SIMULATION OF VEHICLE IMMUNITY TESTS ACCORDING TO ISO 11451-2 STANDARD

EMCoS Studio

Introduction

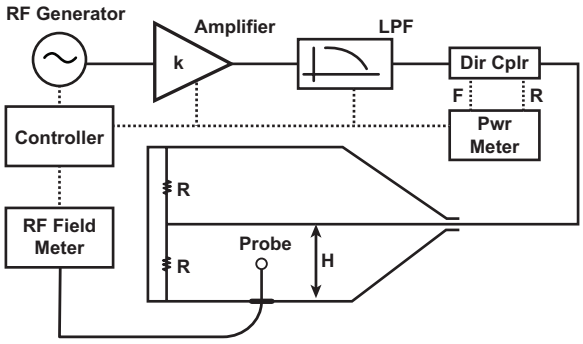
Vertically Polarized Transverse Electromagnetic Mode (VTEM) cells may be used for immunity tests in vehicles. The tests are performed according to the ISO 11451-2 Standard. This application note describes a full wave approach for simulation of a VTEM cell. The investigation is performed in two stages. Firstly, the field uniformity and vertical polarization of the empty cell are verified. Secondly, the impact of the vehicle presence on the field structure inside the cell is examined. The simulation results are compared to measurements.

Vehicle Immunity Test Phases (ISO 11451-2)

For vehicle immunity testing below 30 MHz a large truncated vertically polarized transverse electromagnetic mode (VTEM) cell is used. The height of the cell is 6 m and the septum is placed at the height of 3 m. This cell uses a terminating screen to absorb the RF energy and provide a termination of 50 Ω for the septum. Underneath the septum there is a target area to place the devices under test (DUT).

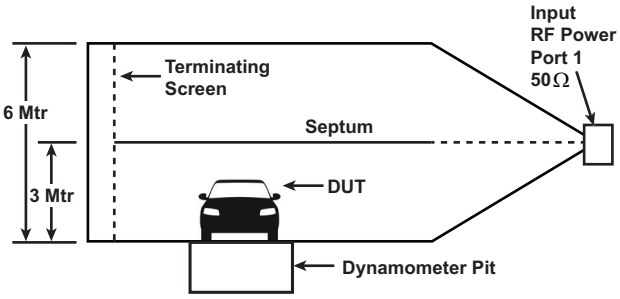
According to the ISO 11451-2 Standard vehicle immunity tests are performed in two phases. Phase 1 is the field calibration of the empty chamber. The input power is calibrated in order to achieve the electric field strength level in the DUT target area, which is specified in the standard. Phase 2 is the test with the vehicle in place.

Phase 1: Field Calibration (Empty Chamber)



- Input power is chosen so that the electric field strength in the middle of the DUT target area achieves the level specified in the standard

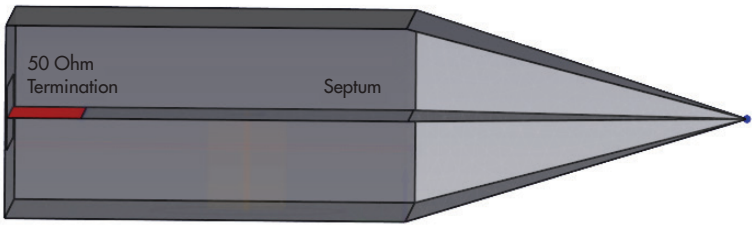
Phase 2: Test with Vehicle in Place

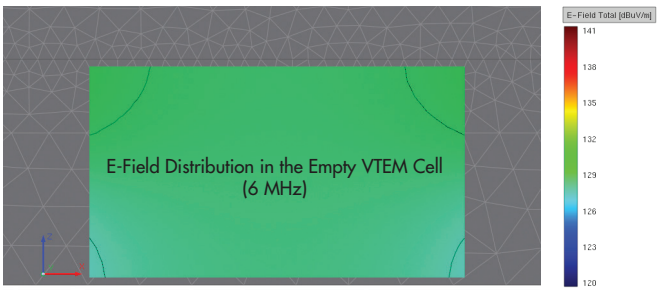


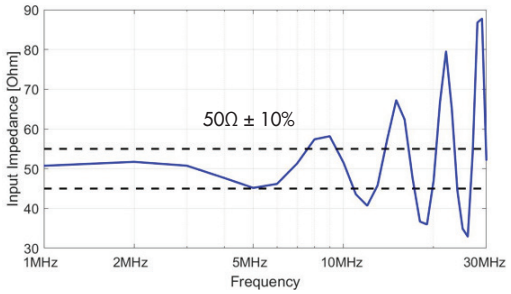
- An evaluation of the immunity of vehicle electronic systems to electromagnetic interference is required
- For vehicle immunity testing below 30 MHz, a large truncated TEM cell is used

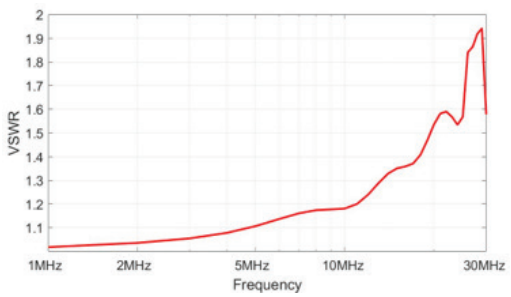
3D Model and EM Characteristics of the VTEM Cell

3D Model of VTEM Cell in EMCoS Studio Environment and Simulated EM Characteristics









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Application note was prepared in cooperation with Fiat Chrysler Automobiles (FCA)

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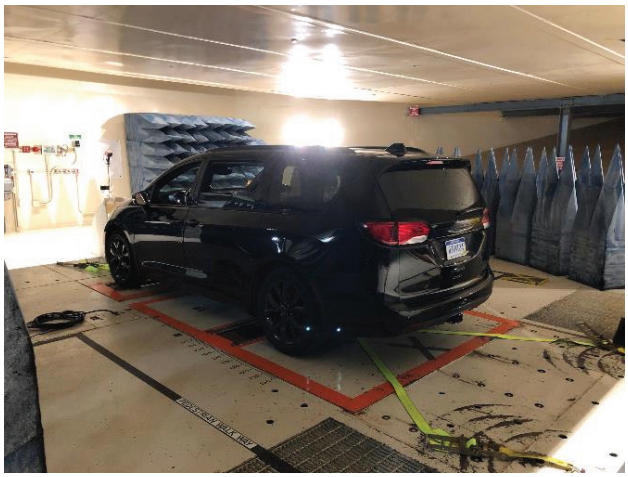
Simulation of Interaction of Vehicles and VTEM Cell (Real Car Application)

Measurements setup for immunity testing according to ISO 11451-2 standard was assembled in FCA Laboratory. Measurement results were compared with simulations.

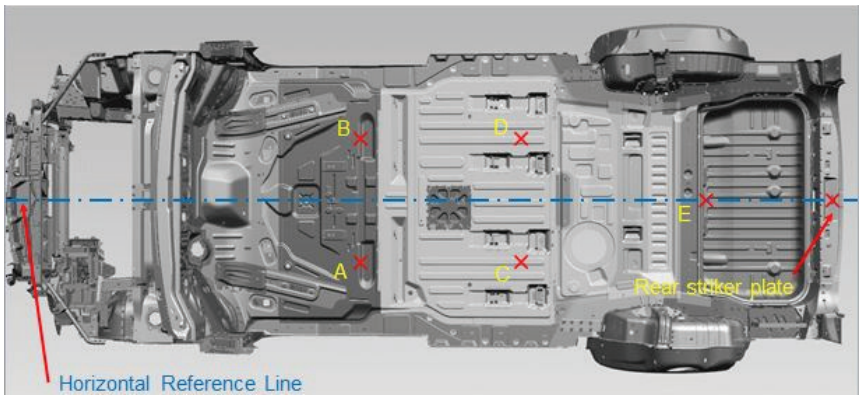
Chrysler Pacifica Car Model in FCA Laboratory

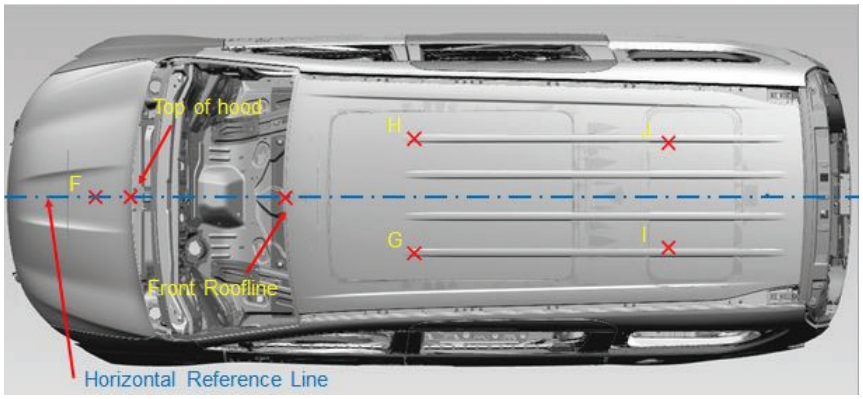


* *Images courtesy of Fiat Chrysler Automobiles (FCA)*

Field Probe Locations in Chrysler Pacifica

- A - Driver Seat
- B - Passenger
- C - 2nd Row Driver
- D - 2nd Row Passenger
- E - 3rd Row Center





- F - Hood Center
- G - Roof Driver Front
- H - Roof Passenger Front
- I - Roof Driver Back
- J - Roof Passenger Back

* *Images courtesy of Fiat Chrysler Automobiles (FCA)*

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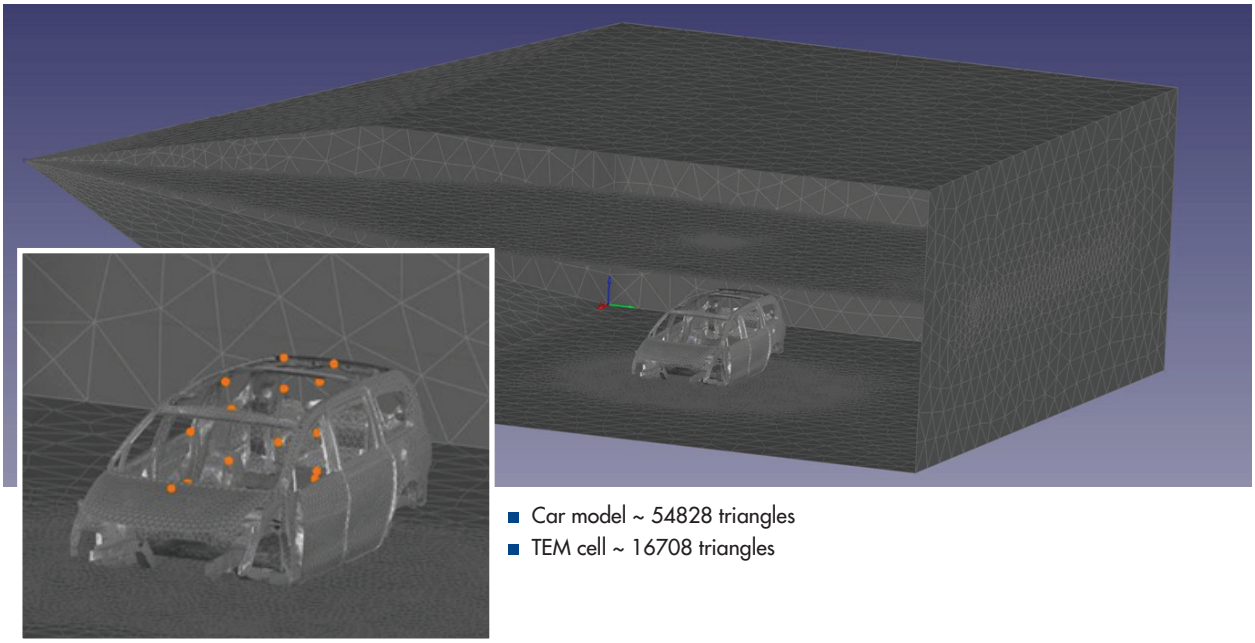
Simulation Model of Chrysler Pacifica inside VTEM Cell

The VTEM structure can be used for immunity testing of the vehicles for frequencies below 30MHz. Below is shown simulation model constructed in EMCoS Studio environment for phase 2 of immunity tests conducted for Chrysler Pacifica car model inside the VTEM Cell:

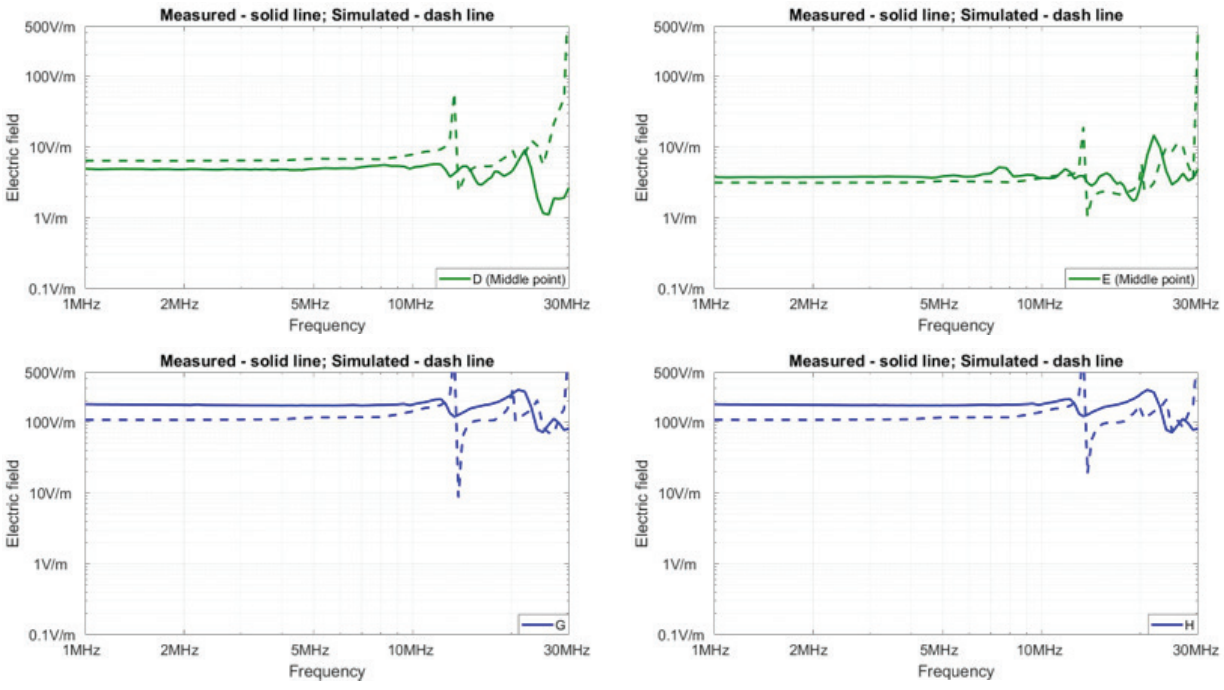
3D Model of Chrysler Pacifica inside VTEM Cell



- Car model ~ 54828 triangles
- TEM cell ~ 16708 triangles

Comparison of Simulation and Measurement Results

Simulation of Interaction of Vehicles and VTEM Cell



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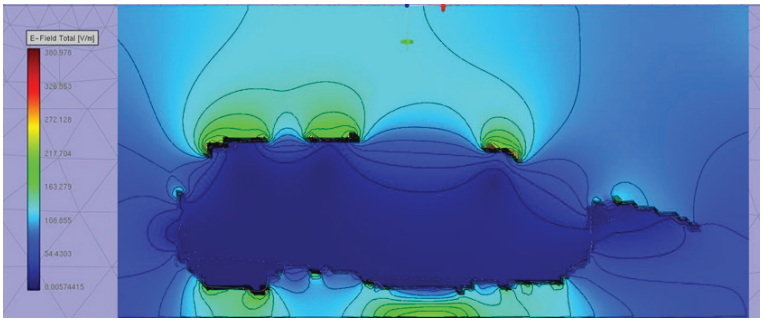
Possible reasons of difference between measurements and simulations:

- The roof of the vehicles is partially made of fiber glass. These parts are neglected in the simulations.
- The measured vehicles were already coated with paint. As it is a composite material the paint coat was neglected in the simulations.
- In Chrysler Pacifica the front seats were removed and the rear seats were folded during the measurements. Whereas in the simulation model the floor of the vehicle was relatively smooth and did not take the seats into account.

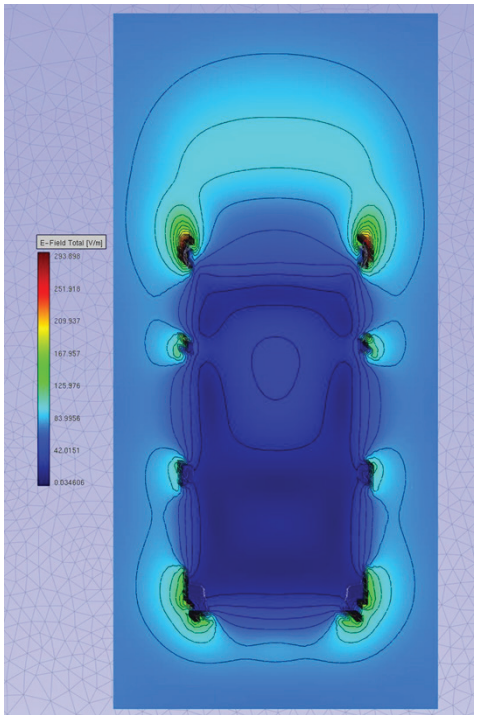
Simulation Results - Electric Field Distribution

While the simulated field inside the empty VTEM Cell is uniform, the conductive vehicle body strongly affects the field around the vehicle. There are reflections from the edges of the car. The field inside the vehicle is much smaller as the car body behaves like shields. Below is shown the electric field distribution obtained by full wave MoM solution in side view and in top view cross sections:

Chrysler Pacifica Car Model
E-Field Distribution Outside Vehicle (6 MHz)



Side View



Overhead View (1.4 m above ground)

Conclusions

- Simulation models of virtual test bench systems based on different EMC test standards can be successfully constructed in EMCoS Studio environment
- The electromagnetic fields can be effectively calculated using MoM solver in frequency domain
- As the simulation results capture thresholds of the measurements, these models can be used for further testing like immunity testing of devices inside the vehicle

References

- T. Jobava, I. Oganezova, R. Jobava, R. Kado "Full Wave Simulation of a Vertically Polarized Transverse Electromagnetic Mode Cell", XXIIIth International Seminar/Workshop on DIRECT AND INVERSE PROBLEMS OF ELECTROMAGNETIC AND ACOUSTIC WAVE THEORY (DIPED-2019), September 11-13, 2019
- R. L. Monahan, T. M. North and A. Z. Xiong, "Characterization of large TEM cells and their interaction with large DUT for vehicle immunity testing and antenna factor determination," 1999 IEEE International Symposium on Electromagnetic Compatibility. Symposium Record (Cat. No.99CH36261), Seattle, WA, USA, 1999, pp. 245-249 vol.1.

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