

3DEXPERIENCE®

PCB의 Thermal 및 EMI/EMC 시뮬레이션

Dassault Systemes

배종선

(JBE9@3ds.com)

Agenda

DASSAULT SYSTEMES 소개

PCB Thermal & EMC 해석의 필요성

CST를 이용한 PCB Thermal 해석

CST를 이용한 EMI/EMC 해석 사례

DASSAULT SYSTEMES



과학적인 기업

- 과학 & 기술 & 예술을 결합하여 지속 가능한 사회를 위해 공헌하는 과학회사



15,000 열정적인 직원

- 124개 국가 / 179개 지역
- 단일의 글로벌 R&D 구성하는 64곳의 연구소
- 3DEXPERIENCE 솔루션 제공



220,000 기업고객

- 140개 국가 / 12개 산업군
- 2500만 사용자



12,600 파트너

- 소프트웨어 / 기술 / 아키텍처
- 콘텐츠 / 온라인 서비스
- 세일즈
- 컨설팅/ SI
- 교육 / 연구
- 협력사와의 동반 성장



장기적인 비전

- 안정적인 지배구조
- 연매출: Euro 3.8B (약 5.1조)*
- 영업이익: 31.2%*

* Figures as of FY 2019/ Non-IFRS

CST – Products

Front-End



CST MICROWAVE STUDIO®
고주파 3D 전자기장 해석 시뮬레이션



CST EM STUDIO®
DC 및 저주파 3D 전자기장 시뮬레이션



CST PARTICLE STUDIO®
입자동역학에 대한 3D 전자기장 시뮬레이션



CST PCB STUDIO®
PCB의 신호 및 전력 무결성 분석(2.5D)



CST CABLE STUDIO®
케이블 Harness에 대한 신호 무결성 및 EMC/EMI 분석



CST DESIGN STUDIO™
회로 해석 및 시스템 설계



CST MPHYSICS STUDIO®
열, 구조해석 시뮬레이션

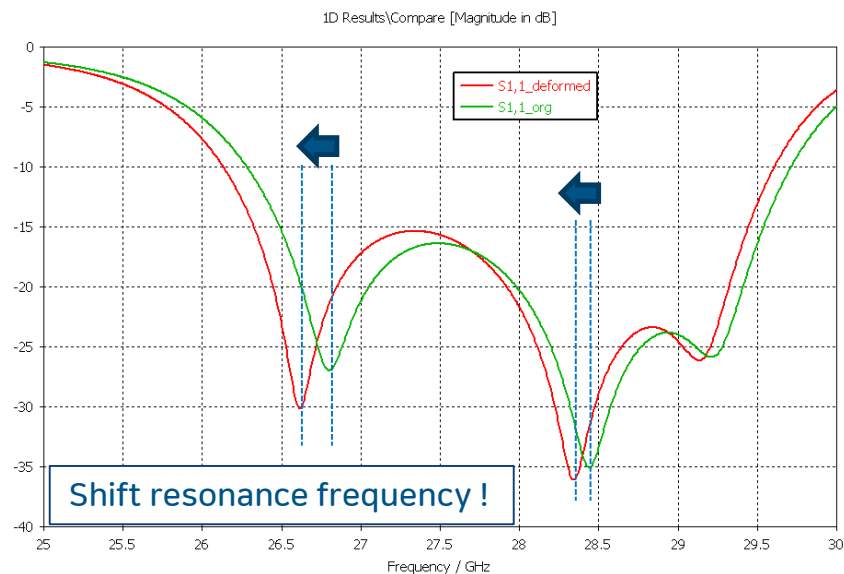
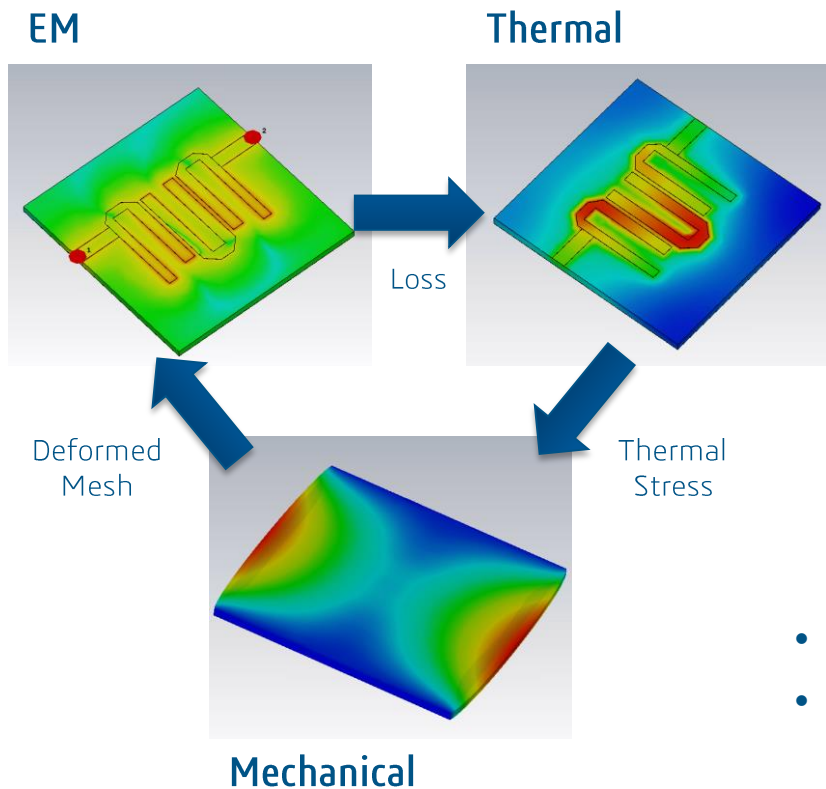


CST BOARDCHECK®
PCB 레이아웃에 회로 무결성 검사

해석의 필요성

PCB Thermal & EMC Simulation

발열에 의한 PCB 신뢰성 문제

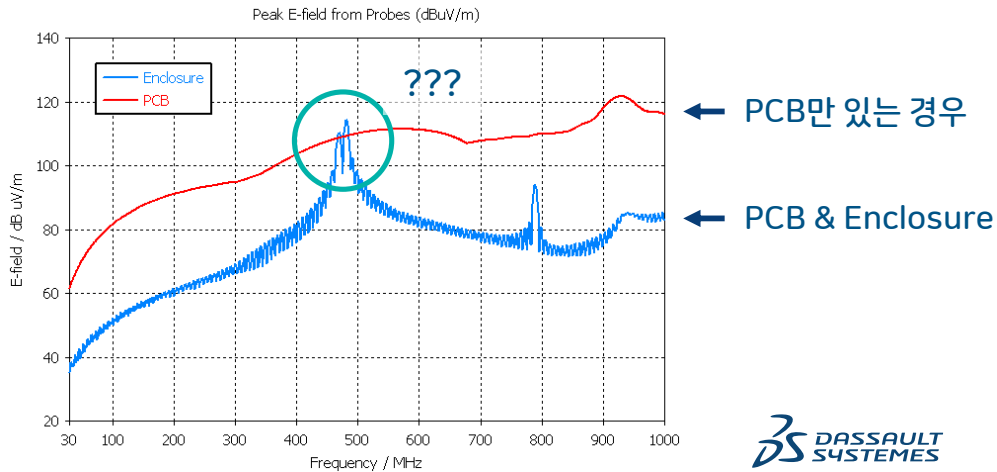
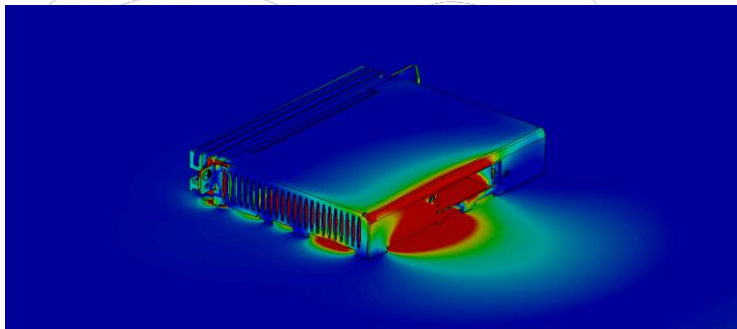


- 전기전자 분야에서 발열 문제는 언제나 “Hot” Issue !
- 신뢰성 있는 제품 개발을 위해서는 PCB의 발열 문제를 어떻게 대책 하느냐가 Key Point !

EMI에 의한 사고 - 신뢰성과 안전성



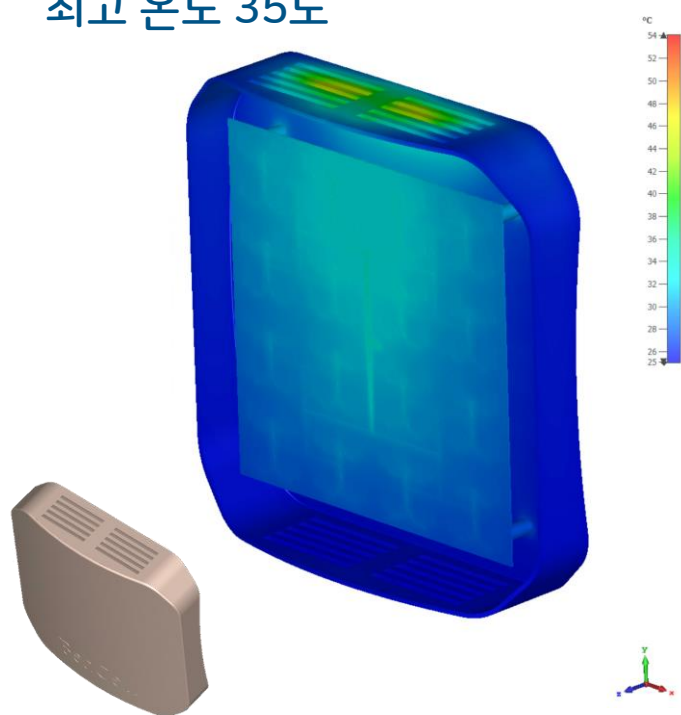
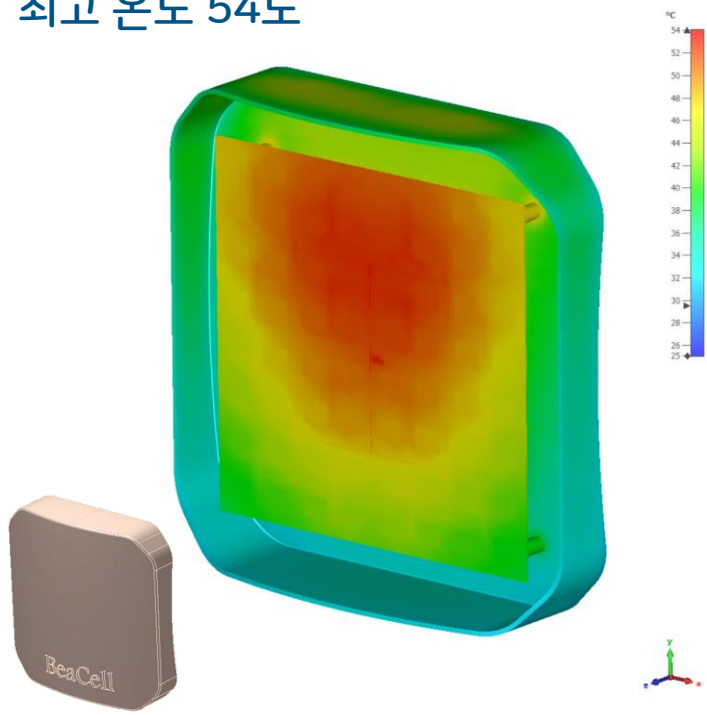
- 2003년 8월 22일 브라질 알칸타라 우주기지에서 3일 후 발사 예정이었던 VSL-1 로켓이 발사대에서 폭발하는 사고 발생
- 많은 사상자 발생
- 사고 원인으로 휴대전화의 전자파가 로켓의 엔진 금속 성분과 마찰을 일으킨 것이 원인이라 보도



Enclosure 구조에 따른 내부 온도

최고 온도 54도

최고 온도 35도



“Enclosure에 따라 Thermal & EMI가 동시에 영향을 받음!”

PCB Thermal Simulation

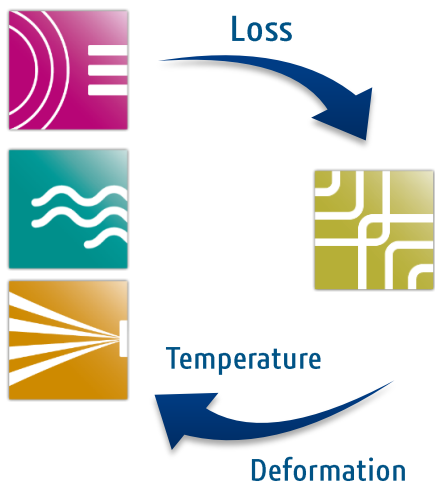
CST MPHYSICS STUDIO

CST MPHYSICS STUDIO®

- ✓ EM Thermal Coupling 분석 가능
- ✓ 하나의 GUI상에서 데이터 연동 가능
- ✓ Package License

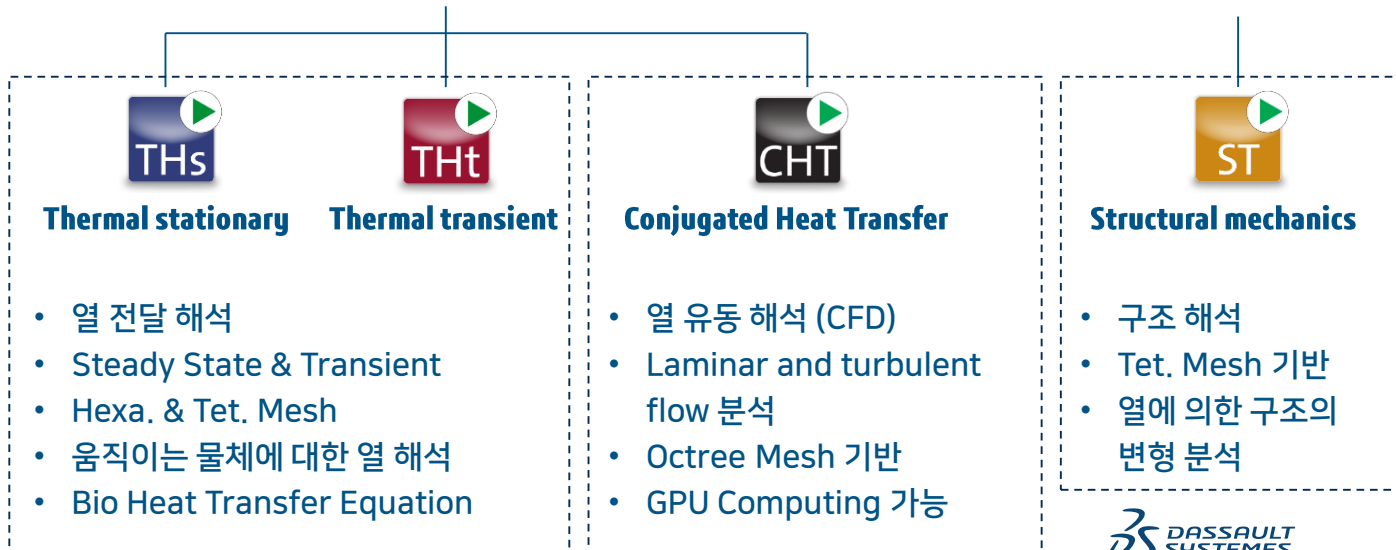


CST MPHYSICS STUDIO®

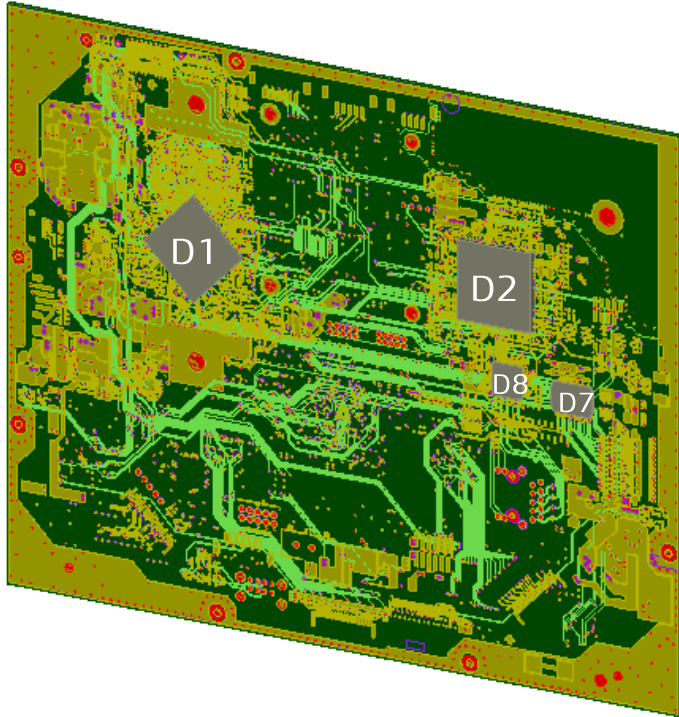


Thermal

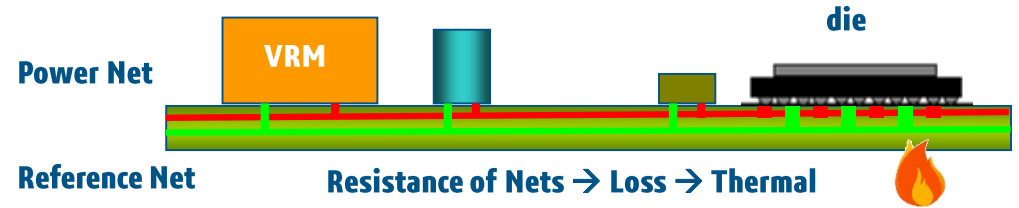
Mechanics



PCB Thermal Simulation

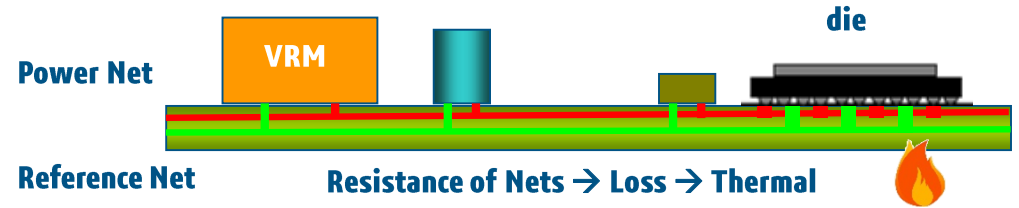


Heating by IR Drop

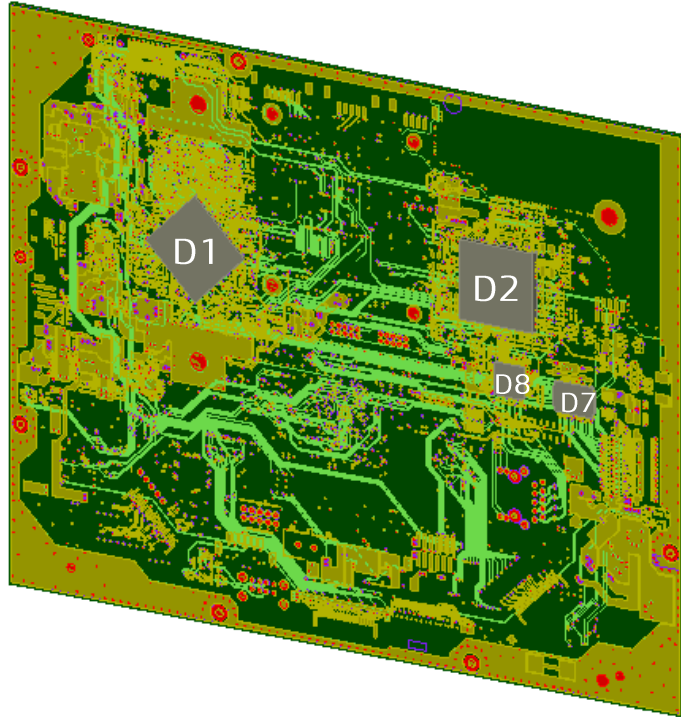
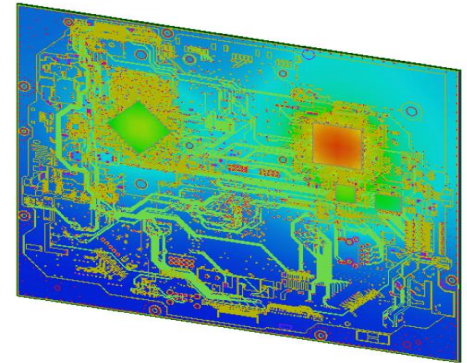
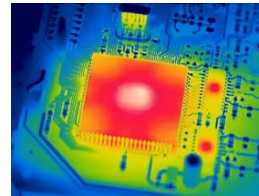


PCB Thermal Simulation

Heating by IR Drop



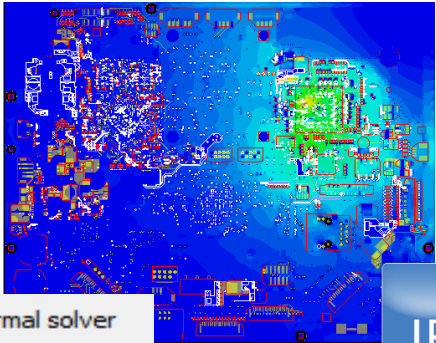
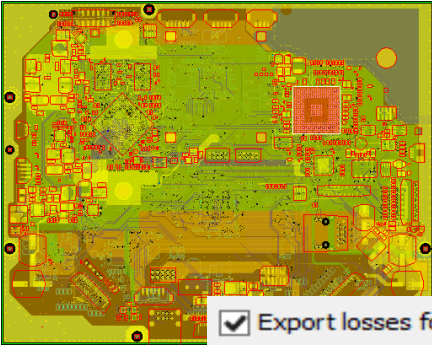
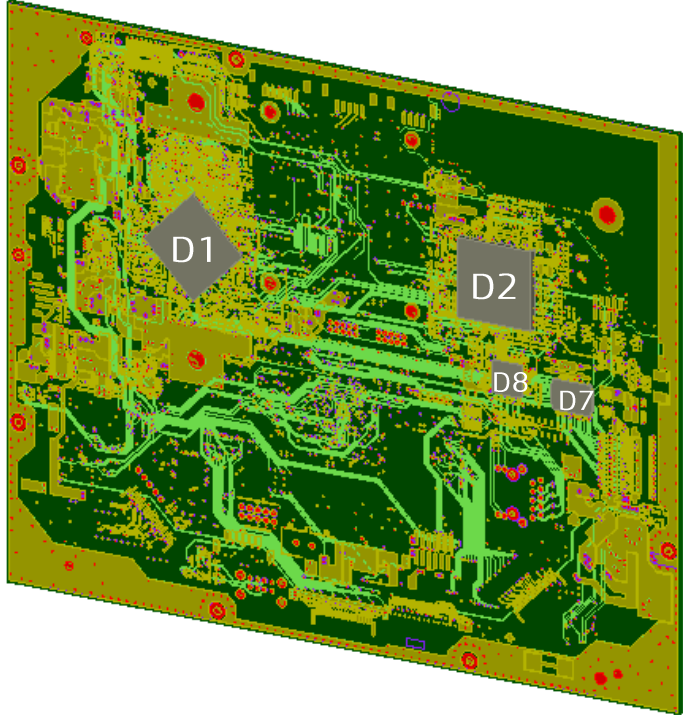
Heating by Power consumption of IC



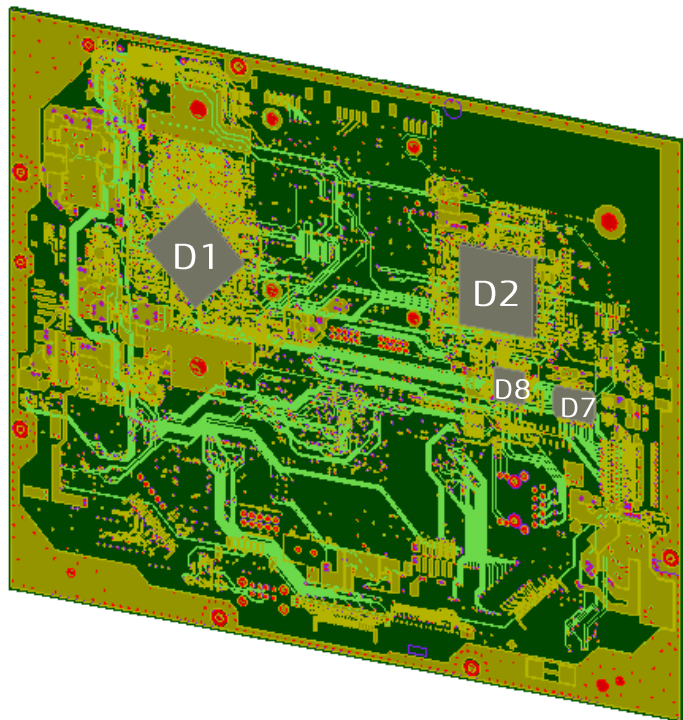
PCB Thermal Simulation

Select PDN

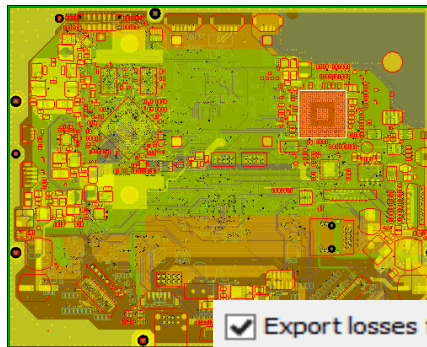
Power Loss Density



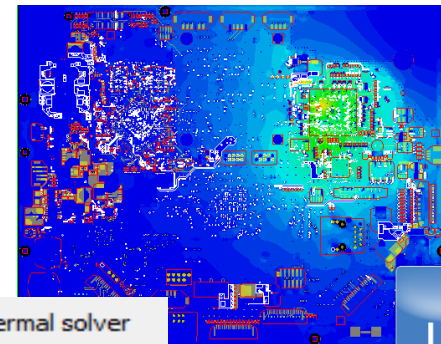
PCB Thermal Simulation



Select PDN



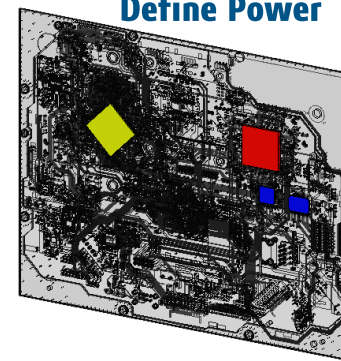
Power Loss Density



Select IC

Refdes	Power (W)	Height (mm)
D8	0.5	1
D7	0.5	1
D2	4	2
D1	3	1

Define Power

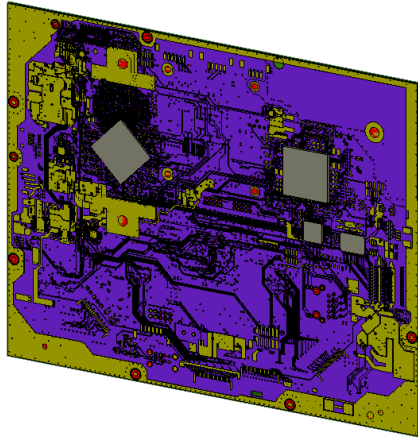


PCB Thermal Simulation

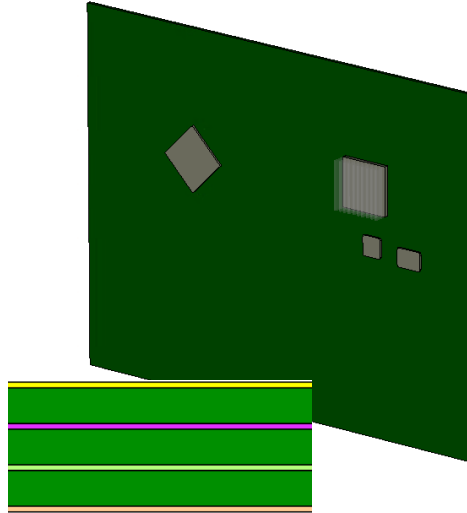
Automatic PCB thermal model simplification:

Effective thicknesses

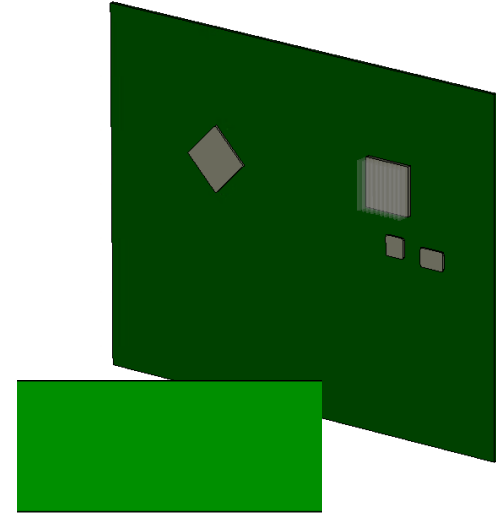
Off



Layerwise



All



PCB Thermal Simulation

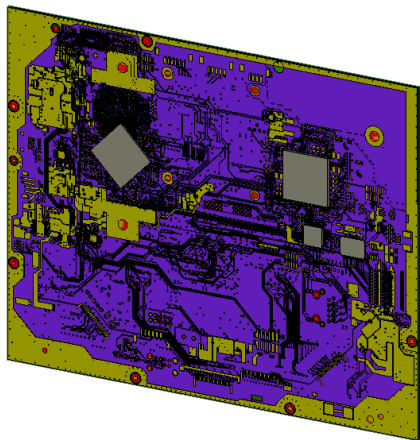
Automatic PCB thermal model simplification:

Effective thicknesses

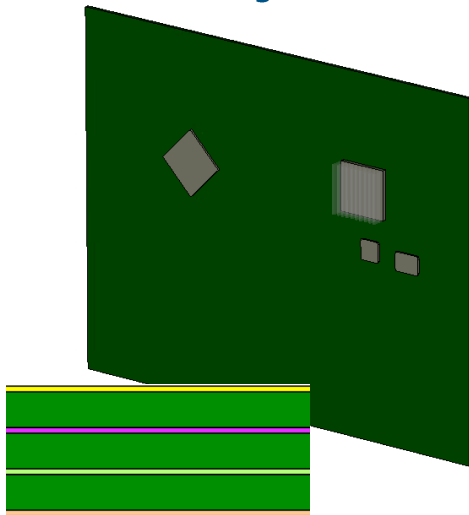
Copper
Thermal Cond. : 401 [W/K/m]
Rho : 8930 [kg/m^3]
FR4
Thermal Cond. 0.3 [W/K/m]
Rho : 1890 [kg/m^3]

Composite
Thermal Cond. : (43, 43, 0.34)
[W/K/m]
Rho : 2640.55 [kg/m^3]

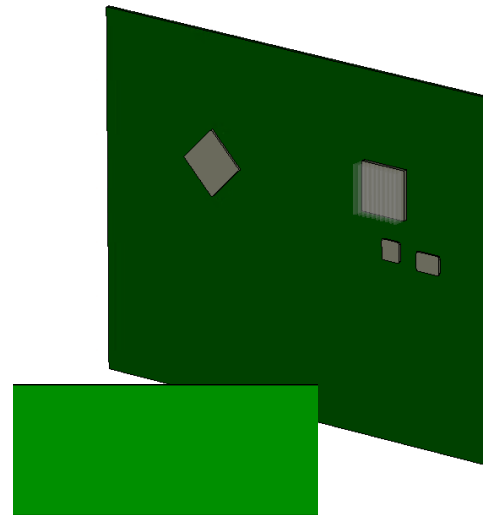
Off



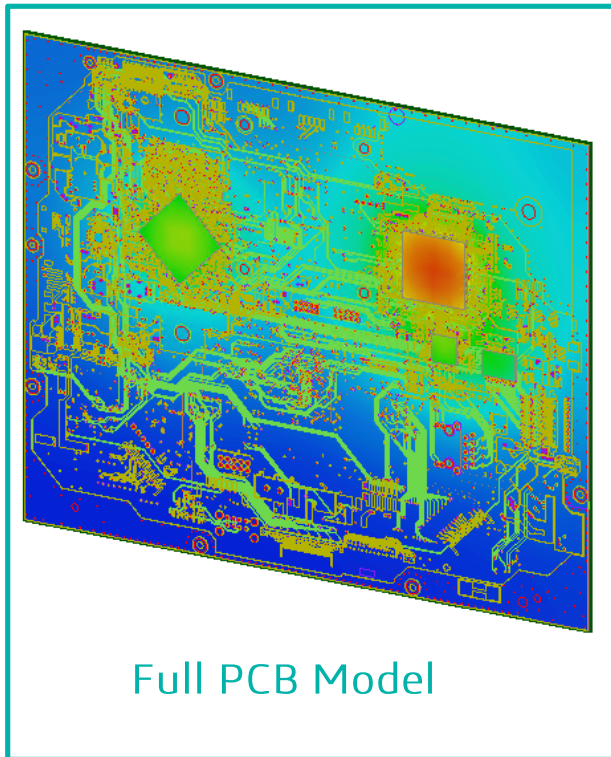
Layerwise



All



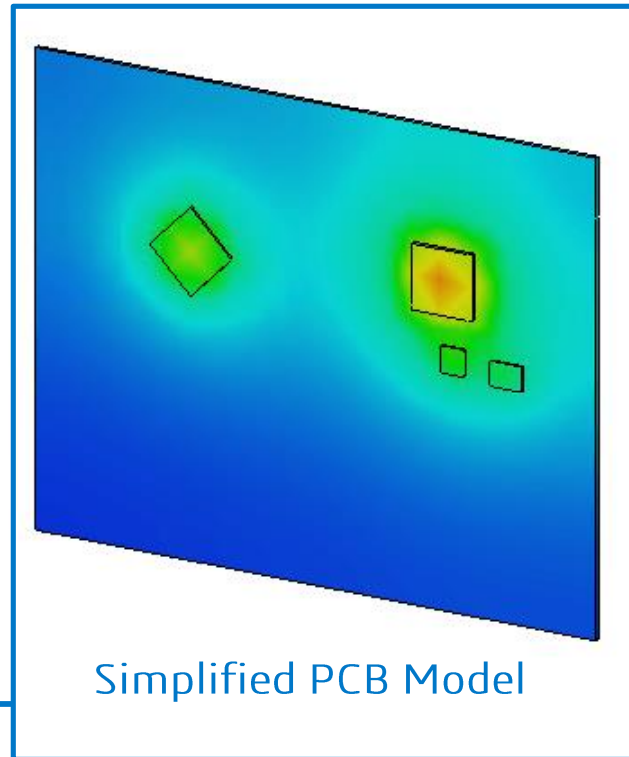
PCB Thermal Simulation



D2 Temperature : 64.4C°
Total Mesh : 9M
Simulation Duration : ~3 hrs

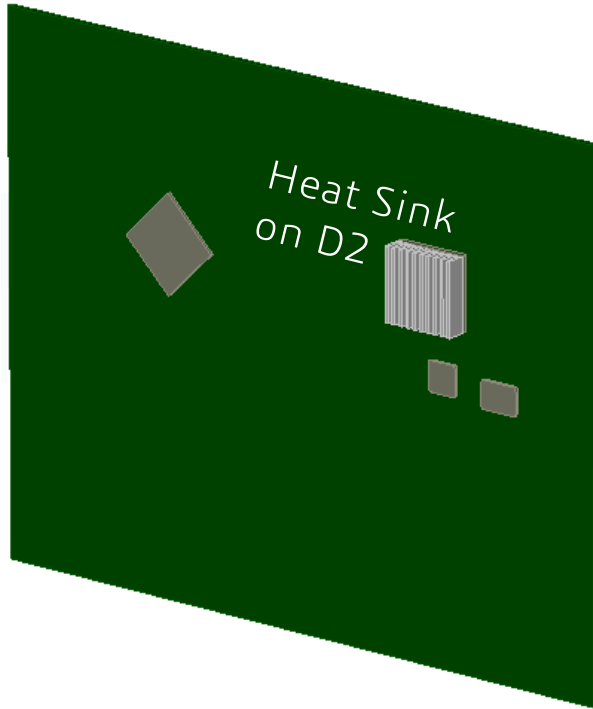
"Quick Tendency Analysis"

D2 Temperature : 66.5C°
Total Mesh : 87K
Simulation Duration : <1 min

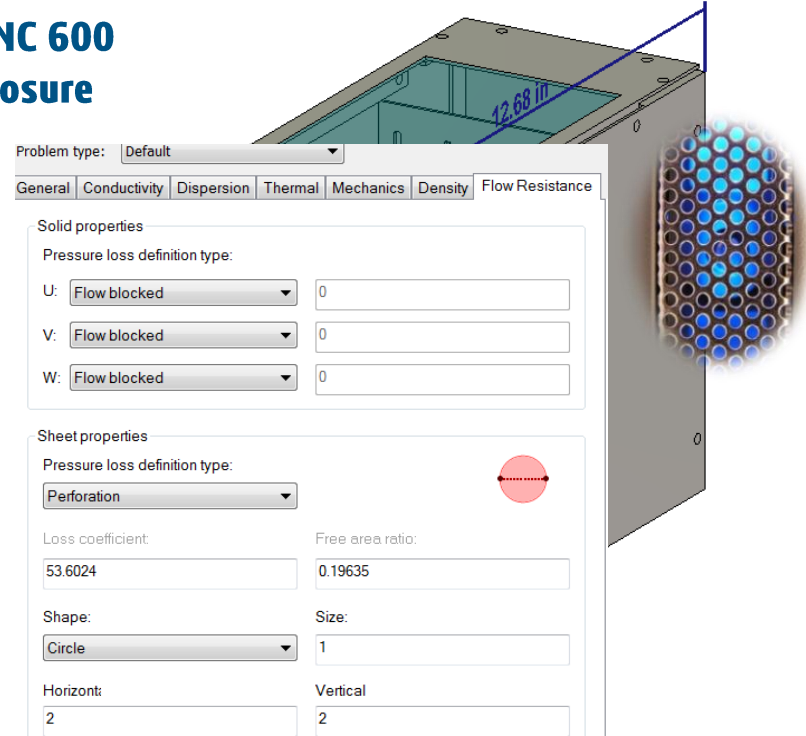


PCB Thermal Simulation – CHT Solver

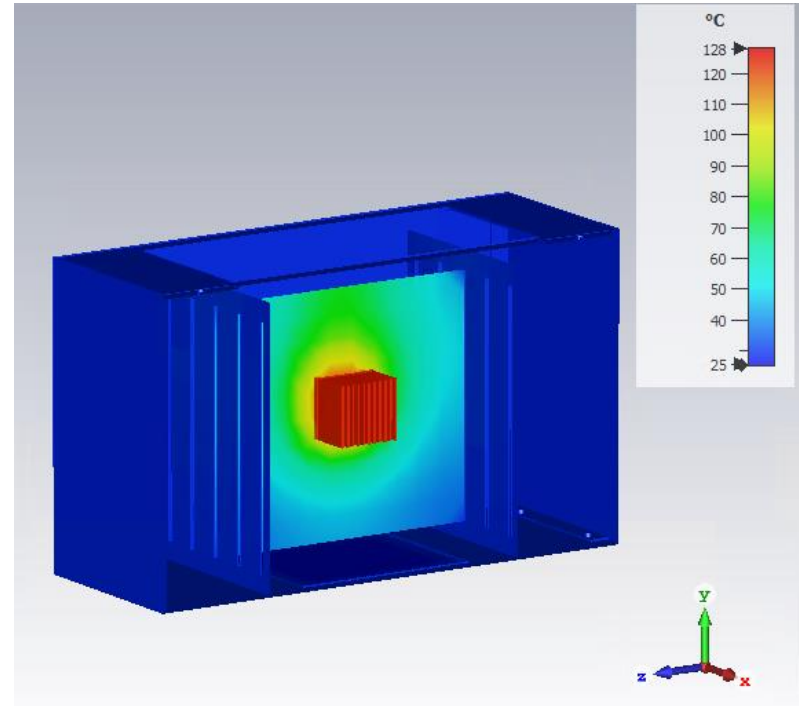
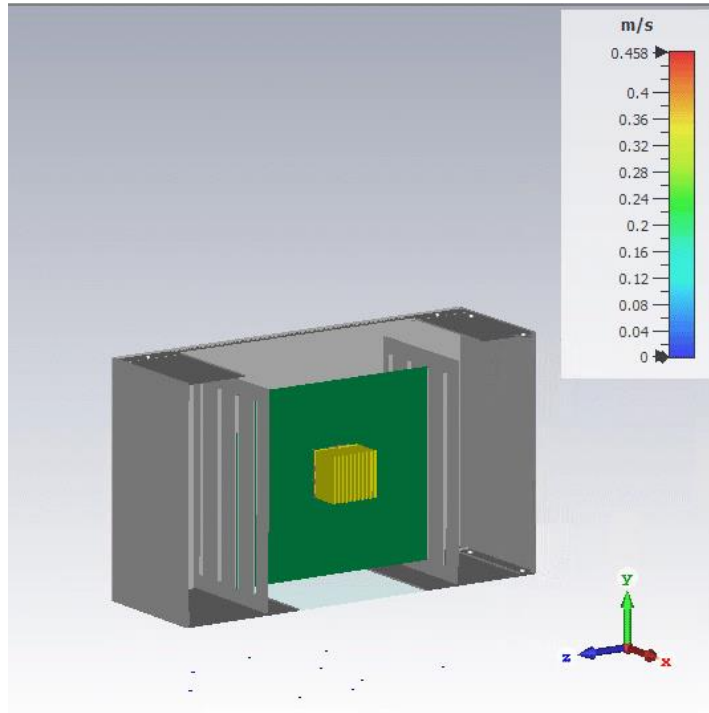
Simplified PCB Model



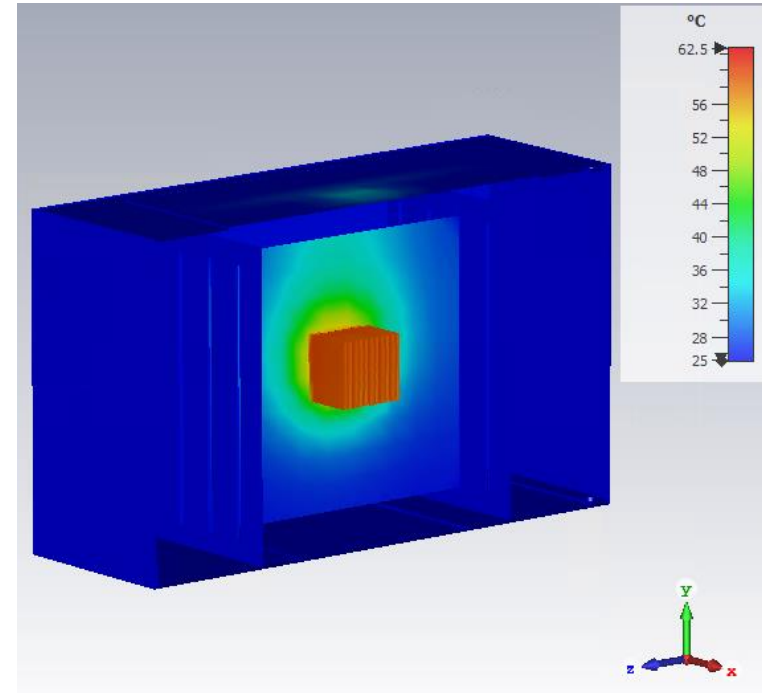
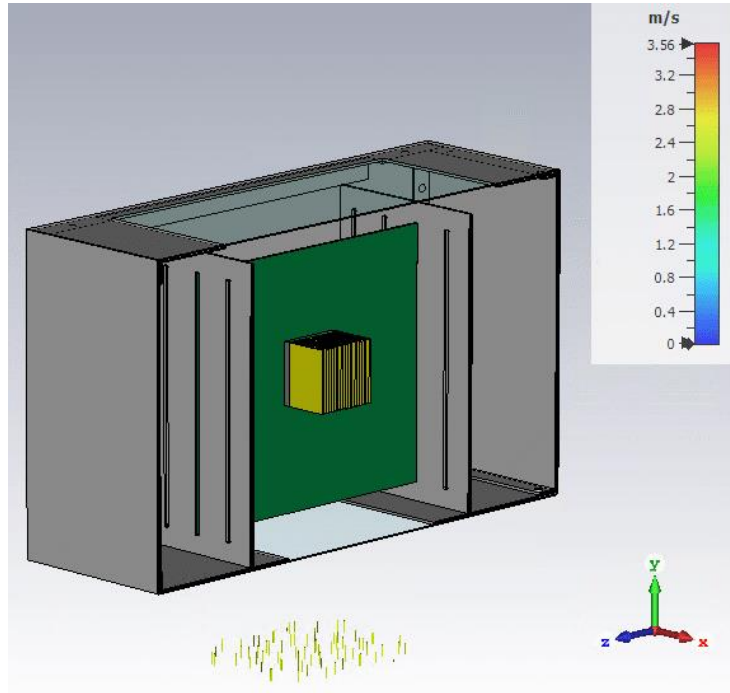
ARINC 600 Enclosure



ARINC 600 Chassis Natural Convection



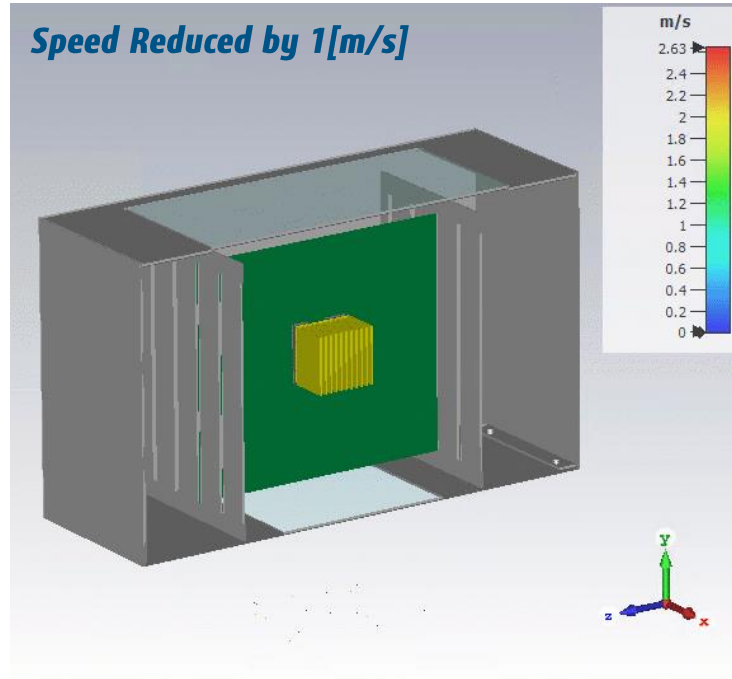
ARINC 600 Chassis Cooled by a Fan



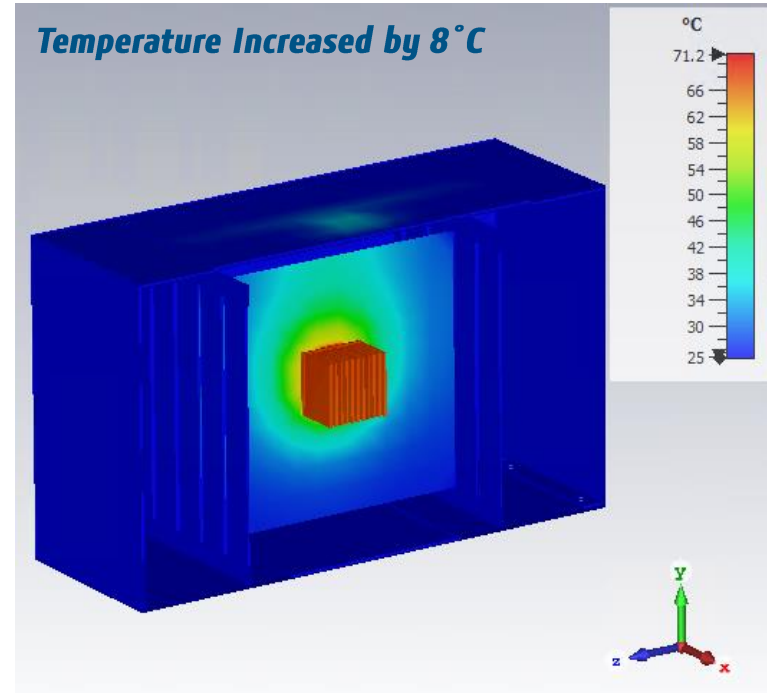
Vent **50%** Open

Cooling Reduction

Speed Reduced by 1[m/s]

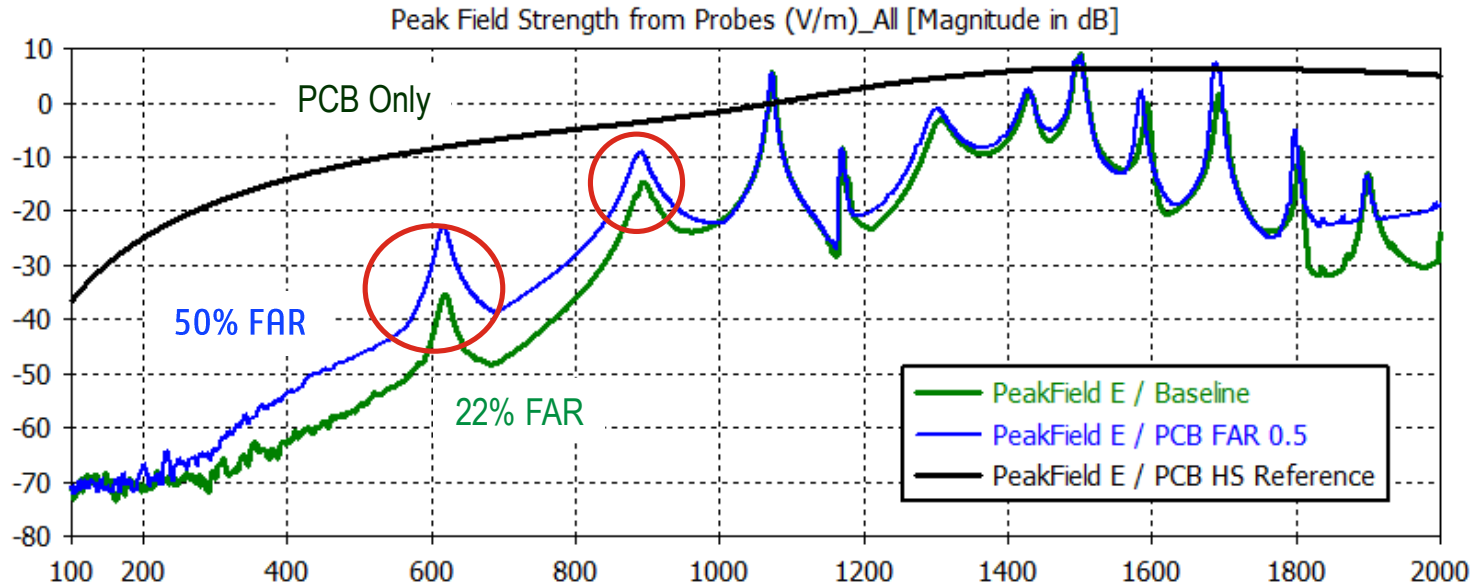


Temperature Increased by 8°C



Vent **22%** Open

ARINC 600 - Effect of Opening Vent Holes

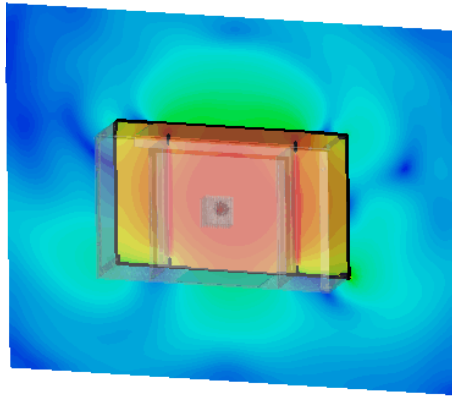


Vent hole radius increased from 0.25 (FAR 22%) to 0.37 in (FAR 50%)

ARINC 600 - Effect of Opening Vent Holes

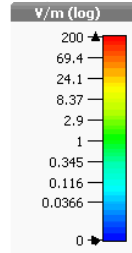


620 MHz



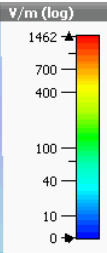
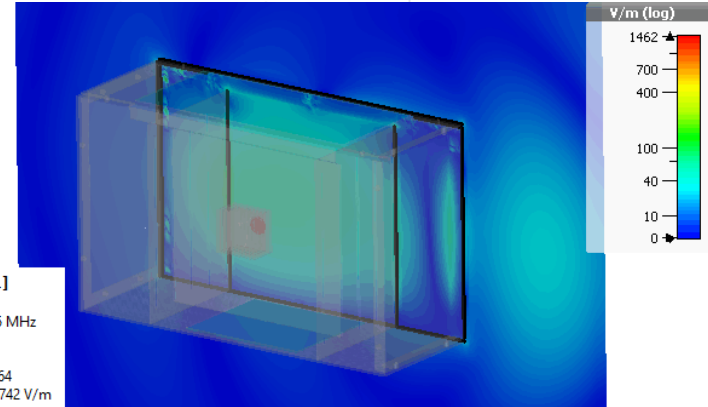
e-field (f=620) [1]
 Component Abs
 Frequency 620 MHz
 Phase 0
 Cross section A
 Cutplane at X -1.000
 Maximum 632.363 V/m

1075 MHz

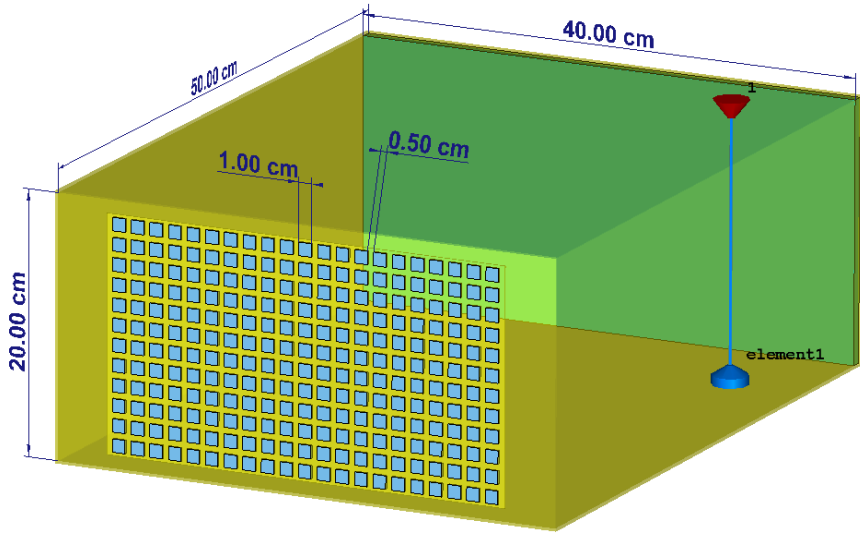


1200
 from

e-field (f=1075) [1]
 Component Abs
 Frequency 1075 MHz
 Phase 0
 Cross section A
 Cutplane at X -2.164
 Maximum 948.742 V/m



Air Vent Radiated Emissions



Geometric vent model

General Perforations

Type

Wire mesh

Vent open area

Vent pitch

Vent parameters

Free area ratio:

0

Thickness:

0 mm

Width:

0 mm

Vent properties

Hole shape:

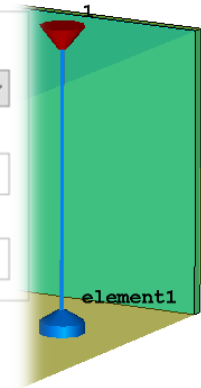
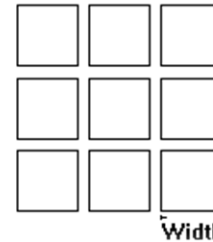
Square

Holes per unit length X dir:

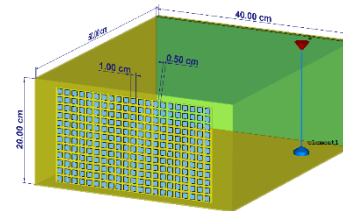
1

Holes per unit length Y dir:

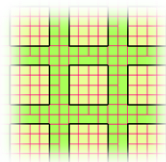
1



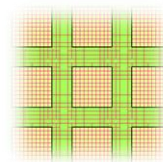
TLM Mesh Comparison



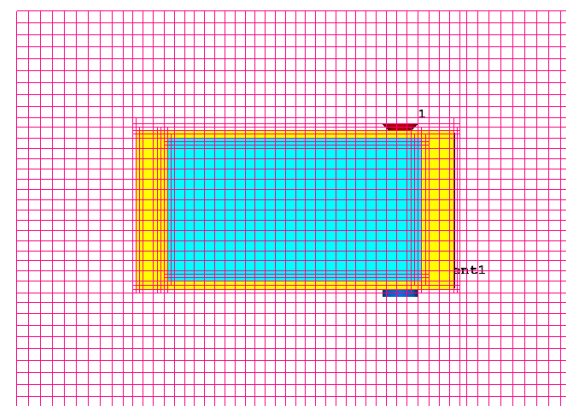
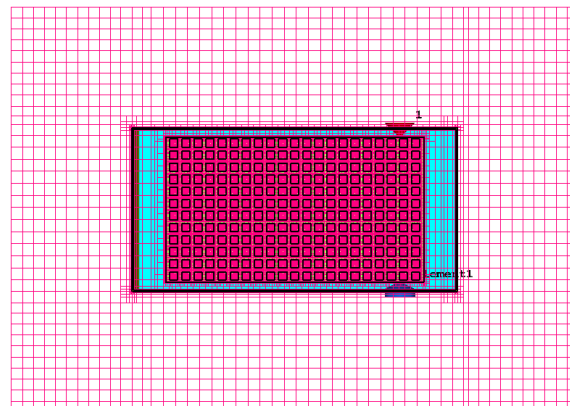
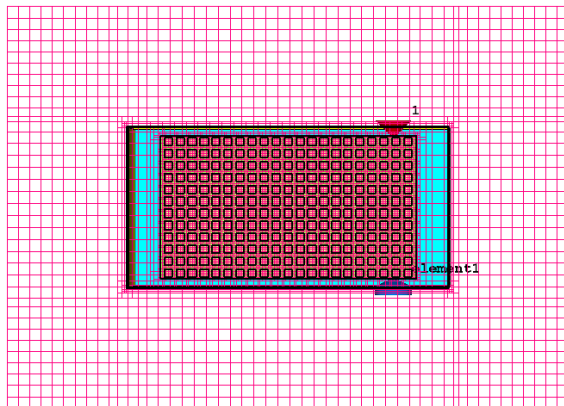
Geometric vent model
16 mesh cells per aperture



Geometric vent model
100 mesh cells per aperture



Compact vent model
Mesh size larger than aperture size!

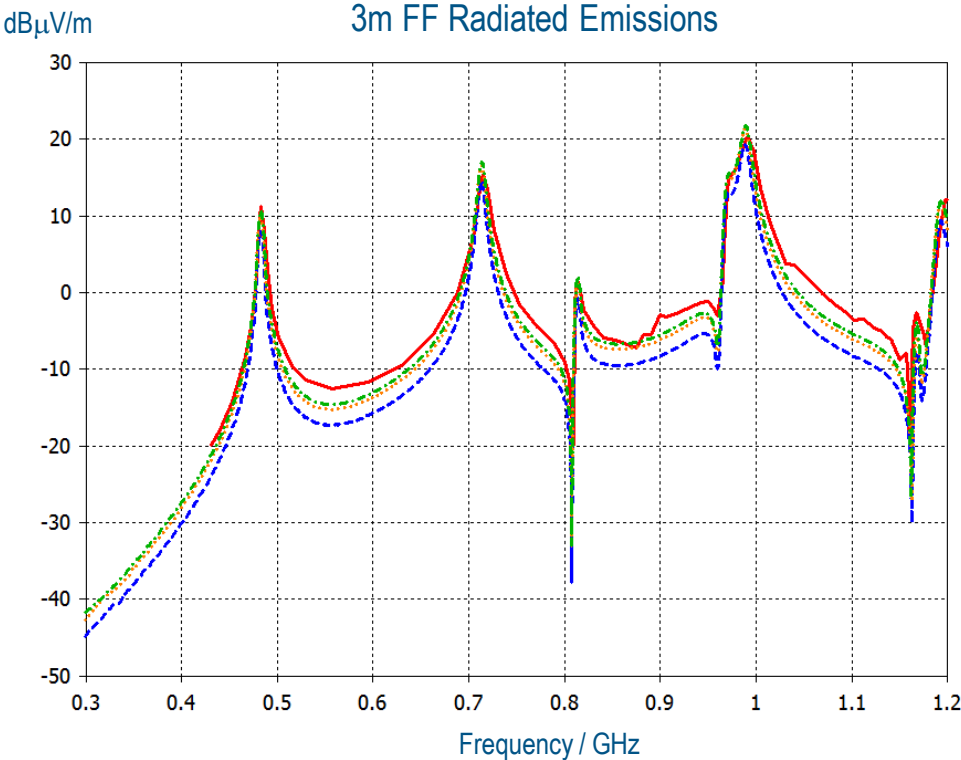


1.4M lumped to 283k mesh cells
3.86 pS DT
54 MB GPU memory
1m 8s on 2 x Tesla K40c

8.47M lumped to 580k mesh cells
1.5pS DT
118 MB GPU memory
4m 48s on 2 x Tesla K40c

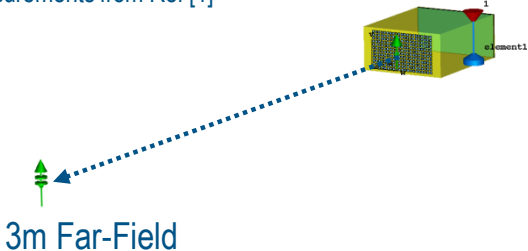
524k lumped to 210k mesh cells
6.6pS DT
37 MB GPU memory
45s on 2 x Tesla K40c

Radiated Emission Results



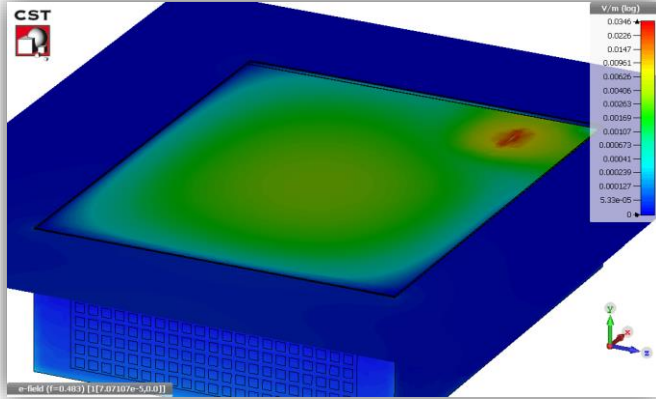
- measured by MST
- - - meshed model 16 cells per a...
- ⋯ meshed model 100 cells per ...
- · - tlm compact vent model

Measurements from Ref [1]

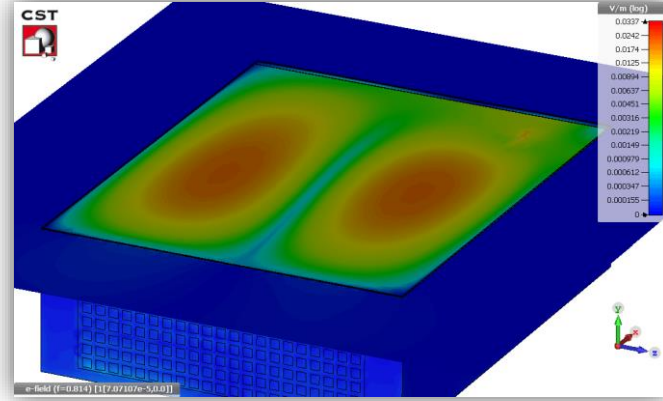


Resonances

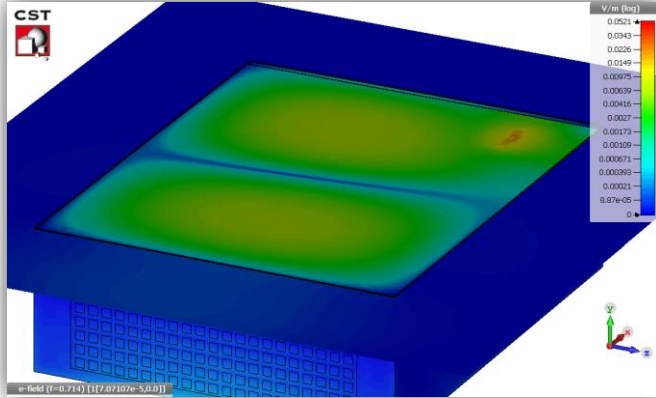
E-Field @
(0.483 GHz)



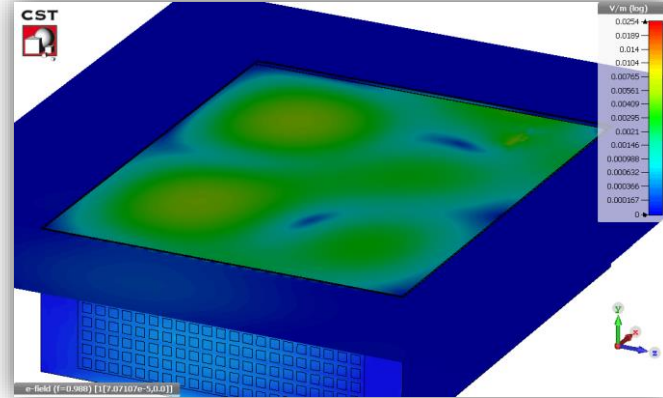
E-Field @
(0.814 GHz)



E-Field @
(0.714 GHz)

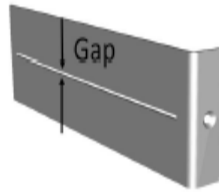


E-Field @
(0.988 GHz)

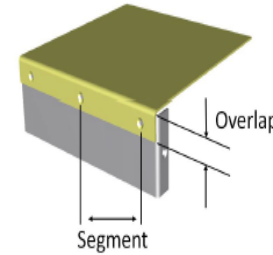


Slot and Seam Apertures

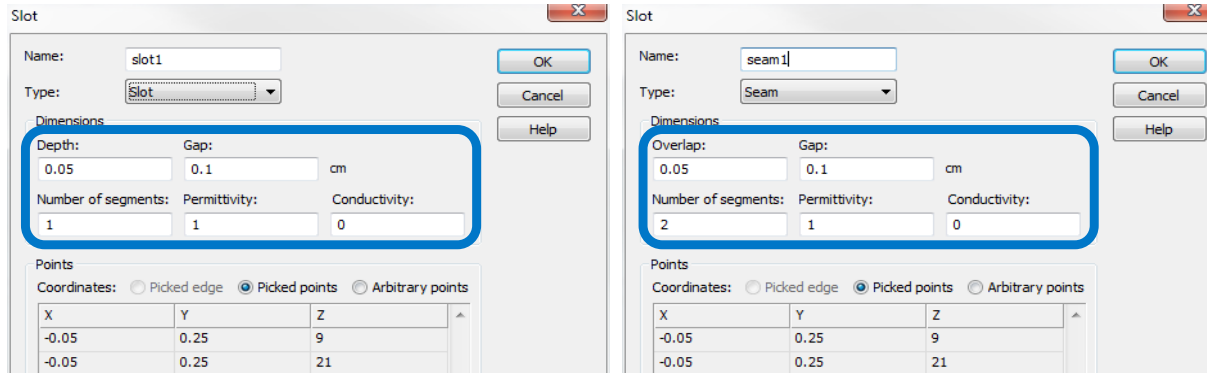
Slot
For modeling air gaps in
between two elements



Seam
Created by two overlapping
panels



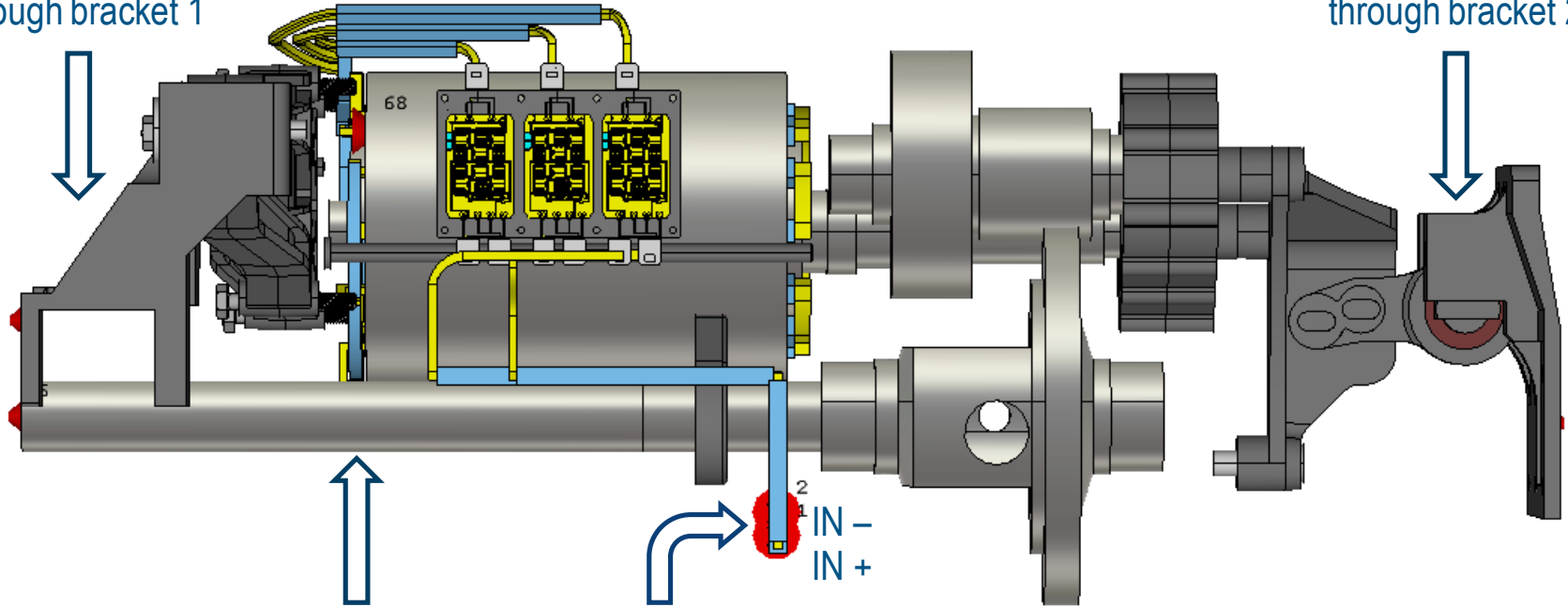
The number of Segments along the slot/seam can be specified to represent electrical connections such as rivets along the slot length



Powertrain EMC Analysis – Simulation Details

CM current path
through bracket 1

CM current path
through bracket 2

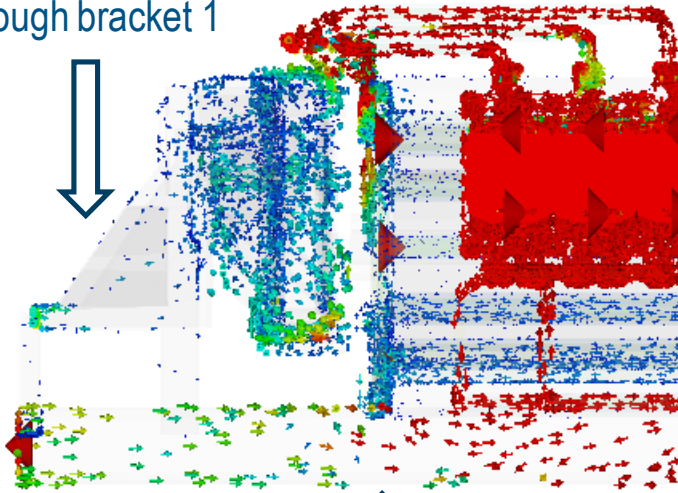


CM current path
through drive shaft

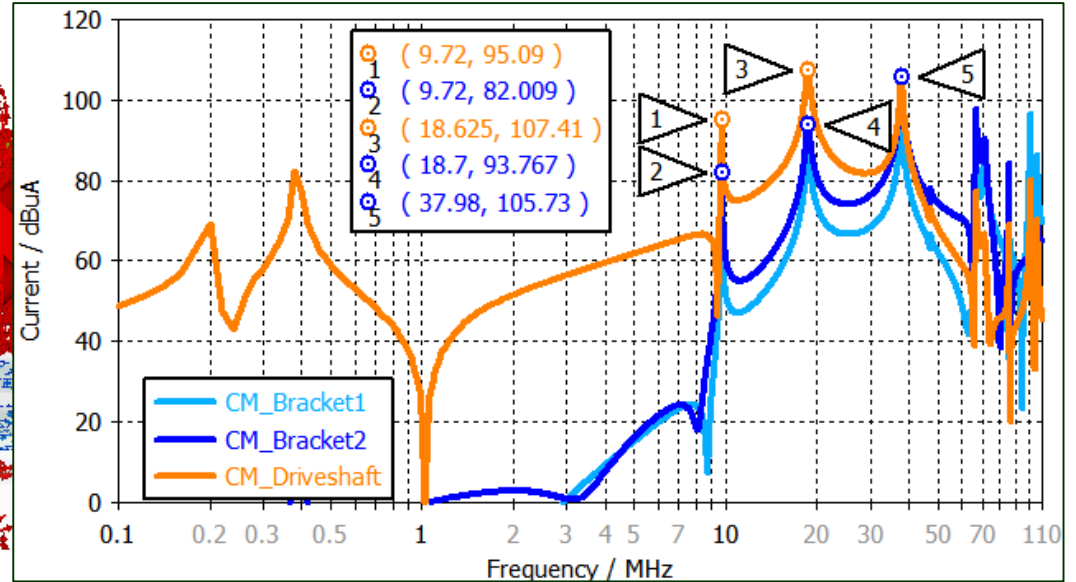
Current path through
PCB and cables

Powertrain EMC Analysis – Current Flow @ 9.7 MHz

CM current path
through bracket 1



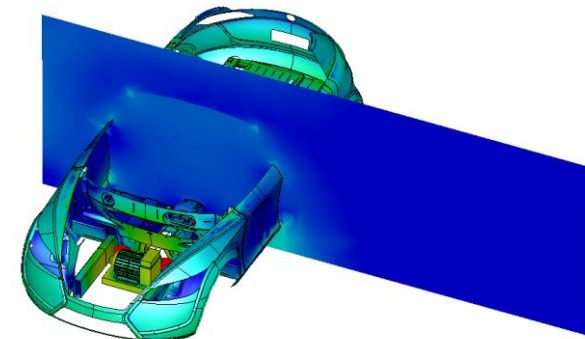
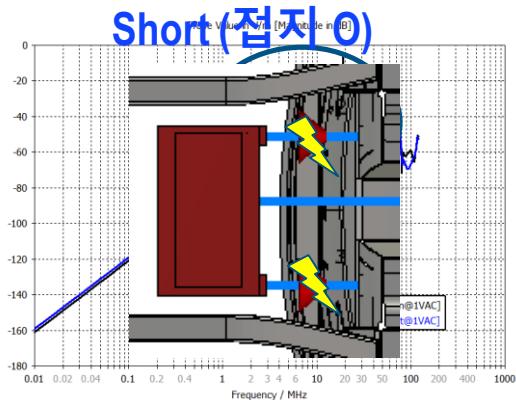
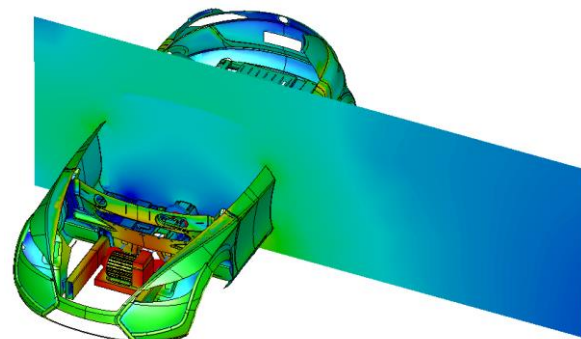
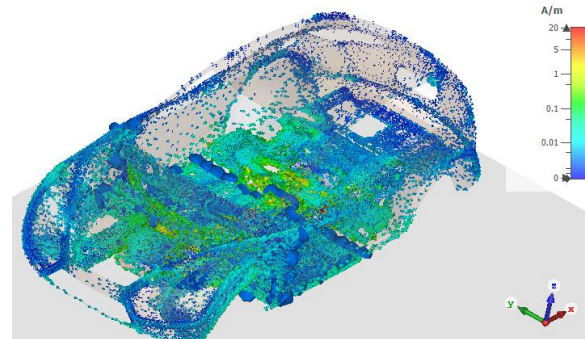
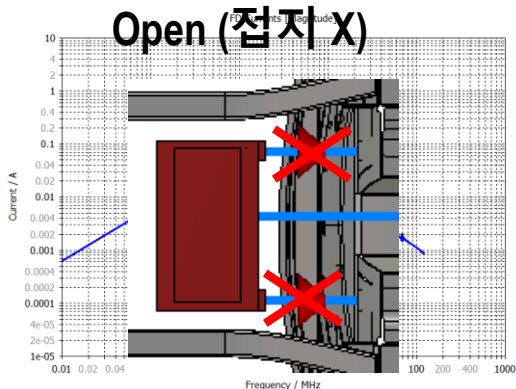
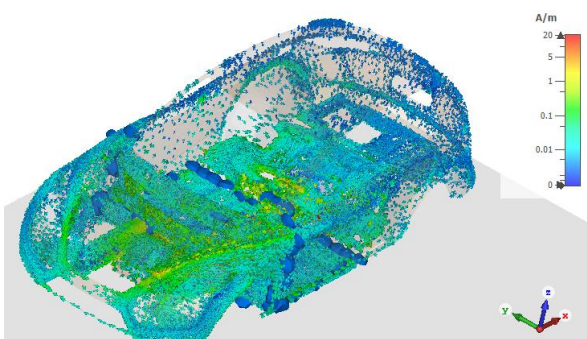
CM current path
through drive shaft



Common Mode Currents in Car Body

Black field curve: large common mode current path

Blue curve: shortened common mode current path



e-field (f=12) [SP1_Open@1VAC]
 Component Abs
 Frequency 12 MHz
 Plot attribute Maximum
 Cross section A
 Cutplane at X -132,500
 Maximum 19.6819 dB(V/m)

High electric field emission

e-field (f=12) [SP1_Short@1VAC]
 Component Abs
 Frequency 12 MHz
 Plot attribute Maximum
 Cross section A
 Cutplane at X -132,500
 Maximum -4.24659 dB(V/m)

Mitigated electric field emission

결론

- Package License 구성 시 다양한 Solver들을 모두 사용할 수 있음
- GPU(Graphics Processing Unit)을 이용한 해석 속도 향상
- 제공하는 다양한 기능들을 이용한 효과적인 해석 가능
- EM-Thermal Coupling Simulation



전자기장 해석 Solver 뿐 아니라 케이블 해석, 열, 구조 해석과 같은 다양한 분석이 가능함



빠른 분석을 통한 개발 주기 단축



복잡한 구조를 등가화 할 수 있는 다양한 기능을 통한 빠른 경향성 파악 가능



동일 GUI 환경에서 전자기와 열 데이터 연동을 통한 손쉬운 발열 분석 가능

