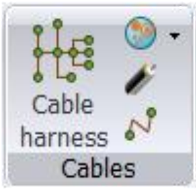
Combined Electromagnetic Field and Cable Coupling Solutions

INTRODUCTION

Many problems of electromagnetic compatibility and interference involve cables, which either radiate through imperfect shields and cause coupling into other cables, devices or antennas, or which receive (irradiation) external electromagnetic fields (radiated from antennas or leaked through other devices) and then cause disturbance voltages and currents potentially resulting in a malfunctioning of the system. From the background that in modern systems cables play such a dominant role (e.g. in the automotive environment a car these days has several kilometers of cables) it is crucial that already in the design process of electromagnetic systems such coupling / radiation / irradiation effects involving cables are taken into account from an EMC perspective. FEKO presents engineers with tools to solve combined electromagnetic field / cable problems.

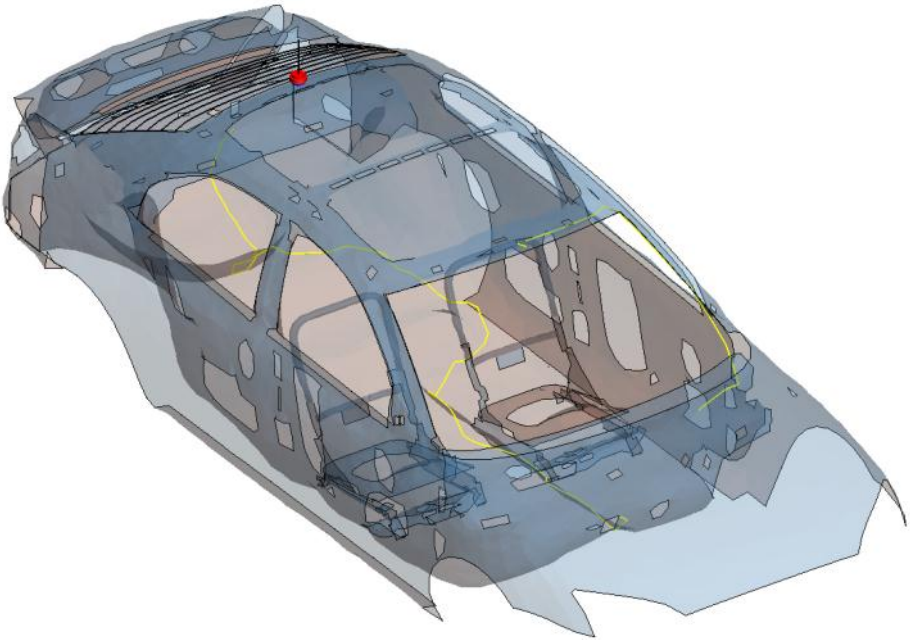


Specifying cable topologies in CADFEKO

SOLUTION TECHNOLOGY

Multi-Conductor Transmission Line (MTL)

In principle, FEKO's numerical methods (MoM, MLFMM, FEM etc.) can solve arbitrary problems which may include cables. For practical problems, this is not possible due to the fact that unknowns in the solution process become too many to solve. MTL theory is ideally suited to the solution of such complex cable problems and does so very efficiently in FEKO's MTL implementation. Simply put, a multi-conductor transmission line model is a distributed parameter network for an arbitrary cable cross section where the voltages and currents can vary in magnitude and in phase over its length. Any of FEKO's solution methods (MoM, MLFMM, FEM, etc.) may be used to compute the external fields and currents that couple to/from such complex cable bundles.



Generic car model highlighting a cable path

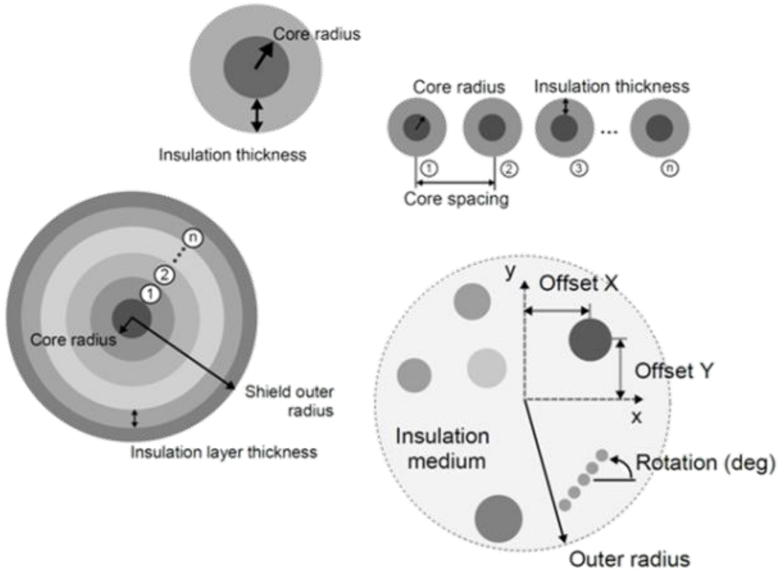
Per Unit Length Cable Parameters

The per unit length parameters of inductance, capacitance, resistance and conductance are essential in the determination of transmission line voltages and currents from the solution of the transmission line equations. All of the cross sectional dimension information about a specific line is contained in these parameters. In FEKO a 2D static FEM solver to Laplace's equation is used to analyse user-defined cable bundles, extracting the per unit length cable parameters to be used during cable simulation.

Treatment of Cable Shields

In transmission line theory, the conductors in a cable bundle can be grouped into outer and inner circuits, each of which is coupled with a mutual conductor called a shield. The outer and inner circuits are completely separated by this shield, except that they are connected by current- and voltage-controlled sources. The shield coupling parameters defining these controlled sources are termed transfer impedance and transfer admittance, both of which are dependent on the physical properties of the conductor system. Transfer impedance and admittance exist for any shielding construction and if known can be used for both solid and braided shields.

In FEKO, solid tubular shields are modelled with the Schelkunoff model while braided shields are modelled with the popular Kley formulation. The Kley formulation accurately models the coupling mechanism giving rise to the transfer impedance and admittance, due to the field penetration through the shield apertures. Apart from these analytical formulations, FEKO provides an internal database listing the transfer impedances for more than 20 popular cable types and allows users to specify their own cable properties with transfer impedance and admittance data.

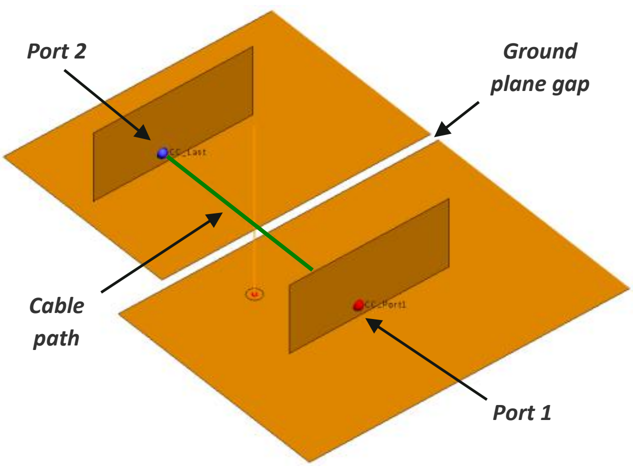


Examples of cables that can be modelled in FEKO

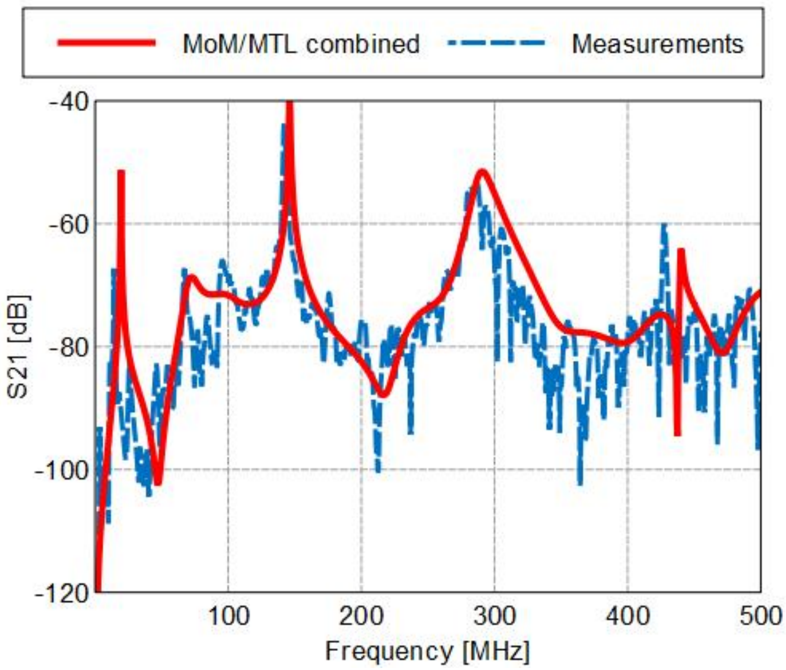
Standard MTL technology is limited in application to situations where cables run close to a ground plane, where it is assumed that the current return path is in the ground plane directly below the cable. Combined MoM/MTL technology is not restricted in this way and can solve problems with unrestricted cable paths. Combined MoM/MTL technology is unique to FEKO and makes it a leading solution for the analysis of complex cable problems.

APPLICATIONS

The combined MoM/MTL implementation in FEKO was tested in cooperation with a leading user of cable simulation technology. A test problem was defined where a length of RG58 C/U cable spanned a gap in the ground plane below the cable (shown here). Typical MTL solvers would not have been able to solve this problem, as the gap in the ground plane invalidates the assumption that the return path for cable current is directly below the cable via the ground plane. The results that are shown here were calculated with FEKO and compared with measurements that were made by the industry partner for the corresponding setup. The excellent comparison proves that FEKO's combined MoM/MTL technology works correctly.



(a) Shielded RG58 cable above ground plane with gap



(b) Combined MoM/MTL FEKO simulation results match measured results well