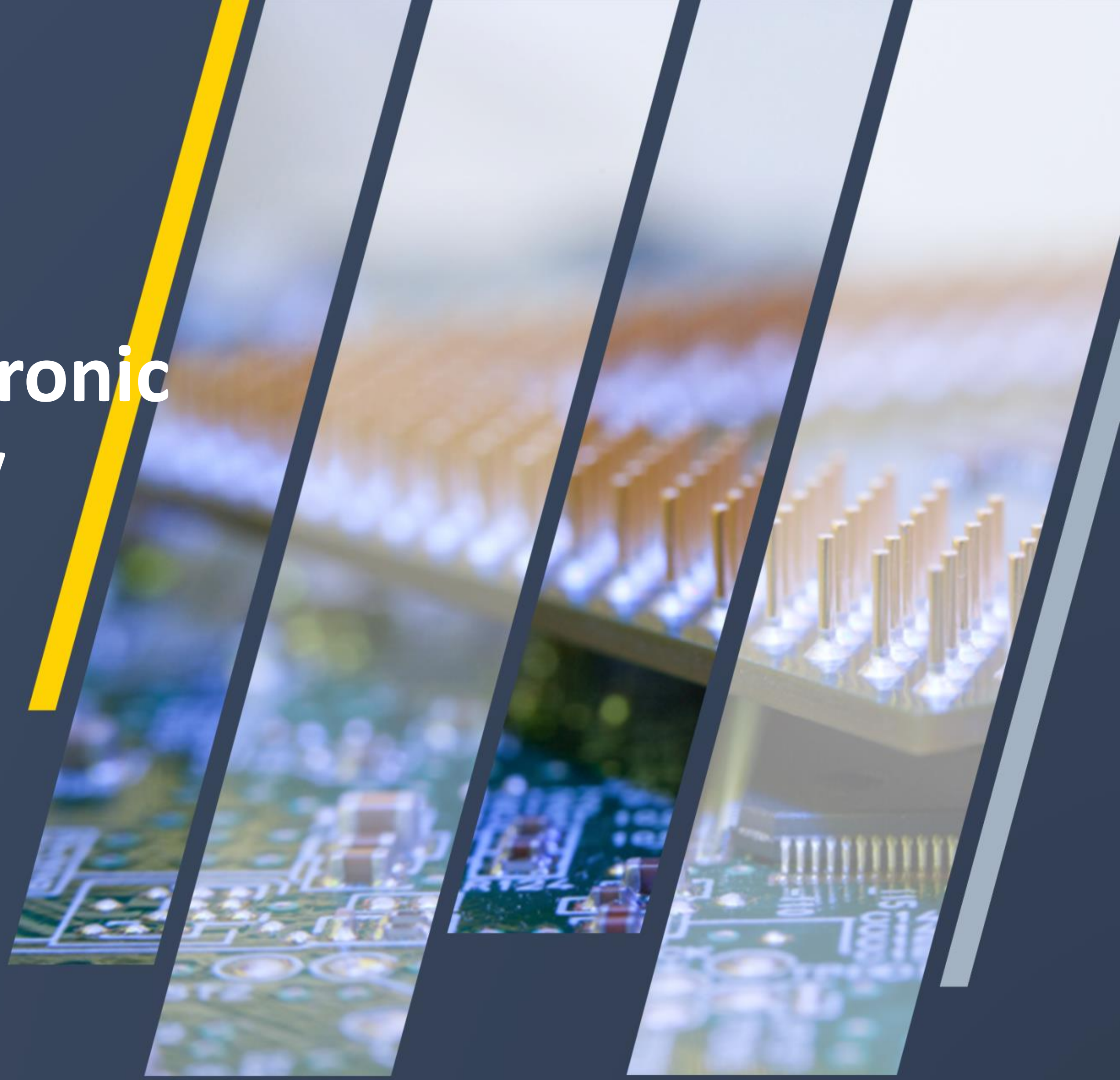
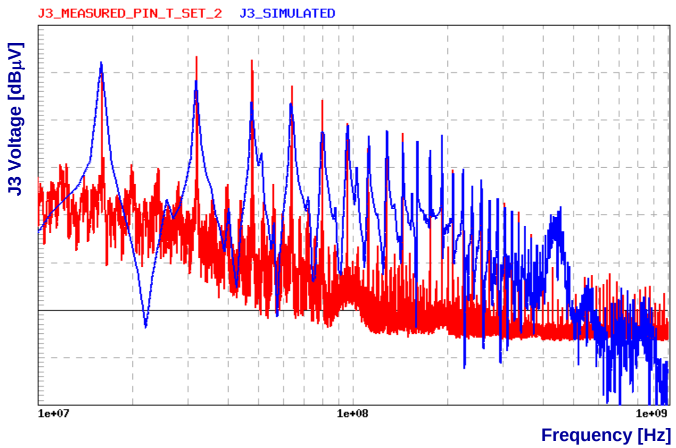
Increasing Reliability of Electronic Systems : EMC and Immunity Analysis

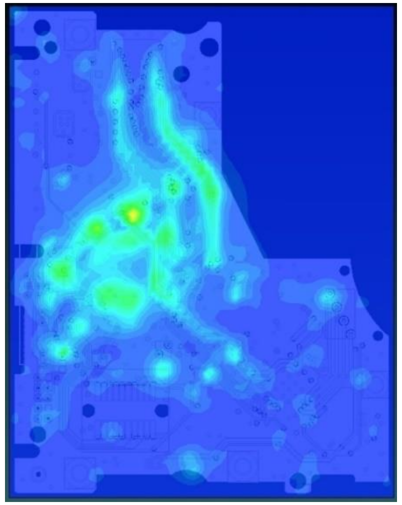


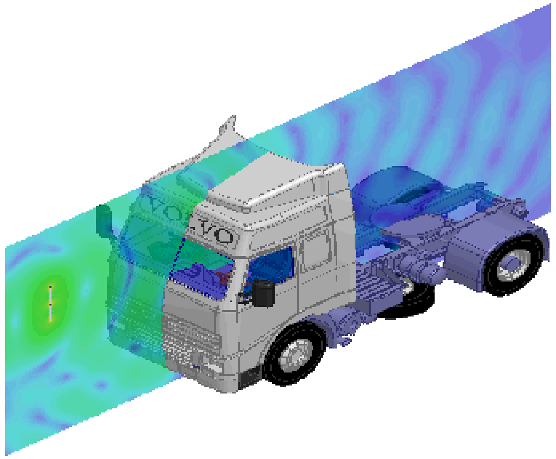
Markus Laudien, Ansys Germany

Agenda

- **Requirements and Importance for EMC characterization**
- **Terminology and Applications**
- **Example Cases ANSYS solutions and value for the user**





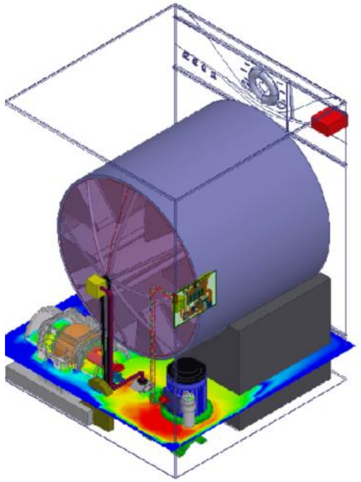


Why do we buy a tech product

A smartphone

A car

A washing machine



… usually not because of a EMC specification within the system

… so how important are EMC requirements for a system ?

Overview : some important EMC standards

Standards about EMC measurement are typically defined by committees of members of electronic industry, for example

- **CISPR** is the acronym of **C**omité **I**nternational **S**pécial des **P**erturbations **R**adio or the International Special Committee for Radio ProtectionExample Cases ANSYS solutions and value for the user

  CISPR 25 (for vehicles, boats, combustion engines); CISPR 32 Electromagnetic compatibility of multimedia equipment
- **IEC** is the acronym **International Electrotechnical Commission** most relevant is the IEC 61000 family which describes Measurent procedures for various applications
- **ISO** is the acronym **I**nternational **O**rganization for **S**tandardization most common for EMC measurement for vehicles is **ISO 11451 (-1, -2 .. -4)**
- **MIL (United States Military Standard)** common are **MIL-STD-461 (**EMC for components and subsystems) MIL-STD 464 (EMC for Systems)
- **EN** (Europan Standard) , e.g. EN61000-6-3 Emission standard for residential, commercial and light-industrial environments

Overview : some important facts about EMC measurement

A product gets the EMC certification (test passed) within a measurement in a certified laboratory

Image source www.nts.com

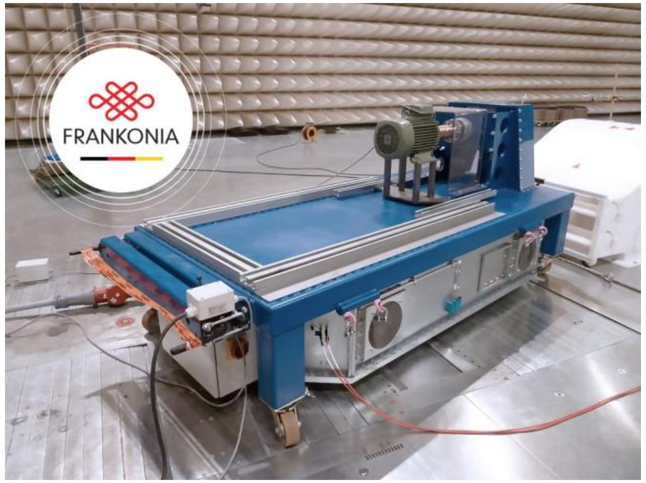


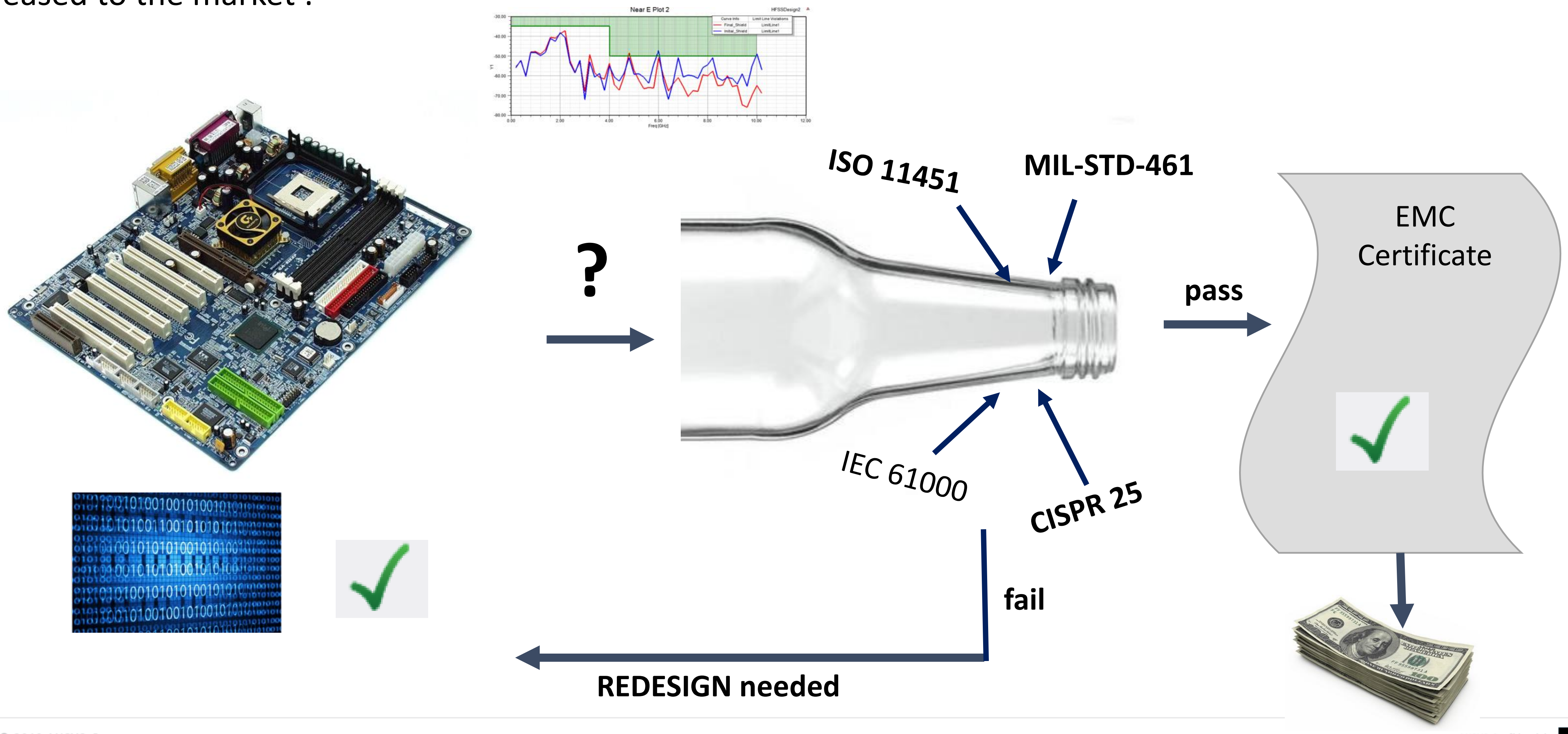
Image source www.franconia.com

EMC engineers need to be familiar with some of these standards which needs some deep training phase for their current work. Experienced Engineers have a deep knowledge about these standards and their implementation. Due to this EMC Engineers are proud of their knowledge and equipment.

Simulation can never completely replace the EMC measurements but scan significantly reduce the time for the overall process until a product will fulfil the given specification of noise levels over frequency

Overview : some important EMC aspects

EMC requirements are in many projects the bottleneck before a functional correct product can be released to the market :



Overview : cost factors of EMC measurement

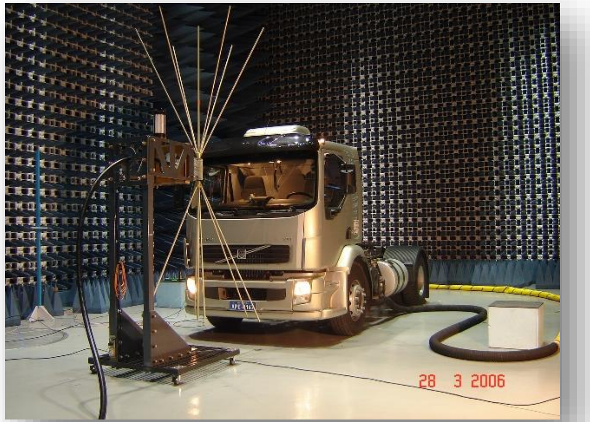
1) The measurement time occupies both the laboratory equipment plus skilled engineer(s)

Average measurement cost :   1000…5000 €/day
Average number of physical prototypes per system: 3…5 prototypes
Total cost for system certification= 1000…2000 €/day x 5 prototypes =5000 … 25000 €

Total Saving per system certification (only 1 prototype) =5000 € -1000 € =4000…20000 €

2) Additional **cost for redesign** of prototype / PCB, assembly etc. depending on complexity : 1000… 100000€

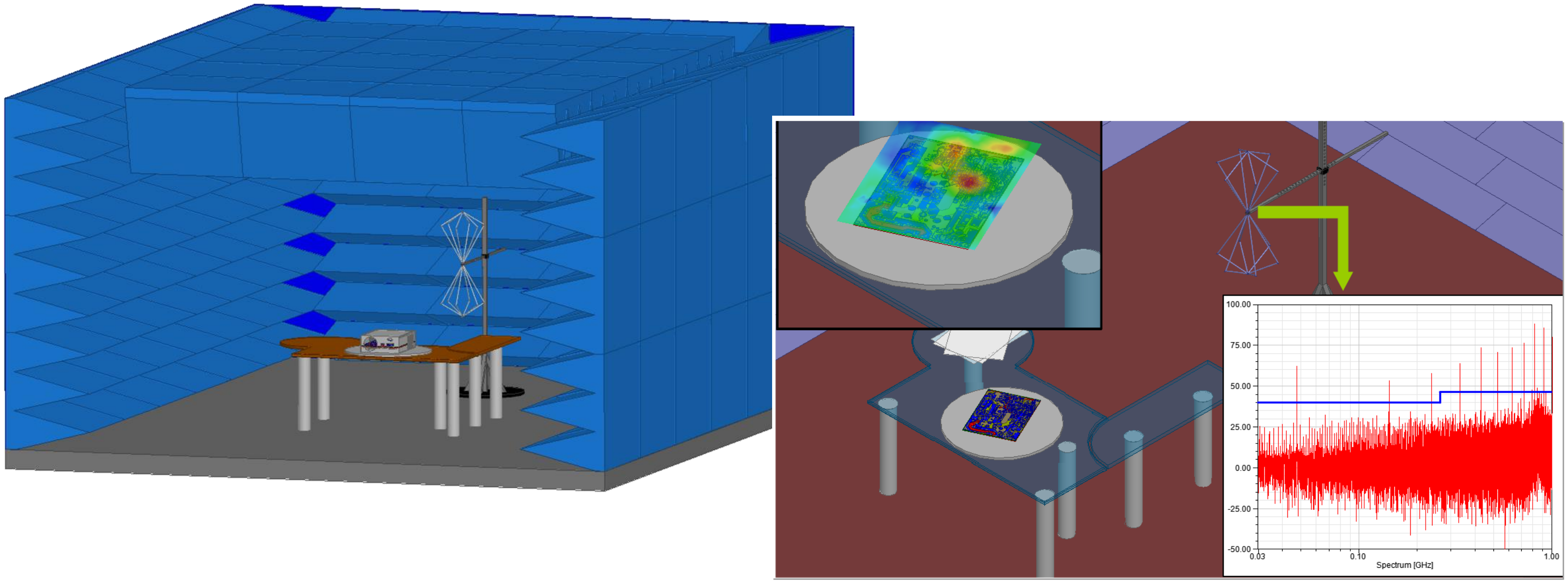
3) Cost of Delay Time to market for changing device under test (DUT) and booking of measurement chamber
 typ some weeks…months for every iteration
This is usually the major cost factor



Picture taken at INPE. Courtesy of Volvo Brasil.

Overview : some important facts about EMC simulation

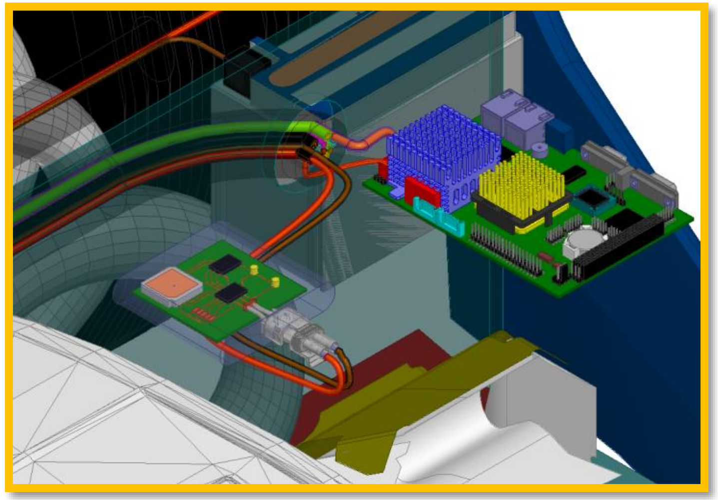
Approaches to simulate the "whole system" in one are extremely difficult and time consuming to accomplish ….



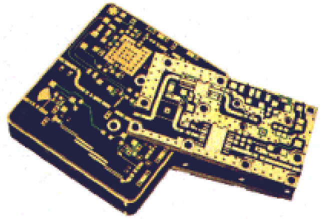
So it is rather recommended to have a smart assembly of simulated parts.

Parts of an Electronic System

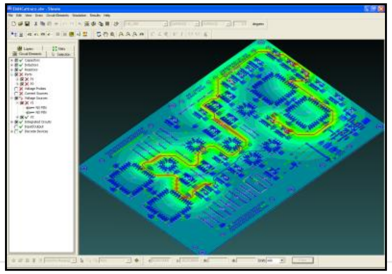
Addressing a simulation of an electronic system requires careful considerations about how to split into different models to represent the overall behavior



Laminated Components/ boards



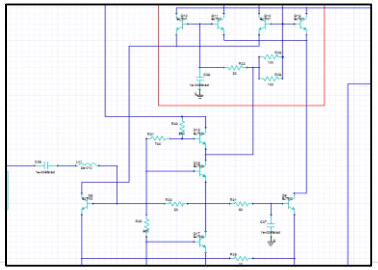
Hybrid EM fullwave solver (e.g SIWAVE)



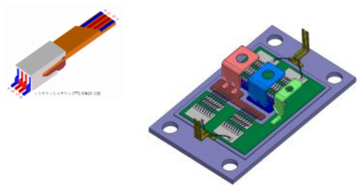
Discrete Components

Dimension < Lambda/10

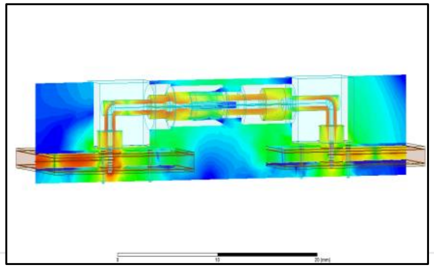
Circuit simulator (SIMPLORER, DESIGNER)



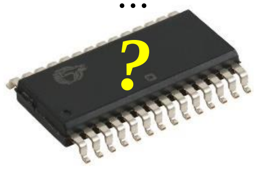
3D Components



3D EM simulator, e.g HFSS, Q3D

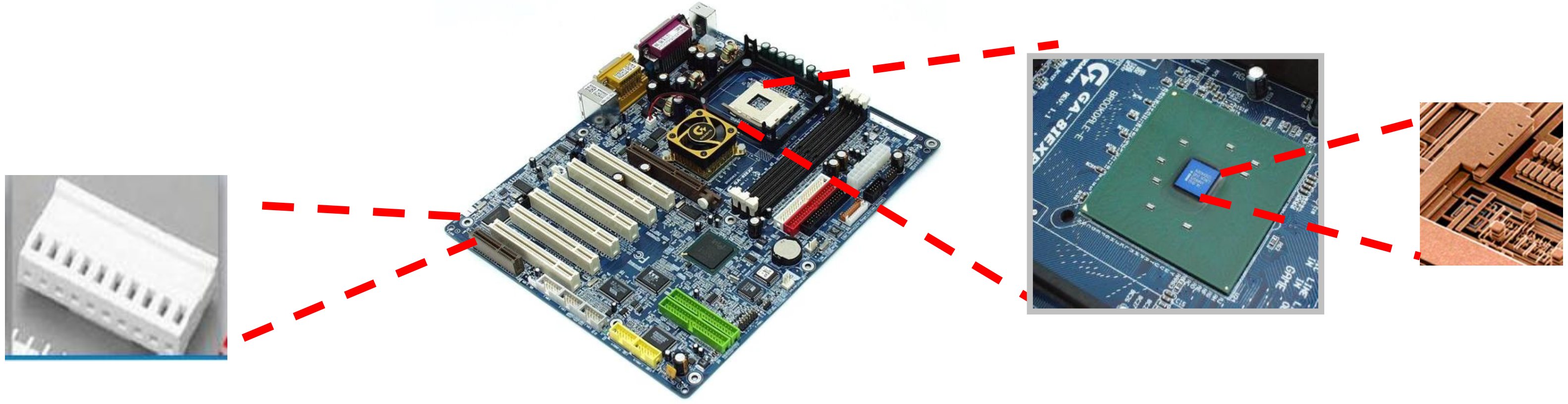


But how to address IC functionality …

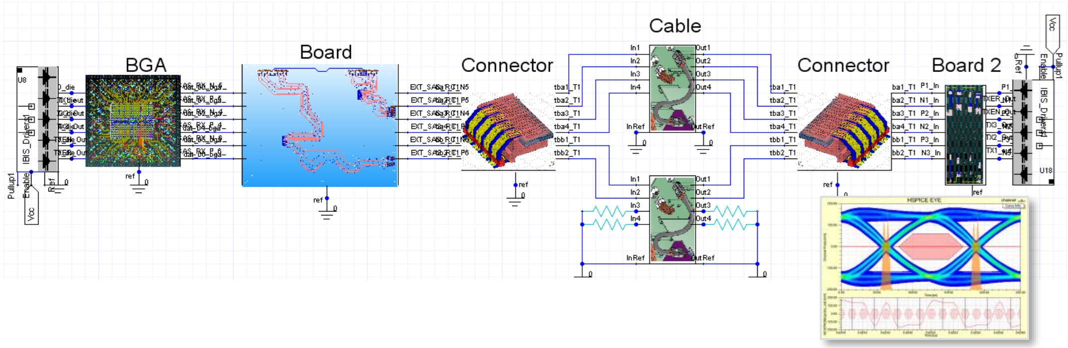


How to combine electronic System-level Solutions

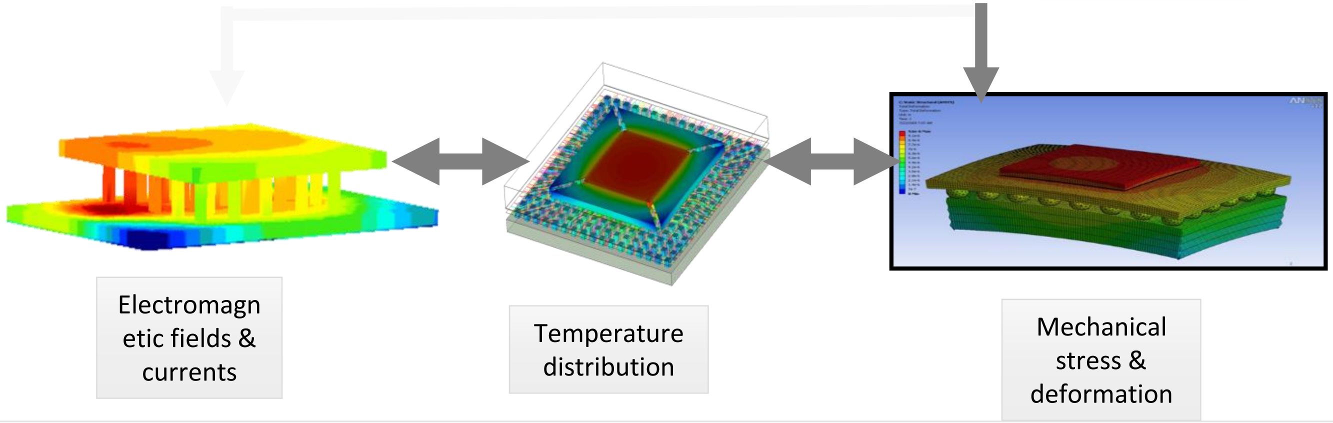
- CAD data based link



- signal based link (coupled matrix data)



- field based link

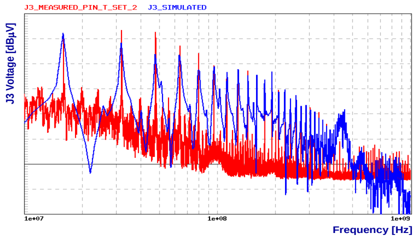


Terminology and Importance of EMC aspects

Unadequate electrical compatibility may effect the functionality of systems in some cases is safety critical

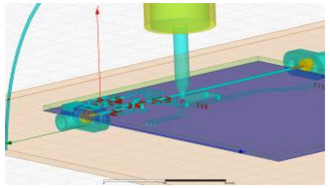
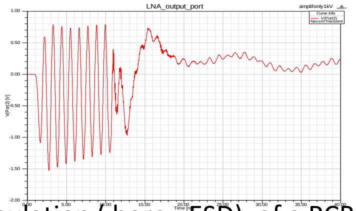
EMC: the branch of electrical engineering concerned with the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects

Emission: the generation of electromagnetic energy, whether deliberate or accidental, by some source and its release into the environment.

Emission simulation of a PCB

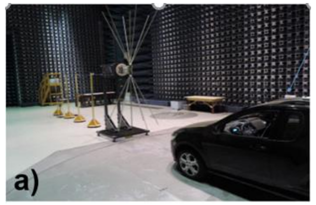
Susceptibility: tendency of electrical equipment, referred to as the victim, to malfunction or break down in the presence of unwanted emissions

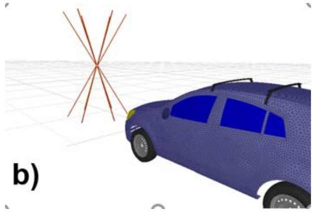



Susceptibility simulation (here : ESD) of a PCB

Immunity: the ability of equipment to function correctly in the presence of Radio Frequency Interference

Definitions taken from Wikipedia


a)


b)

Immunity simulation model of GM/Brazil

Design Flow Summary for EMC analysis in systems (coupling, emission)

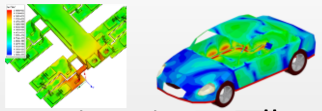
3rd Party PCB Layout, like

- Cadence Allegro, APD/SiP, Virtuoso
- Mentor Expedition, PADS
- Zuken CR5000 /CR8000
- Altium
- GDS / DXF / DWG/ GERBER and more

3D Model import from CAD-file, like

- SAT / STEP / IGES / STL / ProE
- Catia v4/v5
- Parasolids
- Nastran
- Unigraphics and more

ECAD / MCAD -Translator



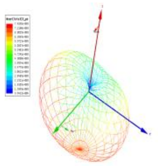
quasi static or Fullwave solution

Results export :
Equivalent circuit
As Spice model or S-parameter

1

3b

Field Based Data:
Near Field, Far Field
Emission test
Fields Calculator

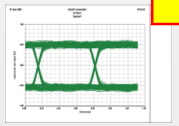


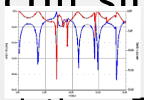
3a

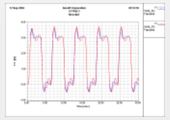
Extracted model

2

Circuit simulation







Circuit / EM cosimulation : Time and frequency domain

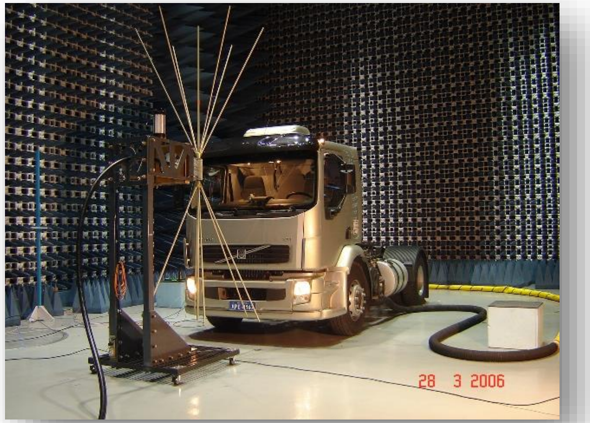
1 **„Coupling Coefficients“**

2 **„Conducted Emission“**

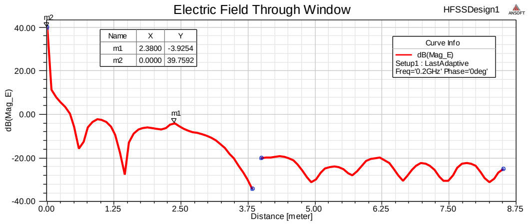
3 **„Radiated Emission“**

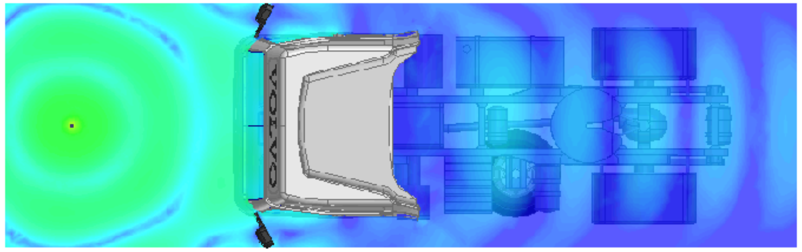
EMC/EMI : increasingly important impact and simulation can be used for Immunity Test

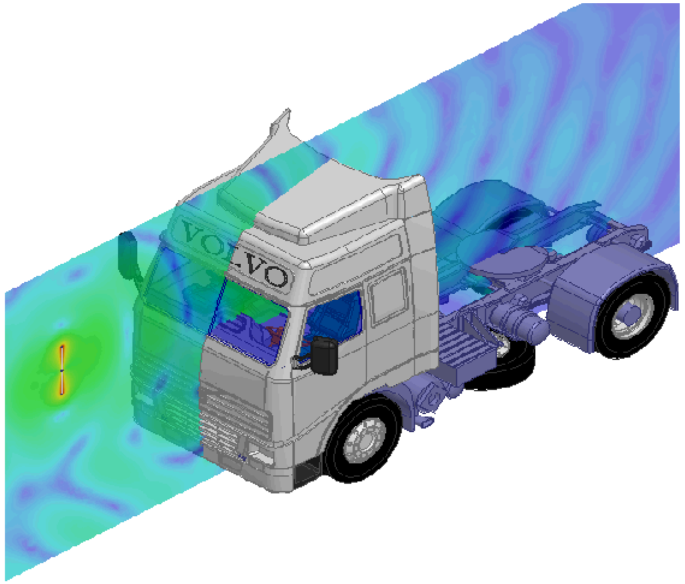
Setup with reference Antenna as “noise signal” source : Automotive EMC Standards – ISO 11451-2



Picture taken at INPE. Courtesy of Volvo Brasil.







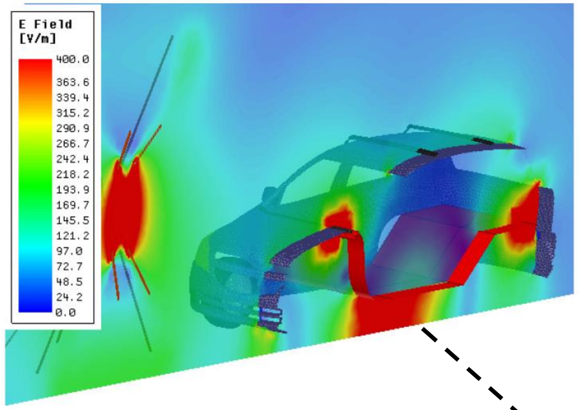
nimations perfomed by

Value of Simulation :

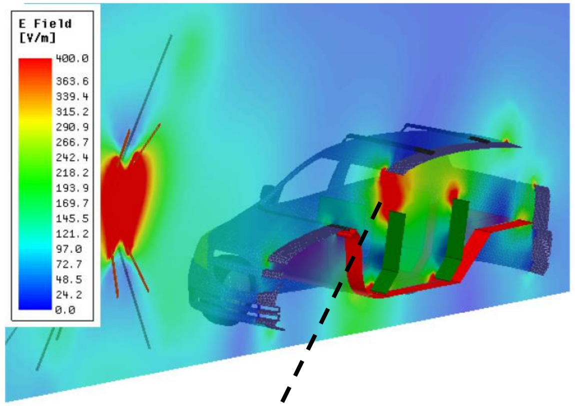
- Avoid booking of test chamber (typ several 10 k€ for a test)
- Reduce possibility of Re-Design (-> delay of several weeks or months)

Immunity Simulation : Fields at resonances

Simulated E-field [V/m] at 72 MHz



Simulated E-field [V/m] at 93 MHz

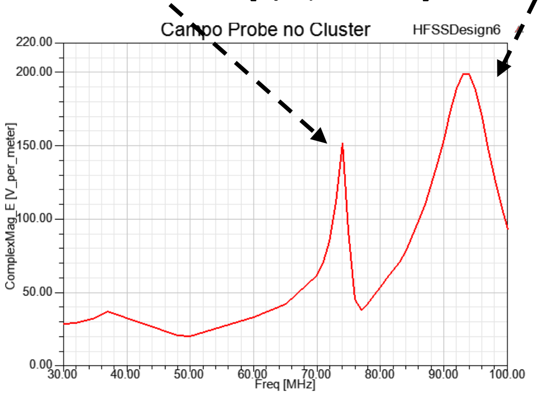


Work Developed by **General Motors do Brasil**

Real scenario: anechoic chamber at INPE (Nacional de Pesquisa Espaciais)

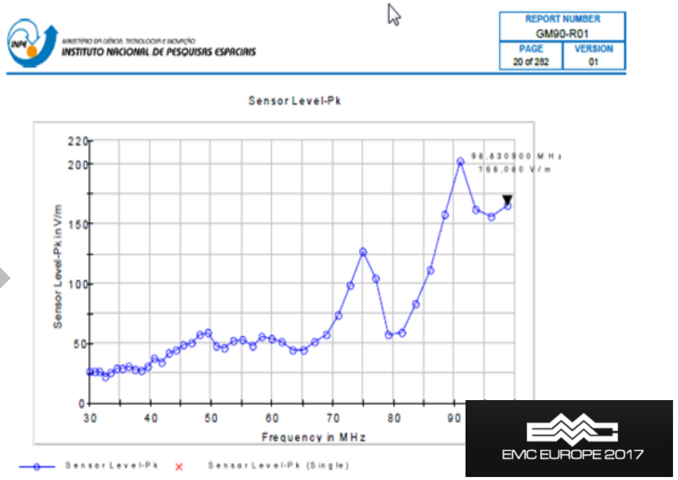
J. Mologni, J. Ribas (ESSS); L. Amaral (General Motors do Brasil); J. P. Filho(UNICAMP) : "The Significance of Specific Vehicle Parts on Automotive Radiated Immunity Numerical Simulations"; IMOC 2015

Simulated E-field [V/m, lin scale]



Good Agreement

Measured E-field [V/m, lin scale]



Value of Simulation :

- Deep understand physical reasons of EMC effects (no „expert knowledge" needed)

EXAMPLE OF A HIGH POWER SWITCHING CONVERTER: BATTERY CHARGER FOR FULL ELECTRIC VEHICLE

DUT description:

up to 7kW Battery Charger

From 250 to 400 VDC output

Input 110/230 VAC

Efficiency up to 95%

PFC for AC input

LLC Type Converter for DC Output

Water cooling

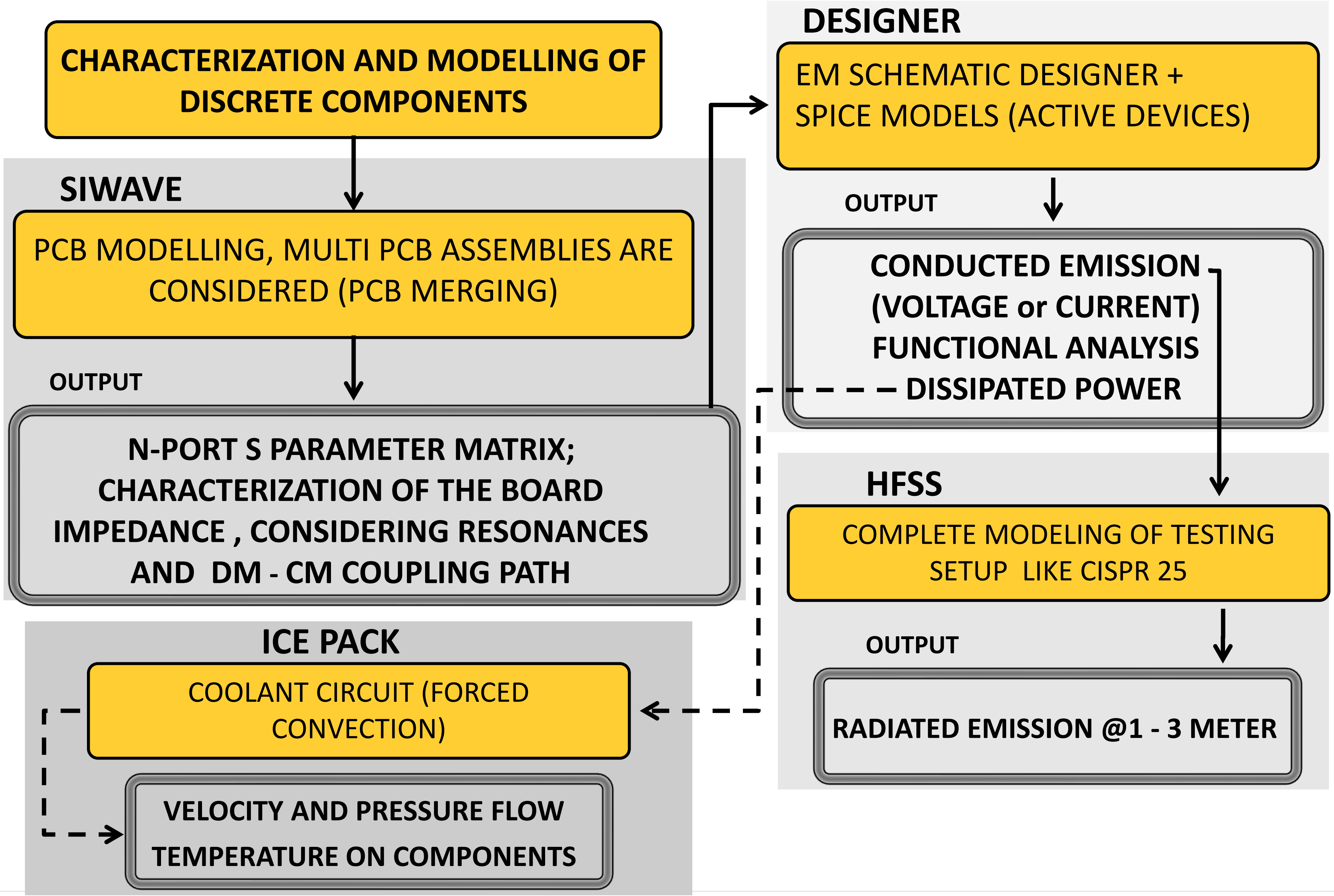
Automotive Simulation WORLD CONGRESS

June 7-8, 2016 Munich

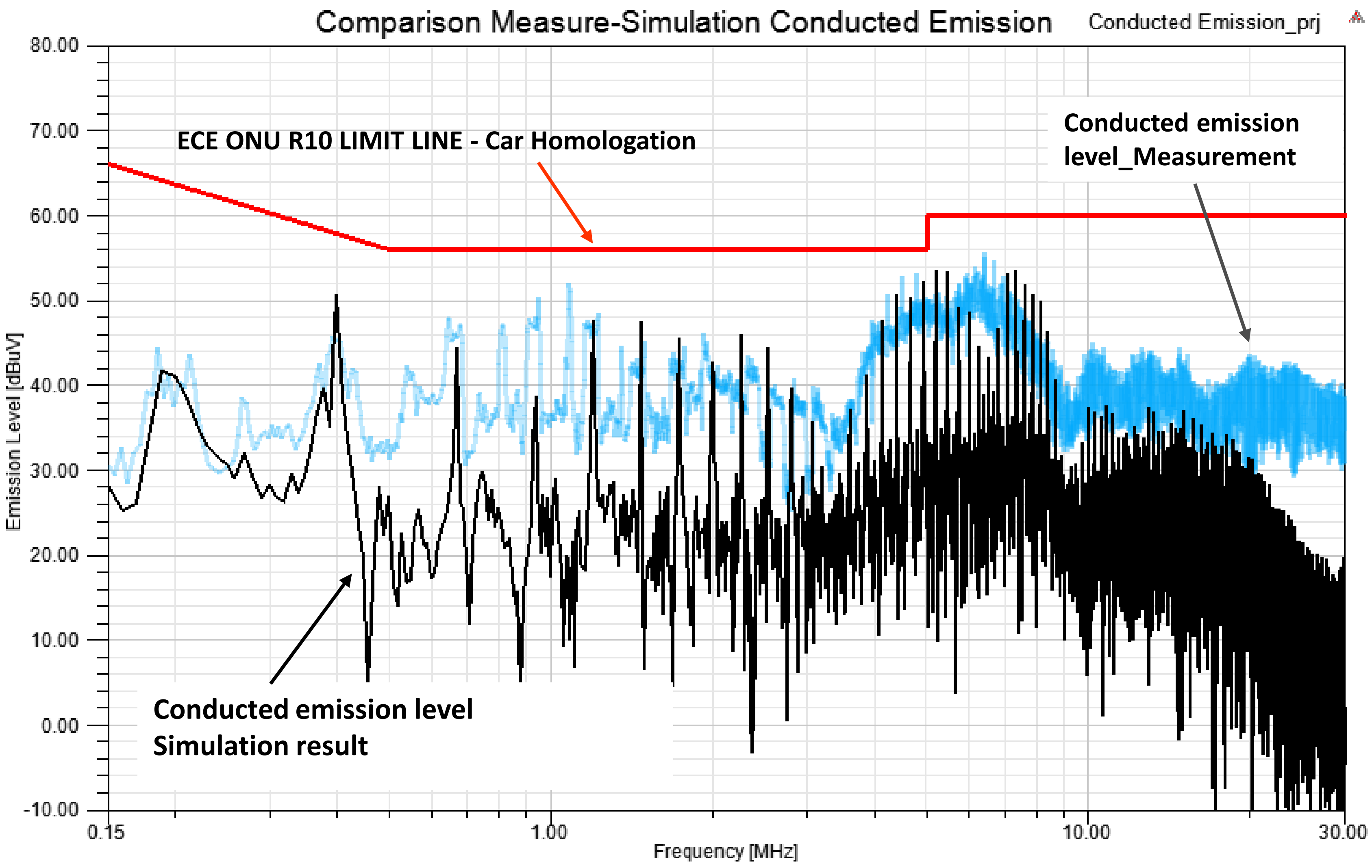
"Efficient Workflow for EMC and Thermal modeling of a High Power Battery Charger for Electric Vehicle"

Daniel Grossi - EMC Simulation Engineer Meta System

WORKFLOW FOR EMC AND THERMAL MODELING



COMPARISON BTW SIMULATION - MEASUREMENT



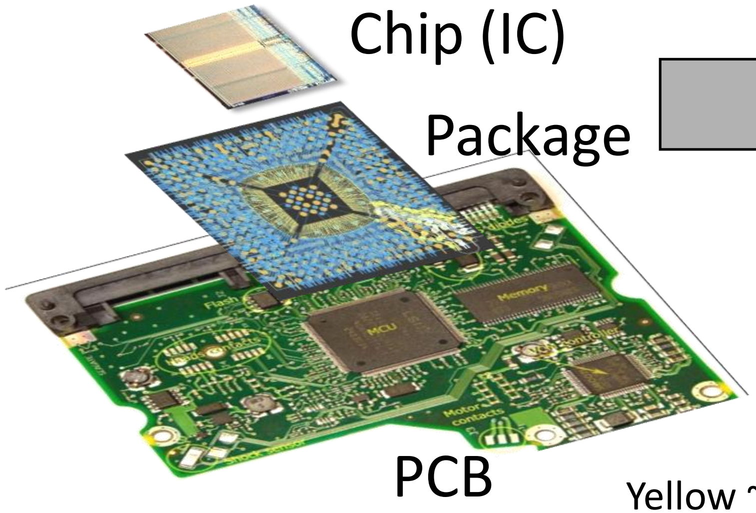
Example Case : MCU on Automotive Airbag board

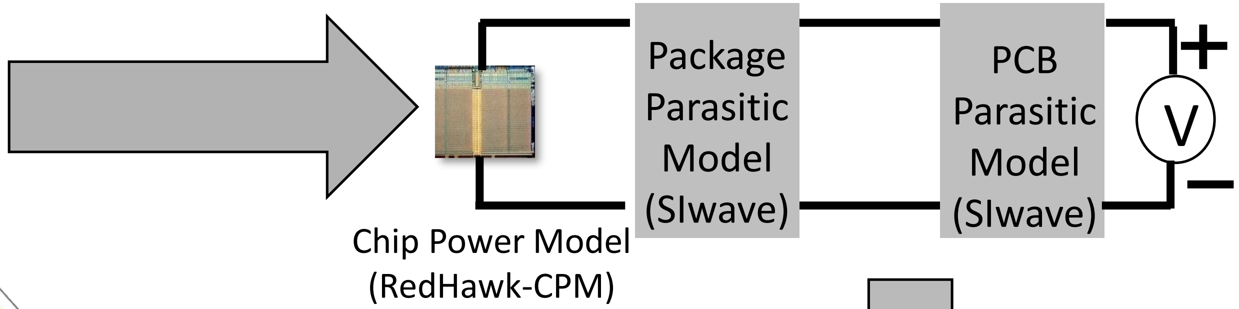
- Operation of safety (airbag) and infotainment systems depend on MCU speed

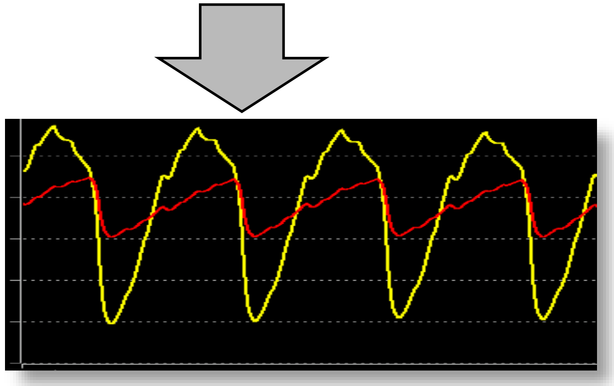
Operating speed of MCU depends on quality of power supply it receives

Poor PCB design can cause 100+mV drop in supply nets

Must design PCB considering MCU and impact on its performance







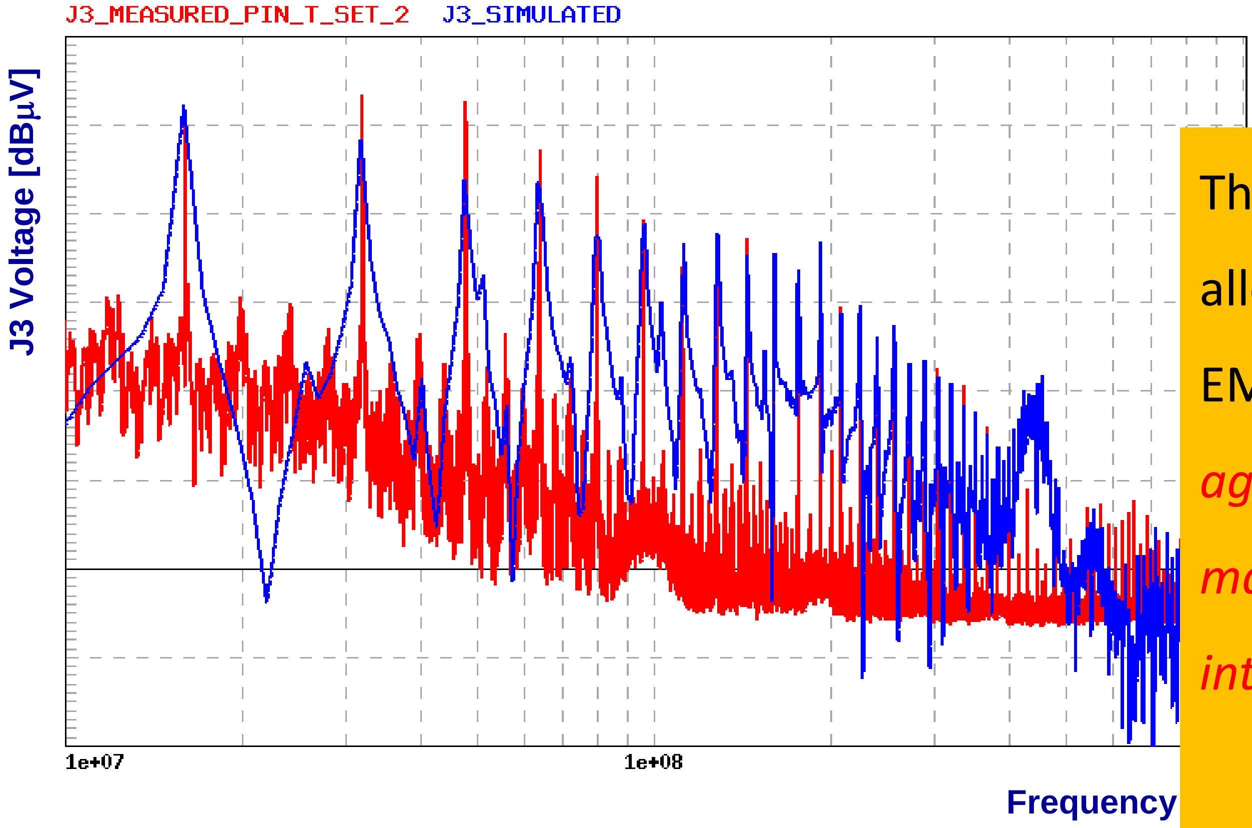
Yellow ~ voltage at MCU with pkg/PCB
Red ~ voltage at MCU/pkg but no PCB

-100+mV drop from PCB

-

EMC ON AUTOMOTIVE COMPONENTS

Chip Package System Example



Automotive

The proposed *simulation* framework allows to predict the true post-silicon EMC behavior vs. *increasingly aggressive EMC targets* dictated by *marketing, customers, and international standards*

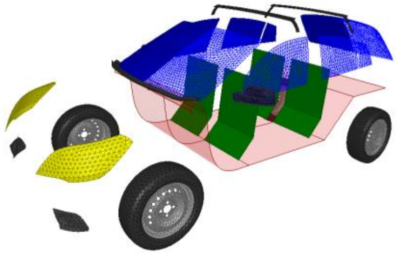
Dr. Davide Pandini, ST Agrate

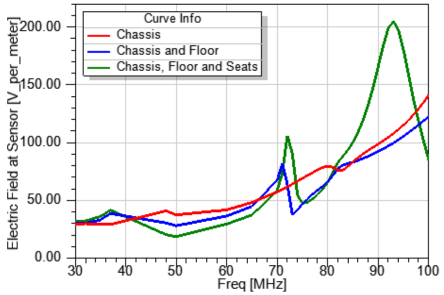
Easy approaches for EMC simulations

Previous Examples described EMC simulation of almost whole systems

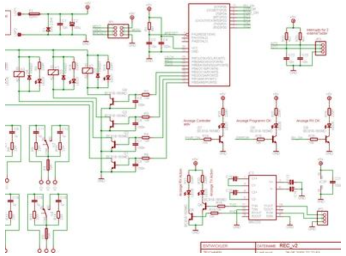
Such “full system simulations” are not trivial and need high technical expertise due to

Sometimes missing details in the geometry or simplification

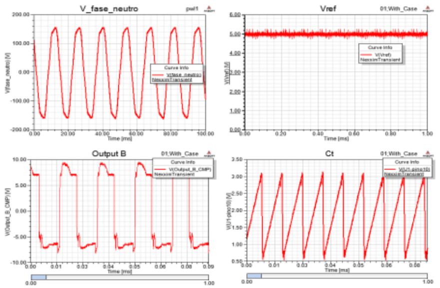




Inadequate or incomplete circuit model



Inaccurate signal modelling

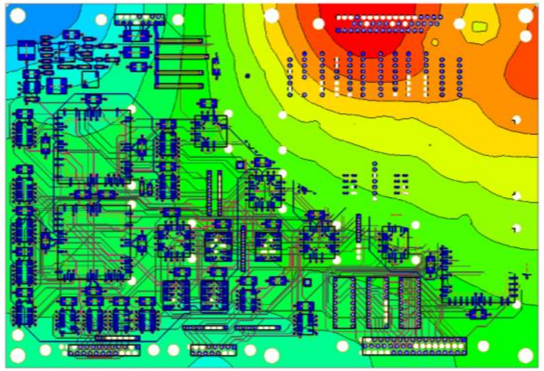


Wrong material parameters or contact modeling

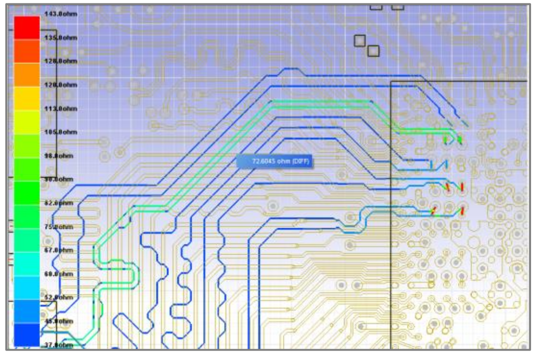
The fast and easy way for EMC analysis

ANSYS provides a set of – partially automated for printed circuit boards (PCB) – solutions which allow characterization of “critical areas” within very short time – even for non experts

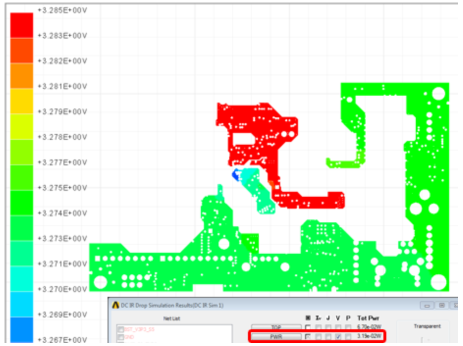
Resonance Analysis



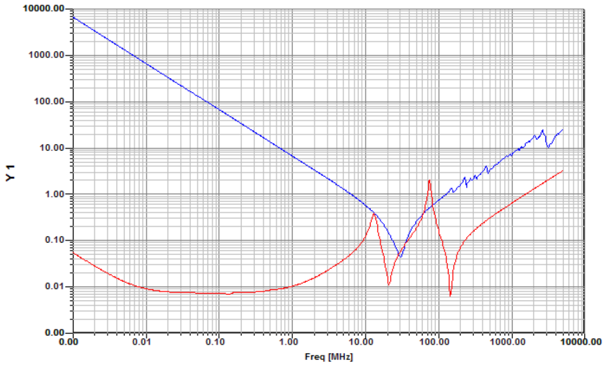
Impedance analysis of lines



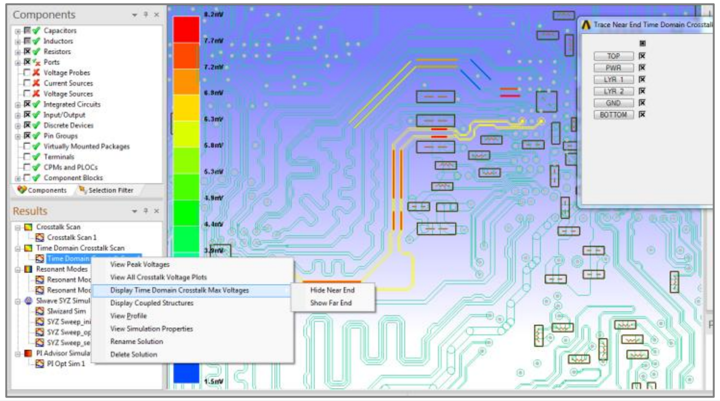
DCIR – Drop analysis



Target Impedance Analysis



Coupling Scan



SUMMARY

ANSYS offers a variety of simulation–solutions for overall or partial analysis which allows to characterize the EMC behaviour of a hole system or to localize the mechanism of the EMC mismatch

In multiple projects ANSYS customers significantly reduced the numbers of design cycles for EMC testing -prototypes with help of simulation tools like SIWAVE, HFSS or Q3D

The use of simulation tools allows a far deeper insight into the physics behind EMC effects than it could ever accomplished with measurement approaches.

Thank You!!!