Simplification process of a complex system into a useful numerical model

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EMC Simulations

- Full prediction of EM fields radiated by a complex, real system is not possible
- Possible to quantify the relative difference between different designs
- Possible to establish and quantify design guidelines (e.g. routing strategies, stitching capacitor locations)
- Geometry simplifications decrease accuracy -> result variations between different design options need to be bigger than the result uncertainties

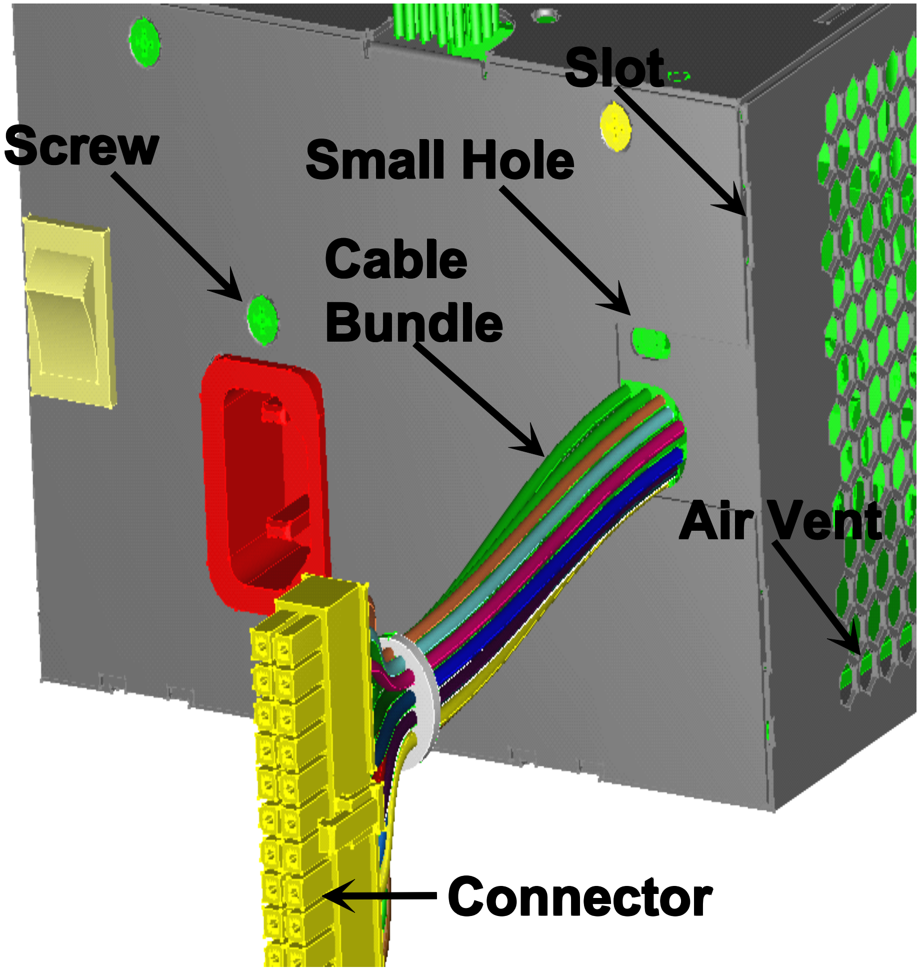
Experts focus on assumptions…..

- … while the rest of people look at results ☺

- Almost every EMC simulation involves a number of assumptions derived from the simplification of the problem, the numerical technique used and its implementation

- Not understanding the implicit assumptions (made by the numerical solution used) or the explicit assumptions (made by the user) usually leads to incorrect results or incorrect interpretation of the results

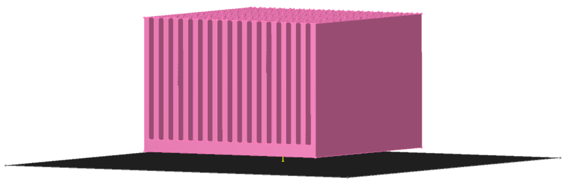
What should I include in the model?



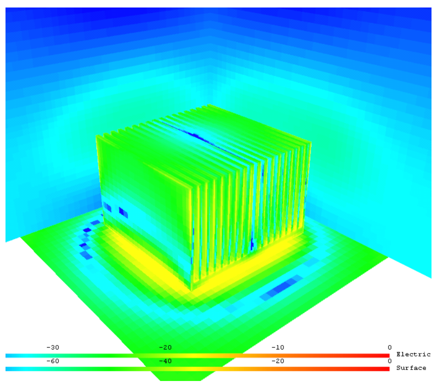
- **Source, coupling path and victim** (if there is one)
- Use the expertise of application engineers
- If you are modeling a new class of problems, verify your assumptions using very simplified models
- Accuracy decreases at higher frequency
- Not every complex model can be modeled

Effect of simulation settings on results

- Effect of grid, boundary conditions, type of ports, convergence etc. should always be investigated
  - dependent on the specific numerical tool used

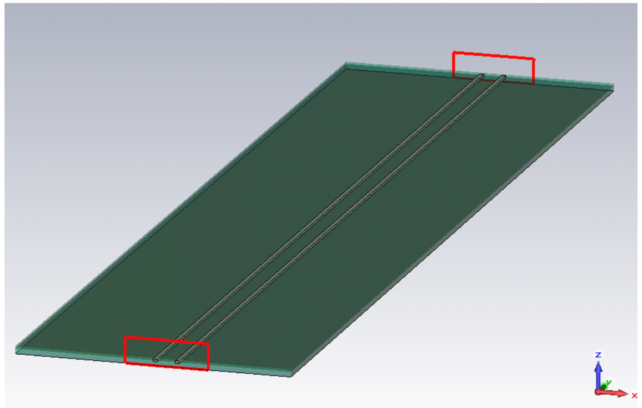


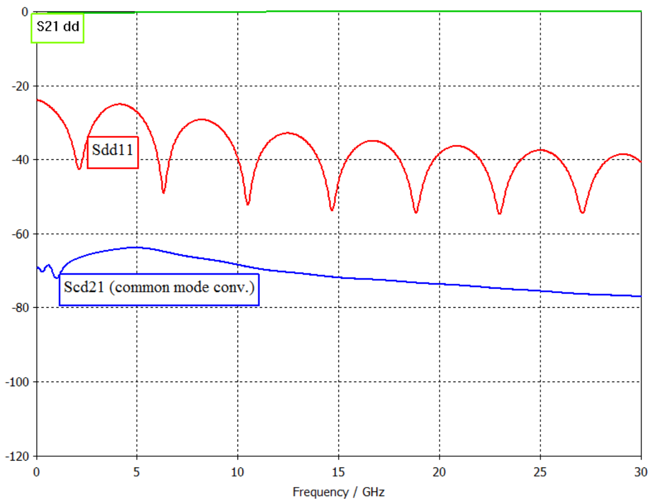
8 cm x 8 cm x 5.5 cm heat sink on a infinite ground plane



- Simulation outputs:
  - Surface current and field distributions: very effective for geometry verification and validation
  - Near field, Far field: use cylinder scan and/or radiation power instead of monitoring the fields in one location
  - S-parameters: if you use a TD solution, examine TD before looking at S-parameters

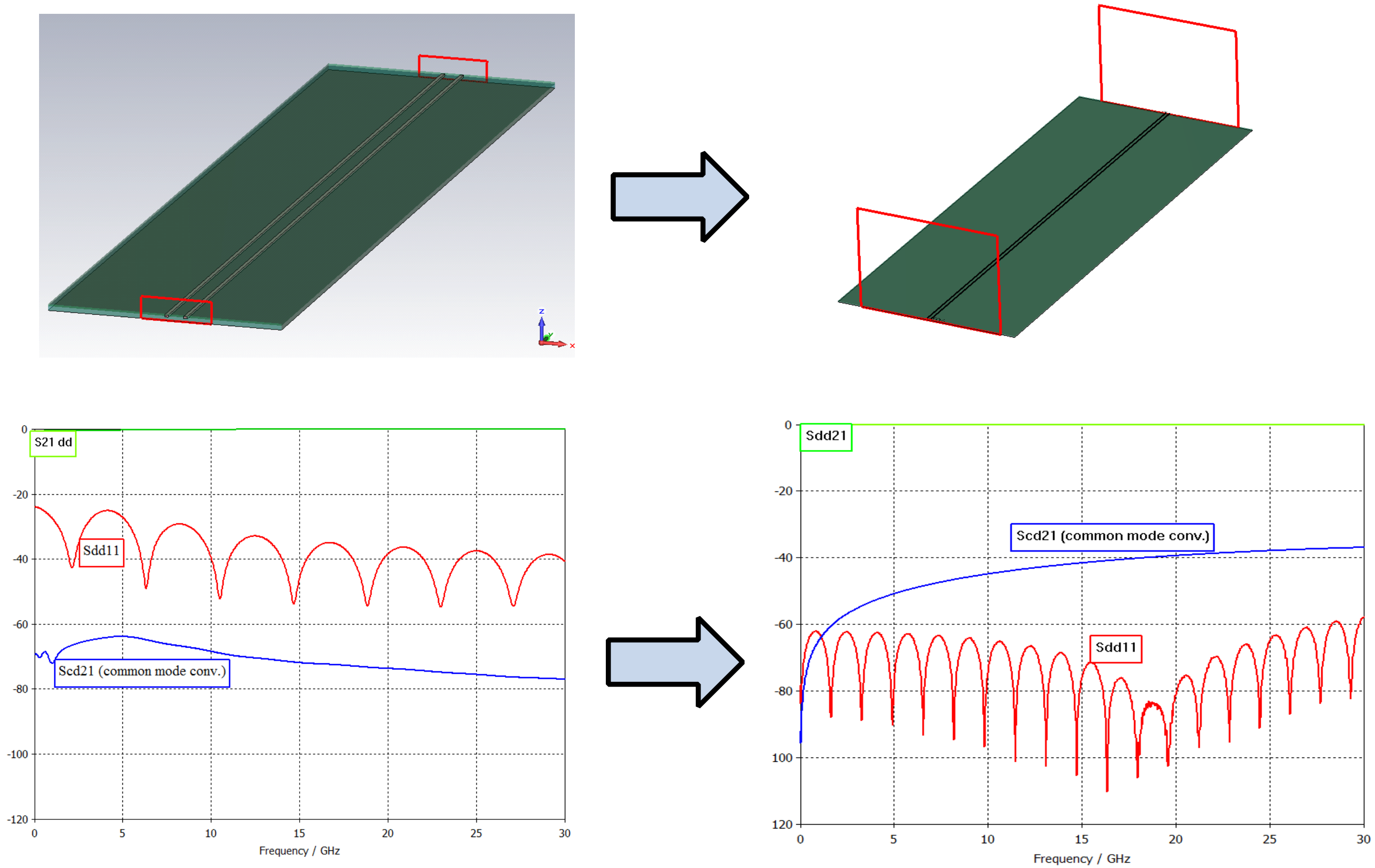
Example of port and grid settings





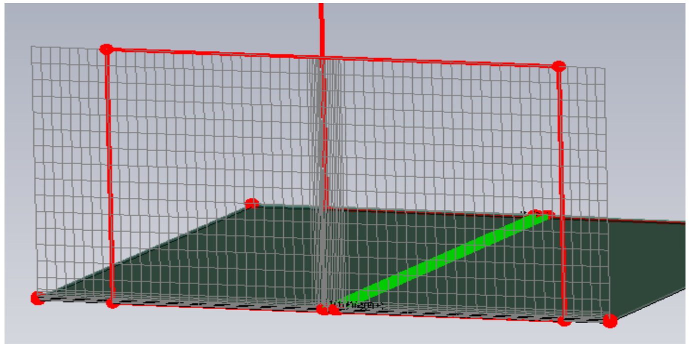
- Straight differential pair on infinite ground plane
  - Objective of the simulation was to study differential to common mode conversion
  - For an ideal straight differential pair there should not be any common mode conversion
  - For a perfectly matched waveguide port there should be no reflection
  - The S_{cd21} and the S_{dd11} show the numerical artifacts of the model

Increase of Port Size

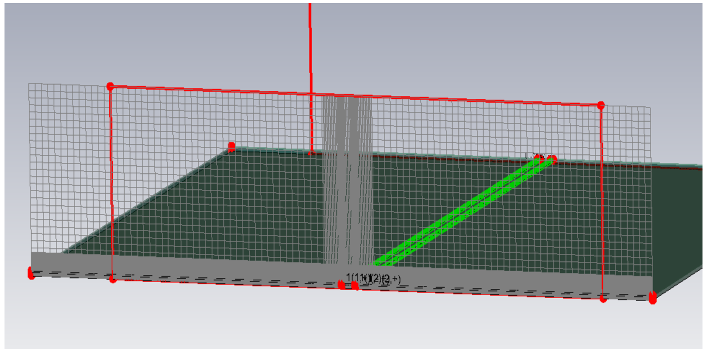


Increasing the port size seems to decrease the port reflection (S_{dd11})
but to increase the artificial common mode conversion (S_{cd21})

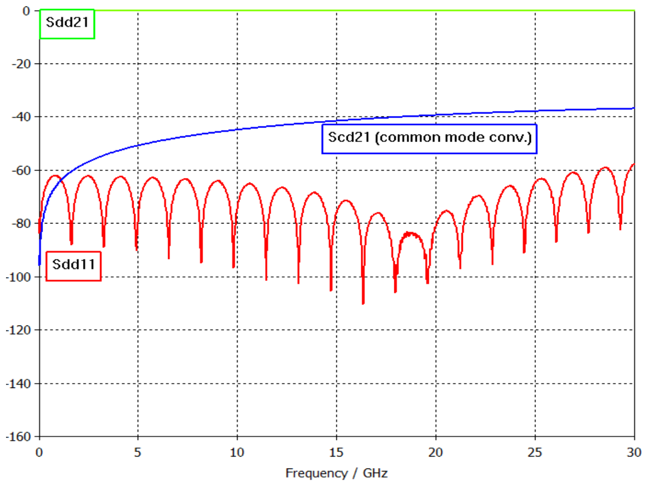
Increase of grid density

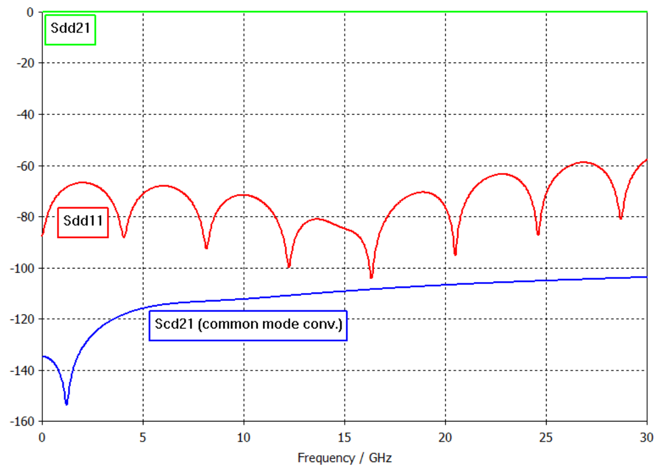


- 117,000 Mesh Cells



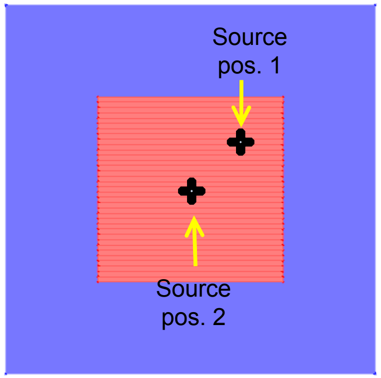
- 2,009,600 Mesh Cells

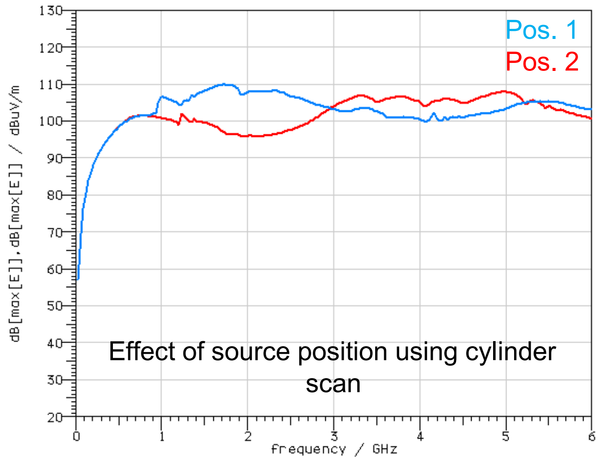


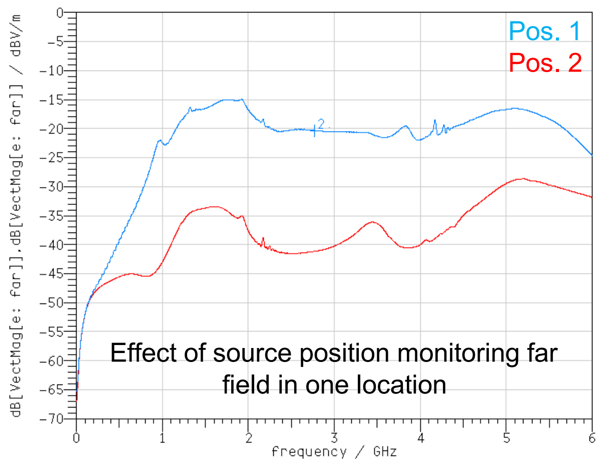


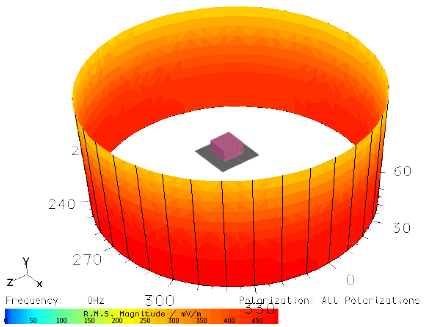
Increasing the grid density decreases the common mode conversion (S_{cd21})

Cylinder Scans/ Radiated Power

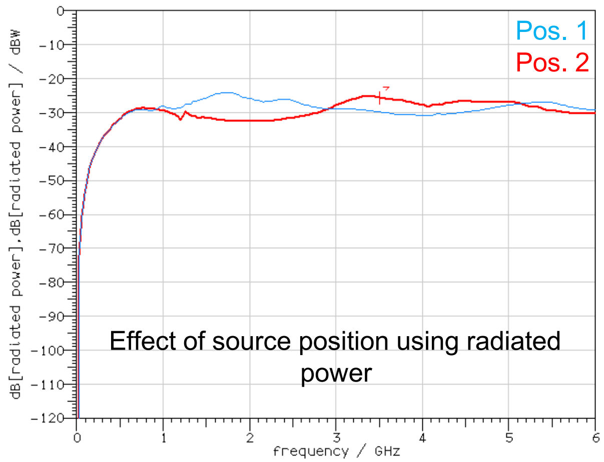


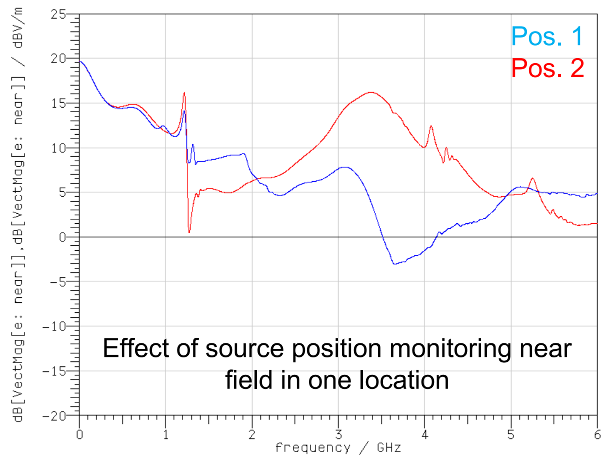






Cylinder Scan output



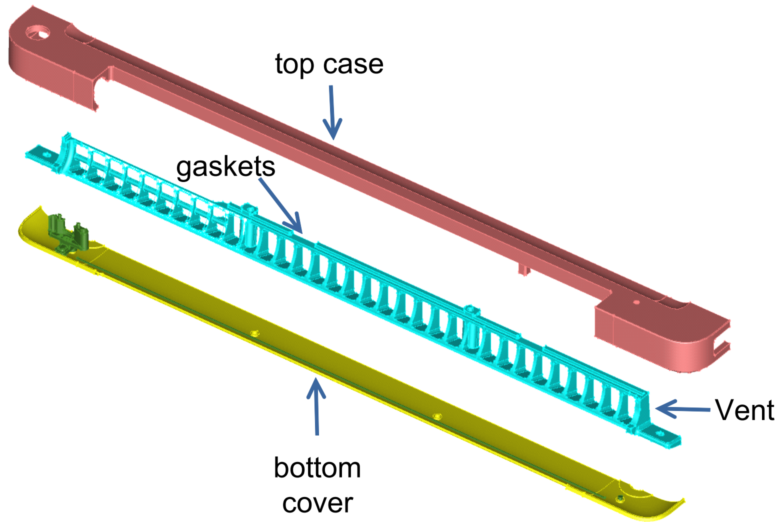


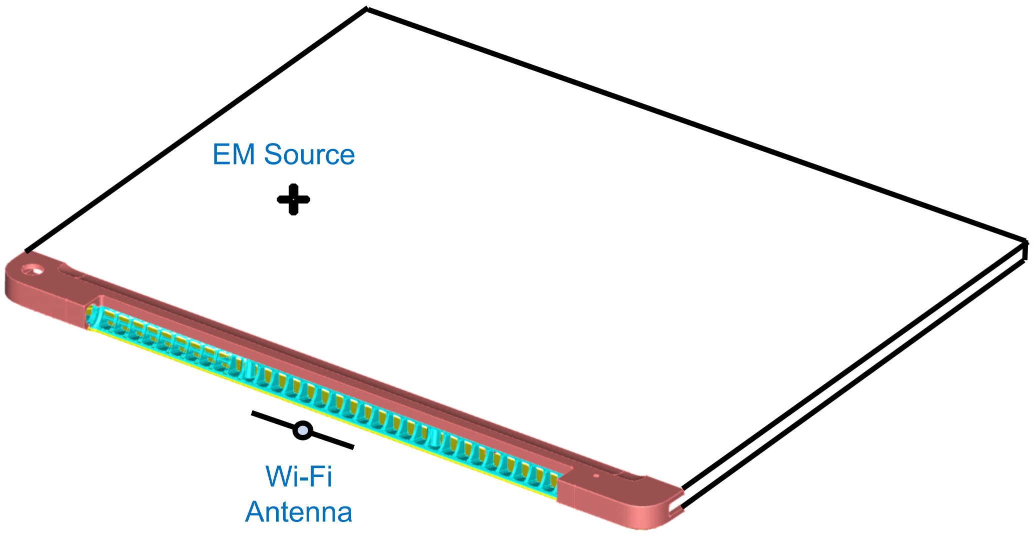
Importing CAD files

- CAD files were not intended to do EMC simulations
  - In most applications, CAD model will have to be significantly simplified before becoming useful for EM simulations.
- Simple modifications of the CAD model can be done using 3D Full wave tools
  - These simplifications are not always possible, may be very time consuming and may even introduce hidden meshing problems.
- Try to use the "Parasolid" file format (.x_t, .x_b, xmt_txt, xmt_bin) to simplify the model using CAD tools before exporting to STEP or SAT
  - Tolerant geometry processing, very robust.

Rear vent and seams design example

- Top case was driven against the bottom cover
- All internal components of the laptop were removed from the model
- Fields monitored at the Wi-Fi antenna location

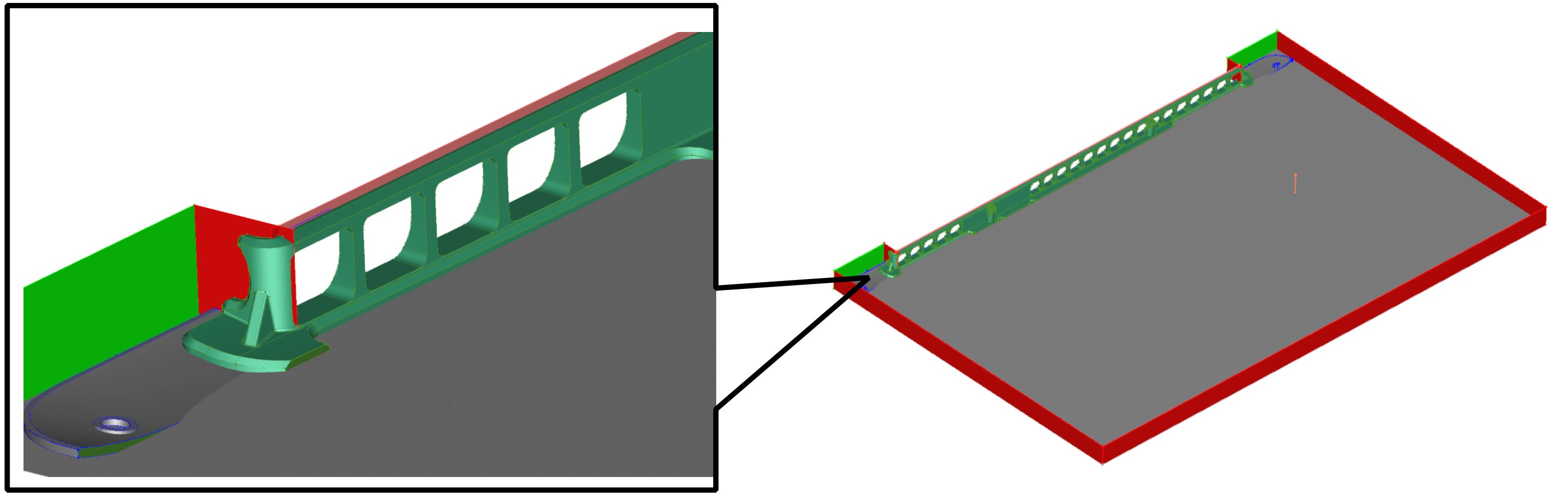




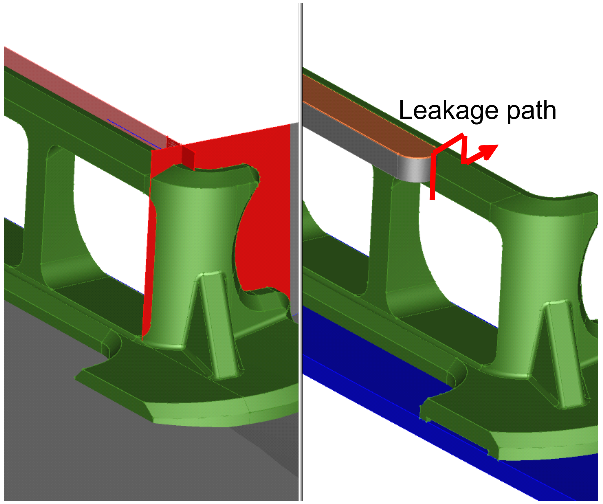
- Effect of ventilation panel and seams on emissions
- Comparison with the previous designs

CAD Simplification

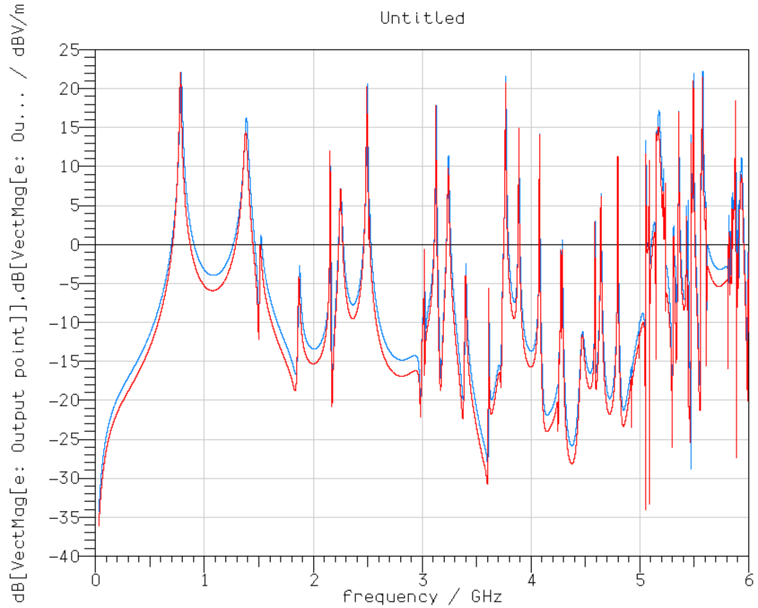
- Laptop case was replaced by a square enclosure of same size with no apertures
- The only coupling path between the Wi-Fi antenna and the enclosure goes through ventilation panel
- Gaskets were removed (assumption of a good electrical contact)
- Seams were modeled using “compact” models
- “Grounding” screws were replaced by simple cylinders
- Ventilation panel was cut to remove unnecessary details
- Seam compact model was verified using a simplified model



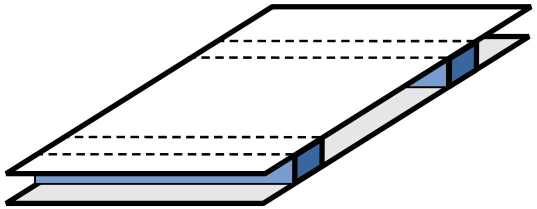
Replacement of seam with compact model

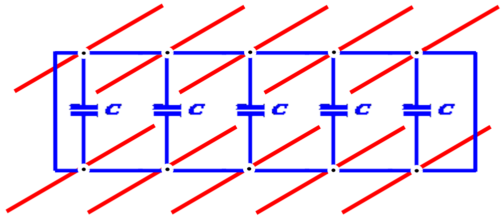


Simplified model compared with the original CAD model ("unibody" not shown)



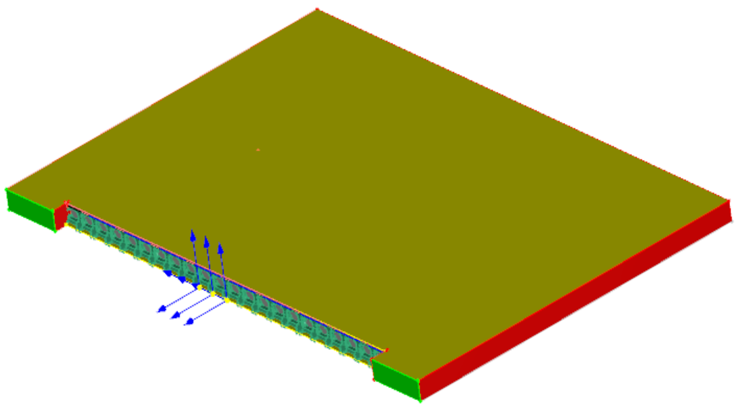
Verification of correct use of seam model

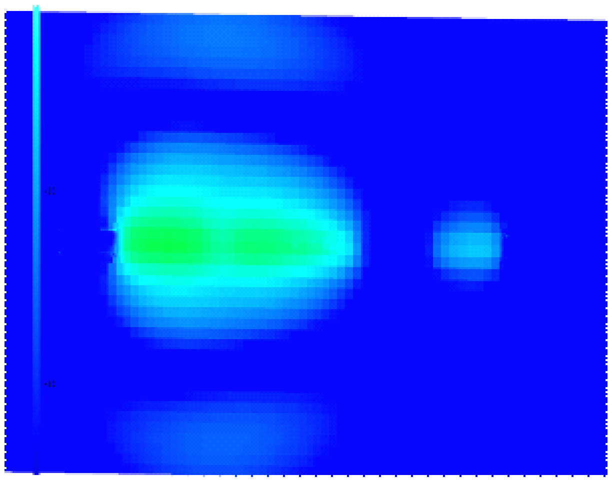


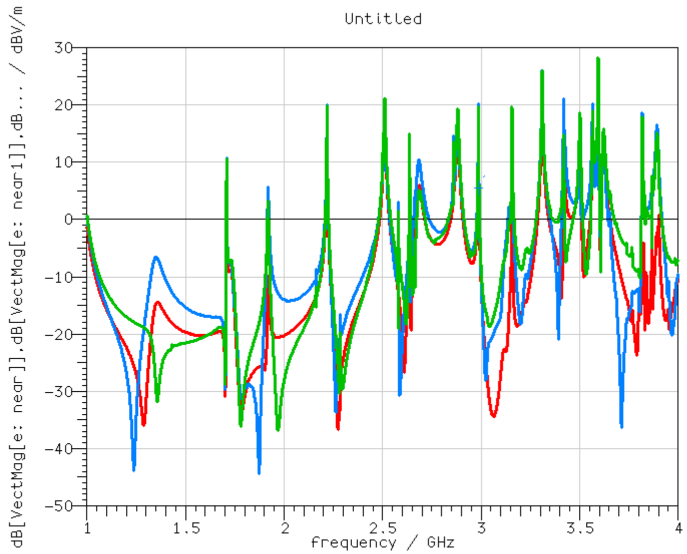


Seam equivalent TLM model

Monitor points at the Wi-Fi location



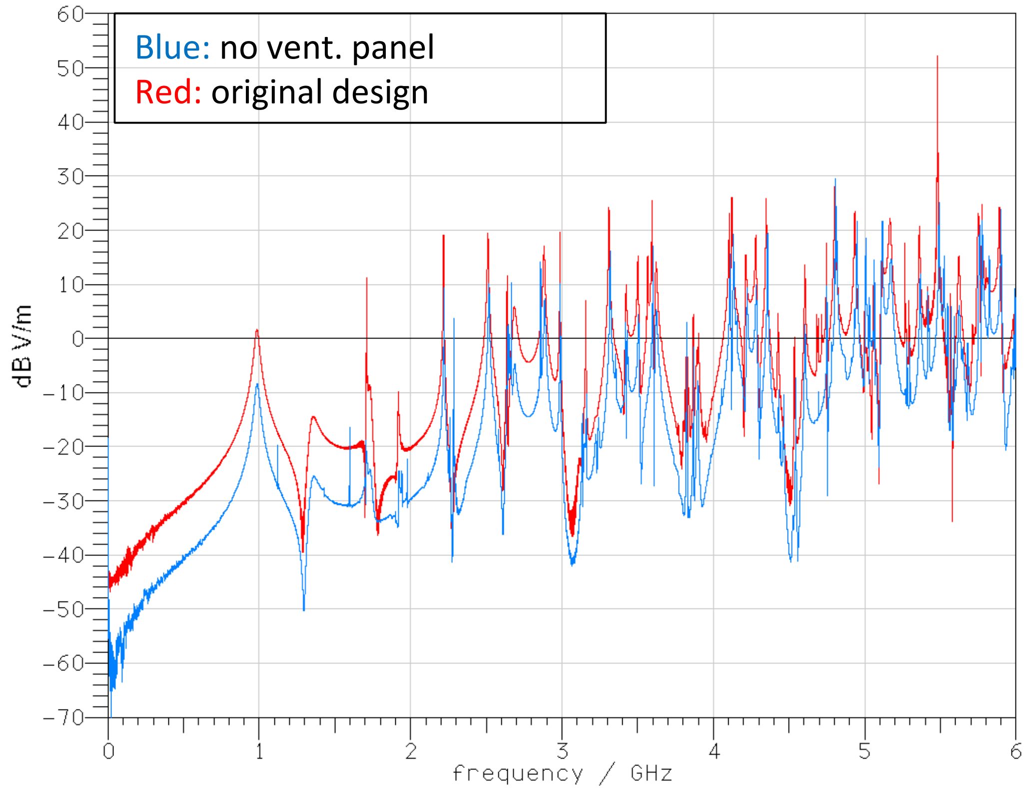




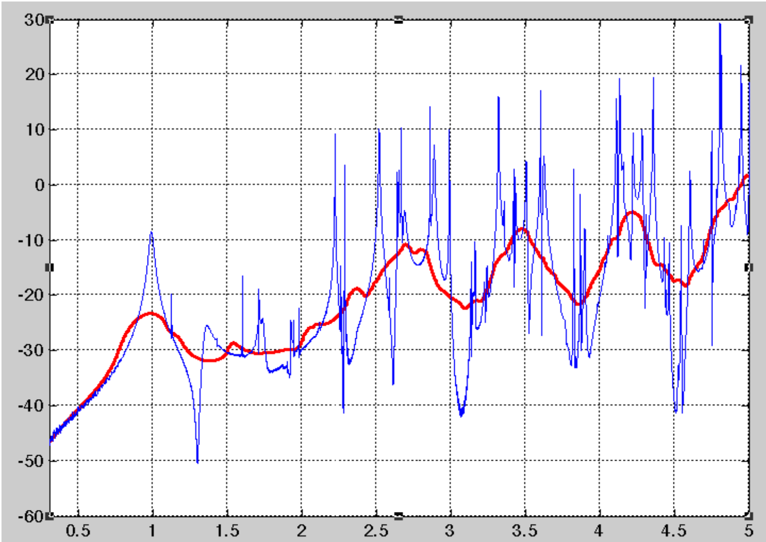
- Field variation at different locations may be significant
- The presence of the Wi-Fi antenna may change the field distribution
- A detailed model of the antenna should be included in the simulation

Contribution of ventilation panel

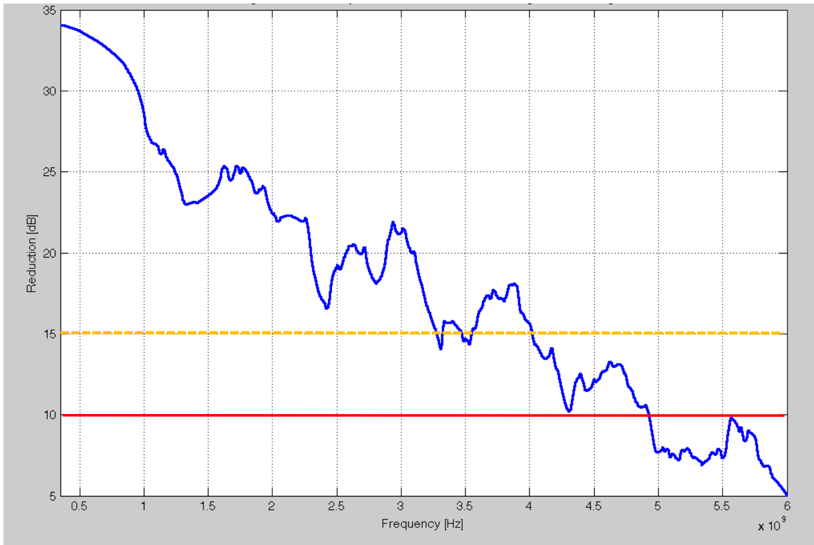
- Unprocessed data can be confusing
- The Q-factor and the resonant frequencies are not modeled correctly as a consequence of our model simplification
- How do we interpret results?



Filtering and Normalization



Simulation result data filtered using Matlab



Shielding reduction between different designs

- A "smooth" function was used to post-process simulated data using Matlab
- The objective is to show the general trend and hide the individual resonant frequencies

- Results were normalized to compare different design configurations
- At higher frequencies result uncertainties increase. Only large variations between designs can be trusted

Summary

- Simplified models are less accurate but accurate results can be achieved if you have enough time and computational resources
- Consider how the simplifications will affect the coupling path that you are trying to model
- Use the expertise of Application Engineers when possible
- Monitor different outputs to verify the model and the robustness of the results
- If you are in doubt, use very simple models to verify uncertain assumptions
- If you have resources do a "sensitivity" study
- Use compact models if available