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EMC Expert System for Architecture Design

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BITS & CHIPS HARDWARE CONFERENCE

Agenda
"EMC Expert System for Architecture Design"

- Trends & Needs
- EMC Expert System approach
- EMC Design Rules
  - At PCB level
  - At Cable level
  - At Enclosure level
- Demo Cavity Resonator
- Summary

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Trends & Needs

- **TRENDS**
  - Semiconductors technology: frequencies increase and rise/fall times decrease (ITRS)
  - CISPR 22 / 32 emission standard for multimedia products:
    - October 2011 upper test frequency raised from 1 to 6 GHz
    - To minimize interference in GHz communication bands
- **NEEDS**
  - New EMC design guidelines for high-speed interfaces (up to 6 GHz)

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Trends: Semiconductors technology*

	2007	2010	2015	2020
Transistor gate length (nm)	32	24	15	10
On-chip local clock (GHz)	4.7	5.9	8.5	12.4
Chip-to-board (GHz) High-speed differential buses (point-to-point)	4.9	9.5	29.1	55.8
Equiv. switching edge rate (ps)	65	34	11	6
Supply voltage (V)	1.1	1.1	1.0	0.8

*Source: International Technology Roadmap for Semiconductors 2010

Frequencies ⇧, Rise/fall-times ⇩ } EMISSION ⬆

Supply voltages ⇩, Noise margin ⇩ } IMMUNITY ⬇

SIGNAL / POWER INTEGRITY PROBLEMS ⬆

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EMC Expert System approach

Objectives

- Develop modeling & simulation framework to predict radiated emission behavior at system level (PCB – cable – enclosure)
  - Implement in 3D EM simulation tool CST MICROWAVE STUDIO®
- Apply Expert System to specific application cases
- Develop quantitative guidelines for system architectures ⇒ Design Guide

Focus on maximum radiated emission according CISPR 22 / 32, 30 MHz – 6 GHz, 10 m distance

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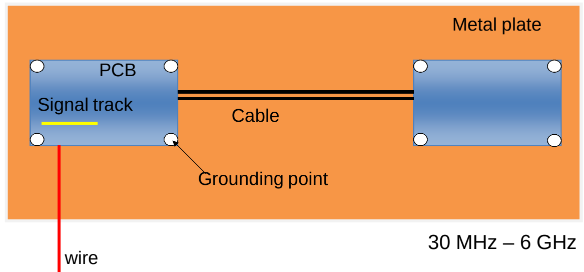
EMC Expert System approach

General modeling framework



Make the model as simple as possible, but no simpler!

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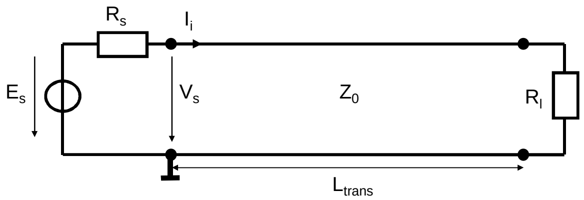
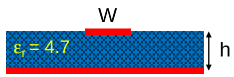
Source model



Transmission line on PCB/cable (microstrip):

E_s = 1 V (30 MHz – 6 GHz)
R_s = 50 Ω
R_l = 50 Ω (matched transmission line)
Z_0 = 50 Ω (characteristic impedance; h/W ≅ 0.6)
I_s = signal current = 1/100 = 0.01 A



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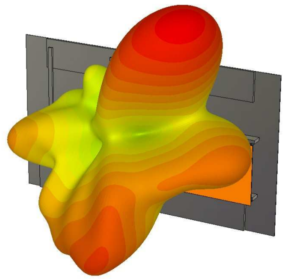
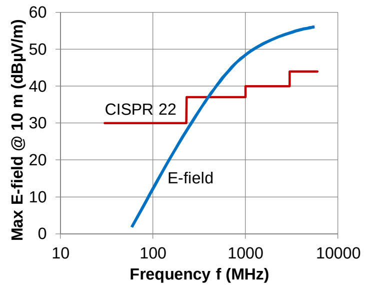
Simulation output: maximum radiation



Radiation pattern at 1 GHz



Max E-field on sphere with radius 10 m as a function of frequency

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Simulation cases

Max radiated field at 10 m from source

Parameter studies

- Single board
  - Track length, height above ground
  - Distance track to board edge (20h-rule)
  - Wire length
- Cable
  - Microstrip vs. co-planar strip
  - Size pig tail
- Enclosure
  - With and without metal plate; amount of ground connections
  - Distance PCBs and cable to metal plate

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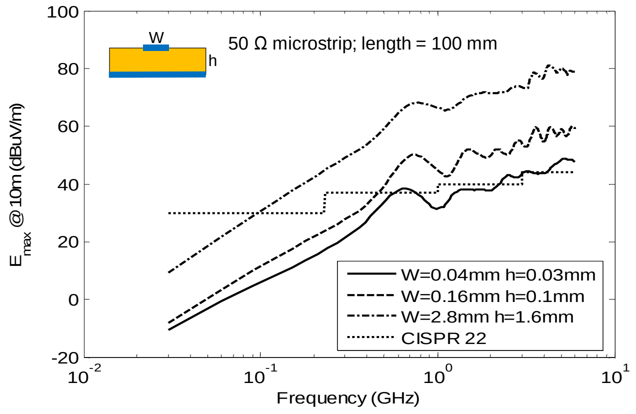
PCB design rules: *Track height*



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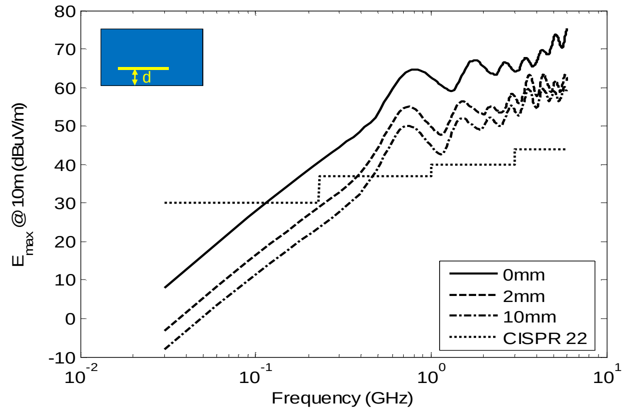
PCB design rules: *Edge distance*



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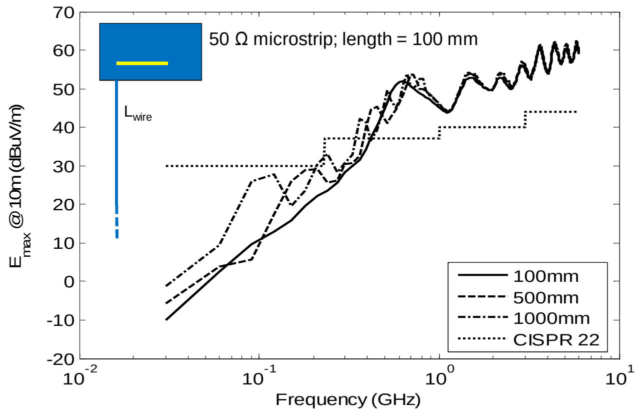
PCB design rules: *Ground wire length*



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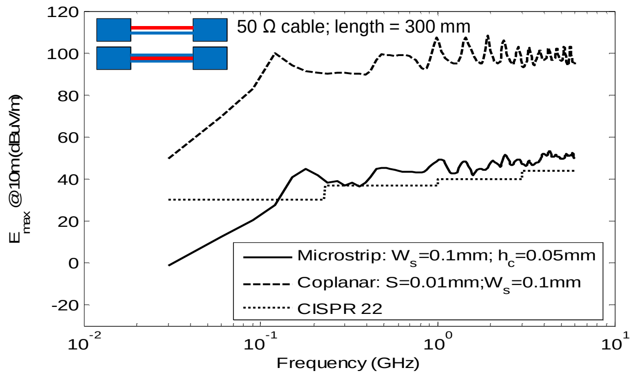
Cable design rules: *Microstrip vs. co-planar strip*



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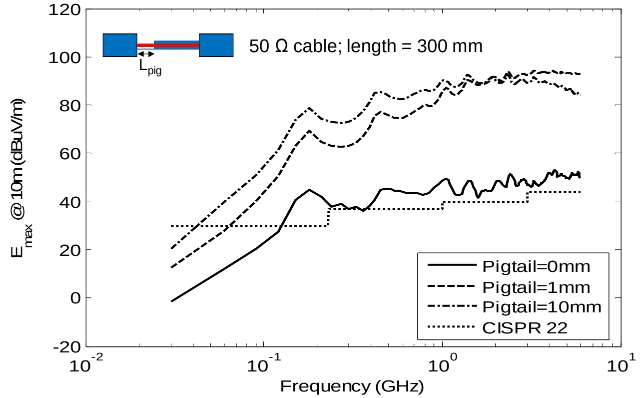
Cable design rules: *Pigtail size*



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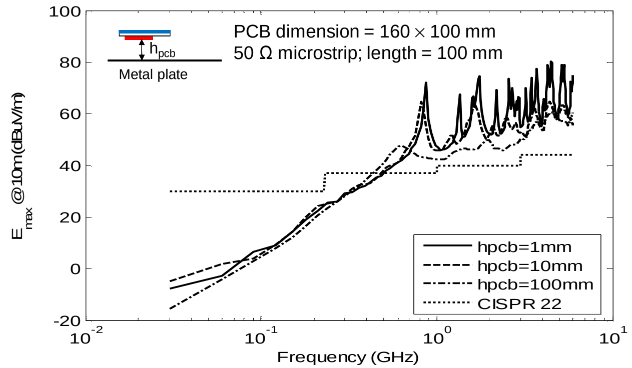
Enclosure design rules: *PCB height above metal plate*



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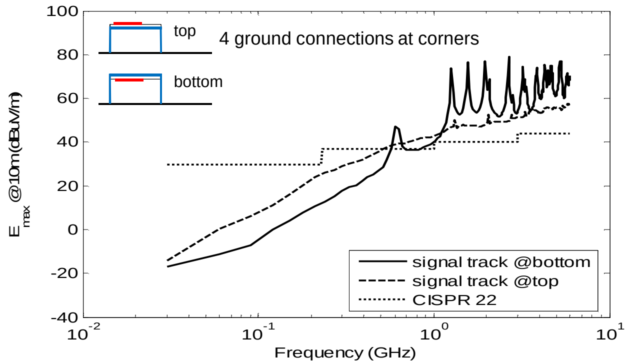
Enclosure design rules: *Signal track at top or bottom*



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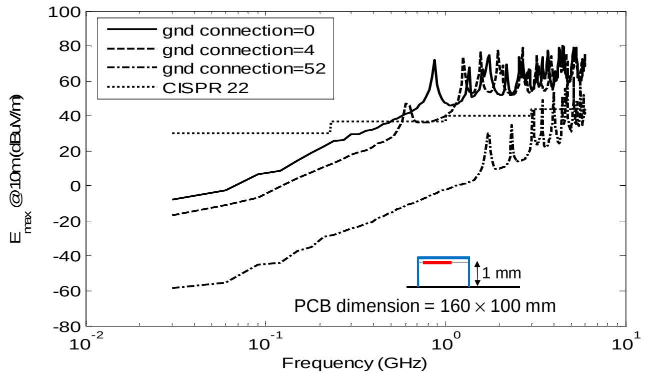
Enclosure design rules: *Number of grounding connections*



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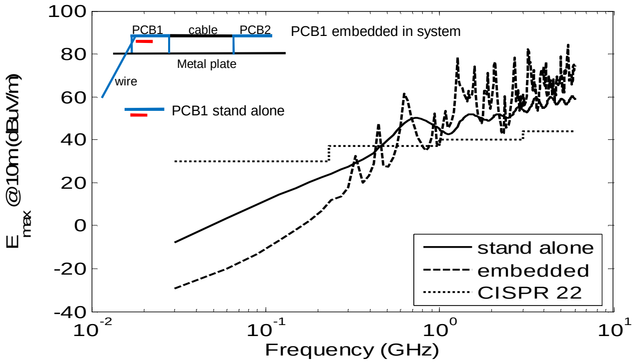
Enclosure design rules: *Complete architecture vs. PCB alone*



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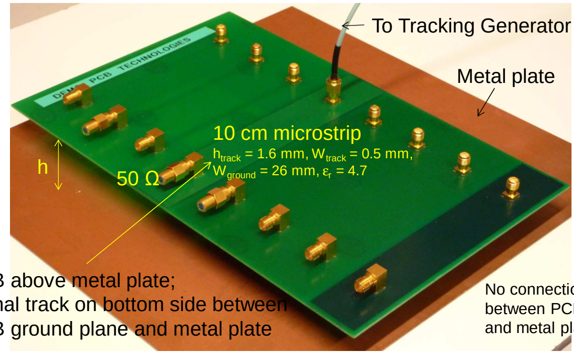
Demo: radiation cavity resonator

Test Set-up PCB above metal plate



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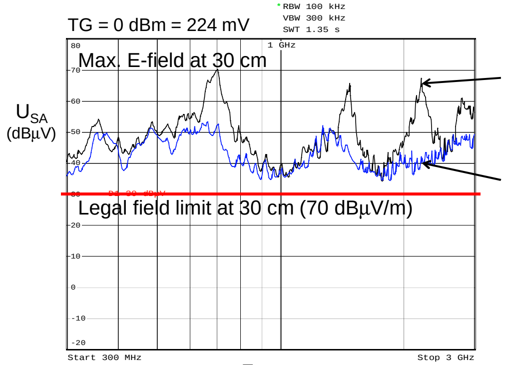
Demo: radiation cavity resonator

PCB 2.6 mm above metal plate vs. no plate



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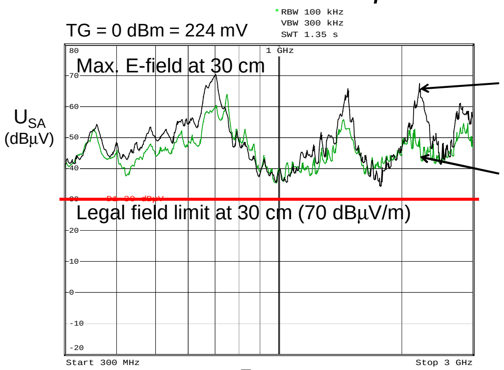
Demo: radiation cavity resonator

PCB 2.6 mm above metal plate vs. 14 mm



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Summary

- ➢New quantitative EMC design guidelines at board, cable and enclosure level have been developed with 3D EM simulations.
- ➢With these guidelines electronic designers can make the right choices during the early architecture phases:
  - PCB technology?
  - Routing critical signals?
  - Cable/connector technology?
  - Additional shielding measures?
  - Position PCBs, cables, and metal plates?
  - Number of grounding connections?
  - Etc.

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Thank you for your attention !

Questions ?

Paper APEMC 2011 Korea (Jeju) "EMC Expert System for Architecture Design", Marcel van Doorn

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Acknowledgement

This work is supported by the Eniac Joint Undertaking project Enlight: *Energy efficient and intelligent lighting systems*

eniac JOINT UNDERTAKING

ENLIGHT Energy efficient & intelligent lighting systems

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