of ground and power).

Horizontal/vertical frequency characteristics







Adjust position of PCB, distance to antenna, and antenna height

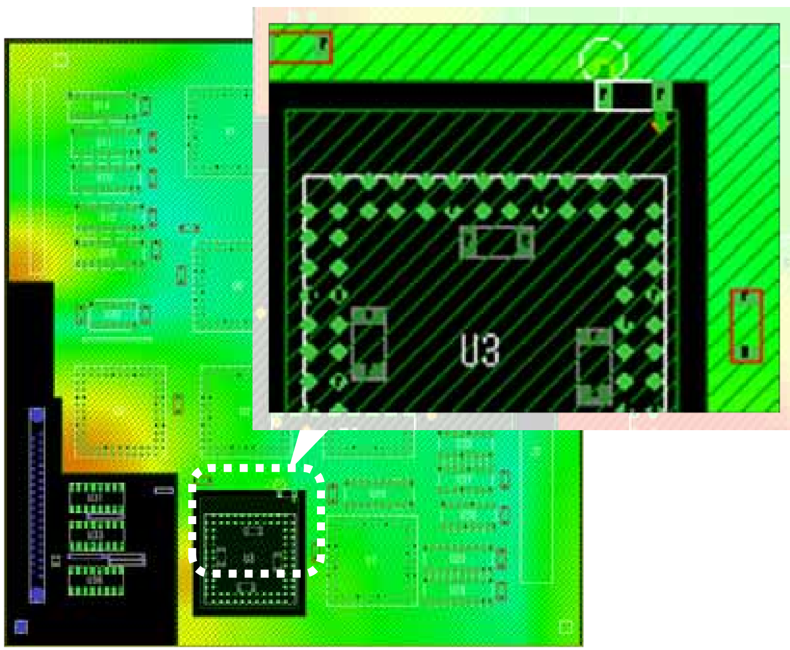
Azimuth pattern

V4.3 Enhancement

Plane Resonance Analysis: Inductor Models

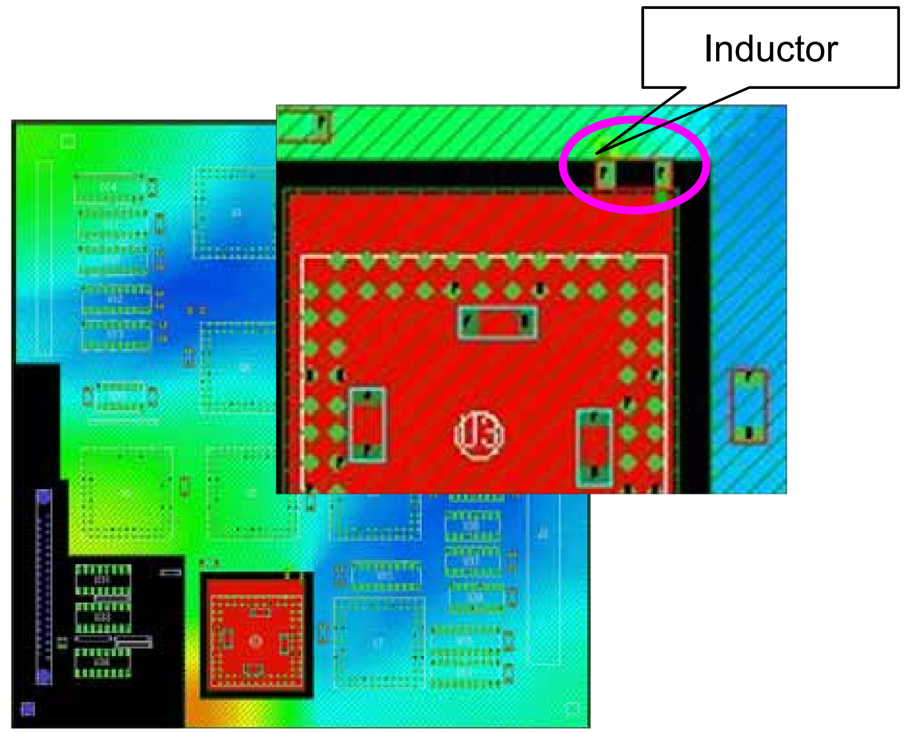
EMIStream will take into account inductors for Plane Resonance Analysis.

Before Inductor Modeling



Max Voltage: -10 dB

After Inductor Modeling



Max Voltage: -40 dB

ADTRAN: User Testimonial

Things ADTRAN Typically Review s to Cover EMC:

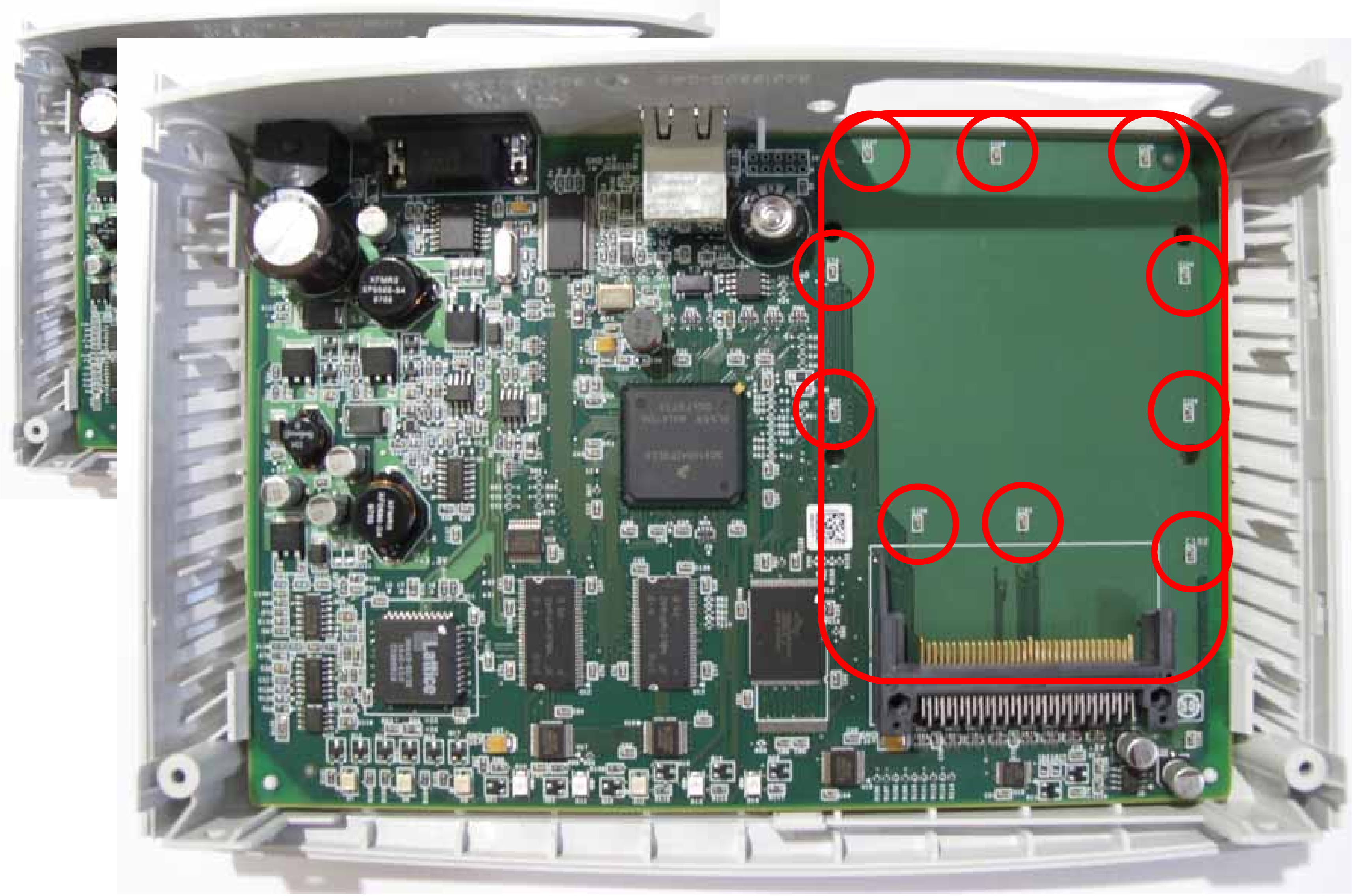
Schematic Concerns
Layer Stackup
Mechanical Concerns
Power Supply Layout
Electrostatic Discharge Protection
Clock Line Trace Length
Clock Line Via Count
Traces Near Plane Edges
Reference Plane Changes
Return Current Path Discontinuities
Signal Guard Traces
Signal Guard Trace Via Spacing
Grounding Vias Along Ground Plane Outline
Filter Component Placement
Decoupling Capacitor Placement
Differential Signal Mismatch
Cross Talk
Power / Ground Plane Resonance Analysis

4 To 8 Hour Review Manually

1 To 3 Hour Review With

EMIStream

ADTRAN: User Testimonial



ADTRAN: User Testimonial

Following the advice of Power Plane Resonance Analysis Auto Capacitor Placement they added capacitors.

Before | **After**

40 MHz Clock Harmonics (MHz)

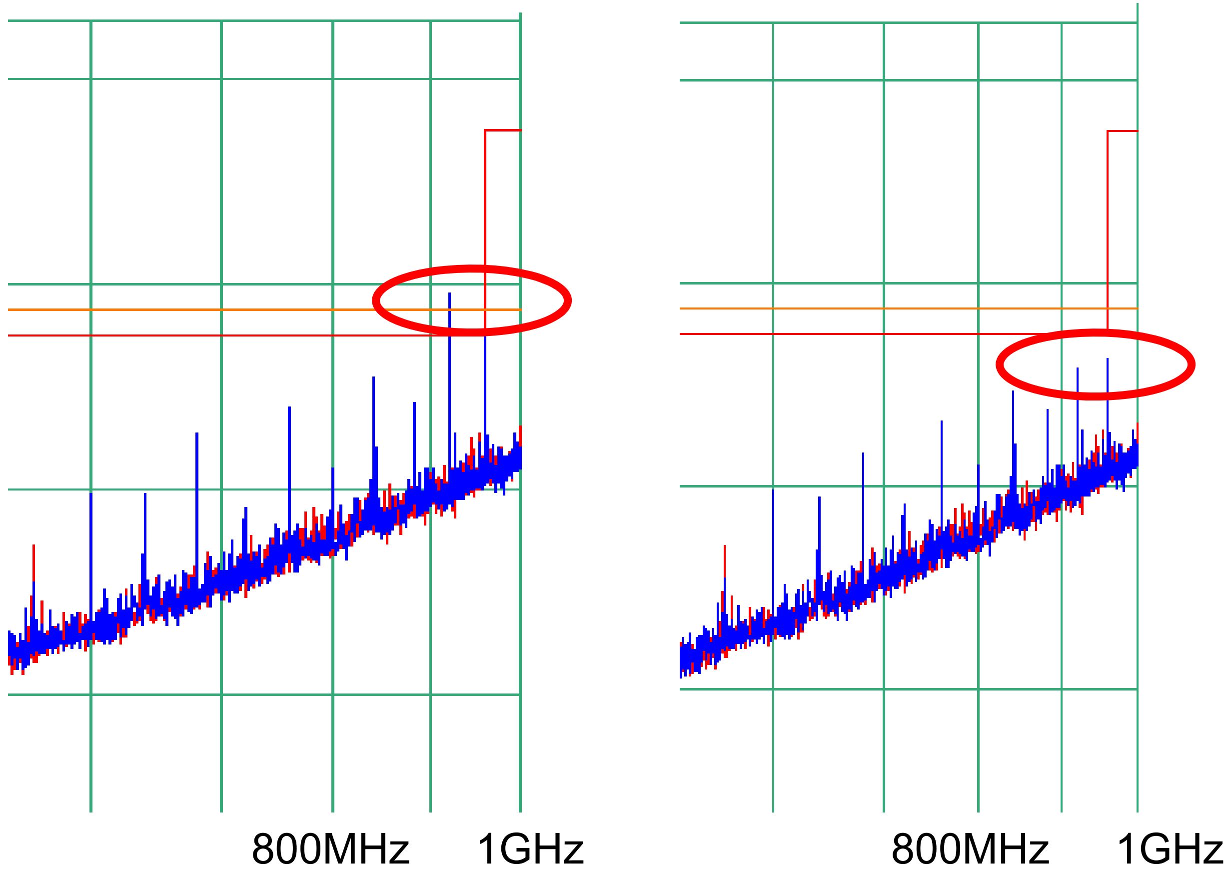
800

840

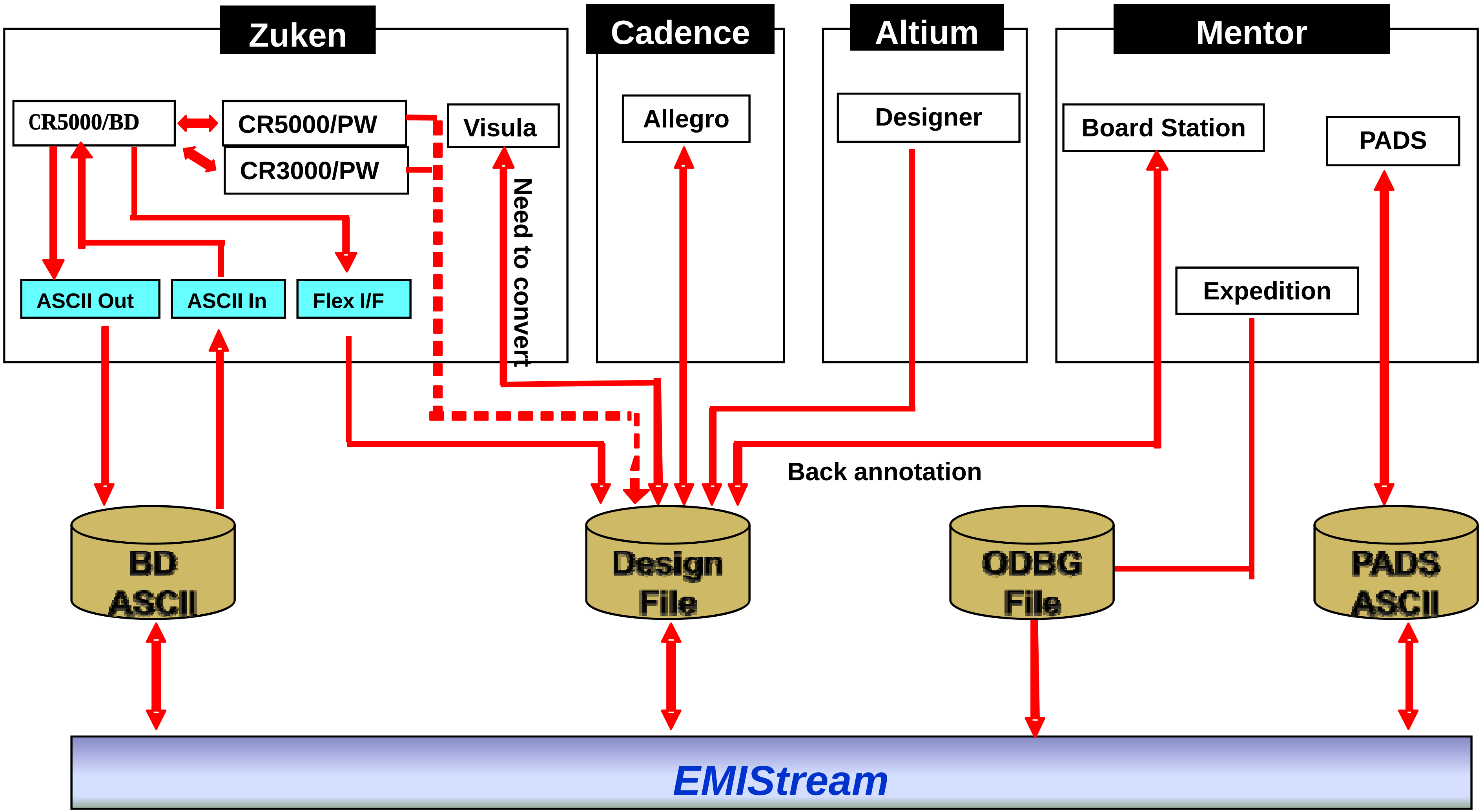
880

920

960



Layout CAD Interface



Thank you!!!

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