



CST


Simulation of PCB Emission

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EMC LIVE

INTRODUCTION

WORKFLOW

EXAMPLE

EMC LIVE

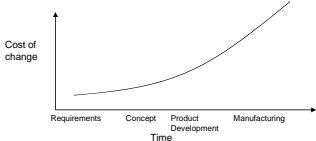
INTRODUCTION

EMC LIVE

EMC Simulation in the Design Process

EMC at all Stages of the Design Process

- multiple troubleshooting iterations
- high effort and costs to correct
- delayed time to market



EMC LIVE

EMC Simulation in the Design Process

Design stage

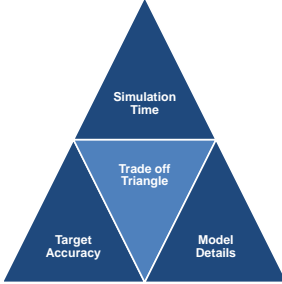
- can accompany the design process and be employed at an early design stage
- can give answers to fundamental "what if" questions
- can deliver output not accessible by measurements
- can be performed without a prototype

Troubleshoot

- can help to understand behavior of the device
- Not a competitor to measurements, both should be used complementary

EMC LIVE

Model Accuracy




Source: Madjid Mahmoudi

EMC LIVE

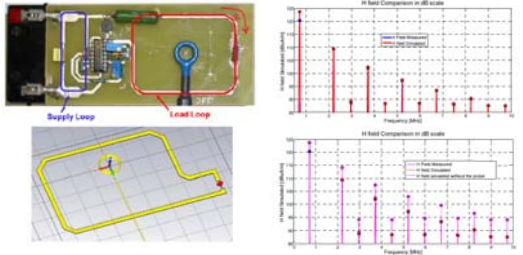
EMC Simulation in the Design Process

Measurement	Simulation
<ul style="list-style-type: none"> Used and relied on for over 50 years Measurement devices are physical objects Ideal conditions are difficult to produce Information about the products is not necessary 	<ul style="list-style-type: none"> Rarely used in EMC industry until 6-7 years ago Measurement devices can be infinitesimally small Ideal conditions are easy to produce (non-ideal is difficult) Only as accurate as the input provided


Source: Scott Piper



Simulation vs. Measurement




EM emissions induced by a DC/DC power converter.
G. Chiappori, S Baranowski, O Cohn,
Proc. of the 2014 International Symposium on Electromagnetic Compatibility (EMC Europe 2014), Gothenburg, Sweden, September 1-4, 2014




Simulation Types

Functional Simulation	EMC Simulation
Regulator modules modeled in full detail - Including control algorithms	Regulator modeled as a simplified source
Connection between components is ideal	Effect of the physical connection on the board included in the simulation
Surrounding Environment not included	Surrounding Environment important

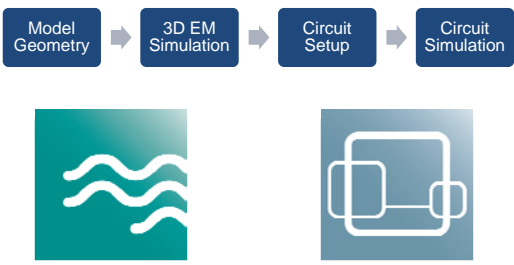

Use the switching waveform from the functional simulation to drive the EMC simulation



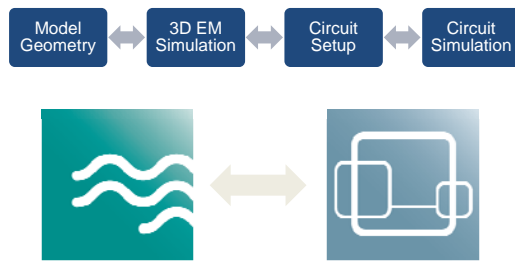

WORKFLOW



Workflow for Emission Simulation

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Workflow for Emission Simulation

Each step has different time requirements

- CPU time vs. engineering time
- Modern user interface is required

Workflow for Emission Simulation

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Combination of 3D EM and circuit is highly efficient

- 3D more time consuming than circuit
- 3D analysis runs unattended during off time
- Circuit simulation used interactively

3D Solver

T

Time Domain

- Ports sequentially but broadband
- Robust meshing, automatic adaptation is time consuming
- Efficient for high geometric complexities
- Slows down at low frequencies
- High Q structures increase simulation time
- Great speedup with GPU

F

Frequency Domain

- Frequency samples sequentially but additional ports not time demanding
- Mesh generation sometimes difficult, but adaptation automatic
- Slows down for high geometric complexities
- Works well below 1 MHz
- Deals well with high Q structures
- Good speedup multi core usage

Circuit Simulation

S-Parameter

- S-Parameter calculation.
- Use for: Antenna matching networks, filter design, cascading of blocks.

AC small signal, Combine results

- AC analysis in frequency domain.
- Voltages and currents in frequency domain at ports and probes.
- Possibility to combine monitor results from the 3D simulation.
- Use for: General electronics applications.

Transient

- Circuit time domain analysis. Arbitrary signals.
- Voltages and currents in time domain at ports and probes.
- Allows inclusion of non-linear elements (diodes, transistors, e.g.). True transient simulation possible.
- Use for: Signal integrity (eye diagram), switching elements.

Combine Results

Combine results

- Calculate 3D field distribution considering an attached circuit
- Apply linear superposition in post-processing

3D EM solver calculates field pattern

- Each port excited separately, other ports passive

Combine Results


AC Analysis calculates the voltages/currents at each pin.

- This excitation is applied to the field patterns of all ports

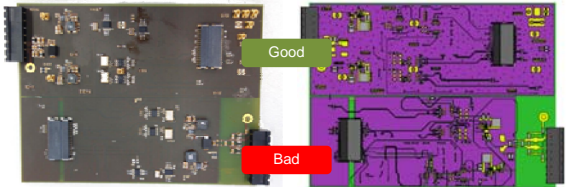
Field results at the speed of a circuit simulation

- No 3D solver run, just post processing
- Even for highly complex models just a few minutes



EXAMPLE



Demonstrator



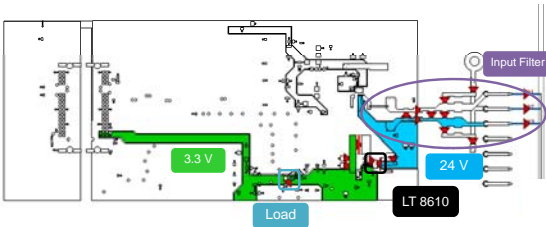

Jens Krämer
Pietro Luzzi

Conducted Emission

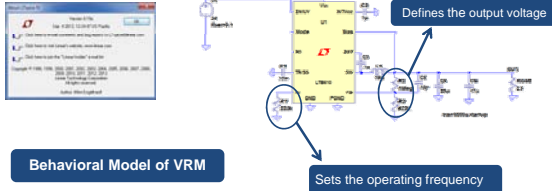
3D simulation in CST Microwave Studio

- Frequency Domain Solver – 47 minutes simulation time





Conducted Emission

LT Spice – Design Tool provided by Linear Technology



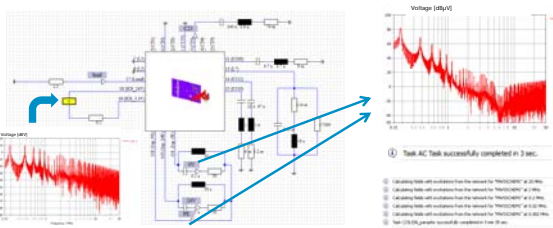
Behavioral Model of VRM




Conducted Emission

Circuit simulation in CST Design Studio

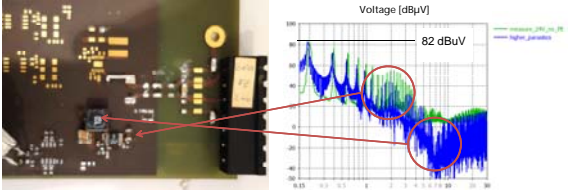

- AC, small signal analysis



Task AC Task successfully completed in 3 sec.

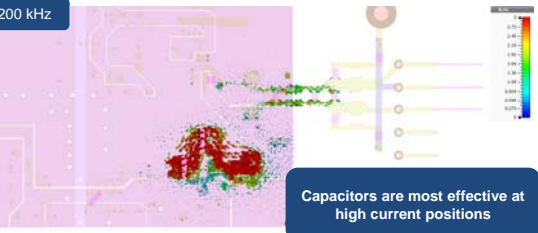


Conducted Emission





Conducted Emission

200 kHz



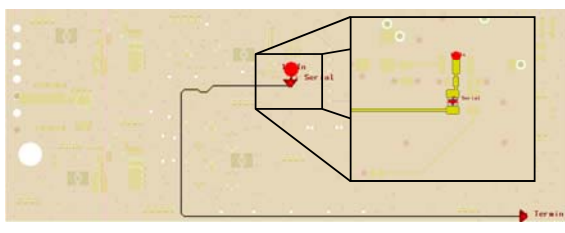
Capacitors are most effective at high current positions




Radiated Emission

3D simulation in CST Microwave Studio

- Time Domain Solver – 31 minutes simulation time (2 GPU's)





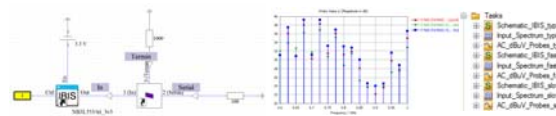
Radiated Emission


Circuit simulation in CST Design Studio

- Transient signal integrity – 42 sec
- AC, small signal analysis for combine results – 37 sec

System Assembly Modeling

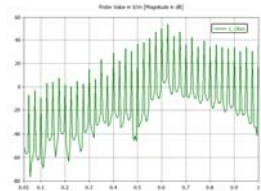
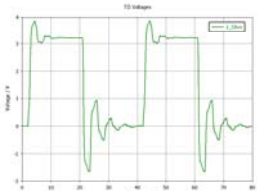
- Advanced management of simulation tasks






Radiated Emission

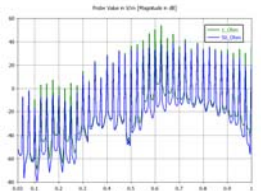
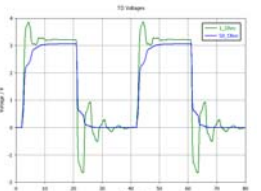
Variation of series resistor







Radiated Emission

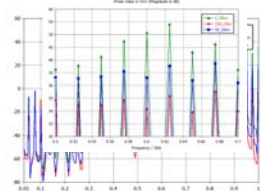
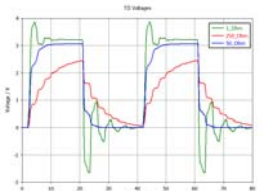
Variation of series resistor








Radiated Emission

Variation of series resistor



SUMMARY



Summary

Simulation and Measurement


- Complementary tools

Workflow for Simulation of Emission

- Coupled 3D and circuit simulation
- Combine Results

Example PCB

- Conducted Emission
- Radiated Emission



FOR MORE INFORMATION VISIT
www.emclive2014.com