Simple Cable Coupling Analyses

A description of how simple cable coupling analyses may be performed with FEKO.

Application

For simple cabling scenarios, field coupling into the cables can be computed directly in FEKO, without having to resort to additional tools. This feature is intended to provide the user a first approach of dealing with the problem of irradiation of cables excited by an external field, e.g. a plane wave, but also any other sources of radiation modeled in FEKO. The analysis approach followed within FEKO is based upon relating the current on the cable's shield (caused by external radiation) to the voltage induced on the inner conductor by means of the cable's transfer impedance.

Technology

Cable coupling modeling technology is based on the application of Transmission Line Theory (TLT) with a resulting formulation able to compute the coupled-in voltage at the termination impedances of a cable close to a conducting metallic ground. The fields around the cable may be computed with the Method of Moments (MoM), Physical Optics (PO), Multilevel Fast Multipole Method (MLFMM) or the Finite Element Method (FEM) and does not take the cable into account when computing the field distribution. The cable therefore does not affect the field distribution at all. In this fact lies the reason for the greatly reduced number of unknowns in comparison to a full MoM solution: The cable itself is not modeled as a geometric entity and therefore not meshed into geometric segments, making it unnecessary to introduce a very fine mesh underneath the cable on the ground plane.

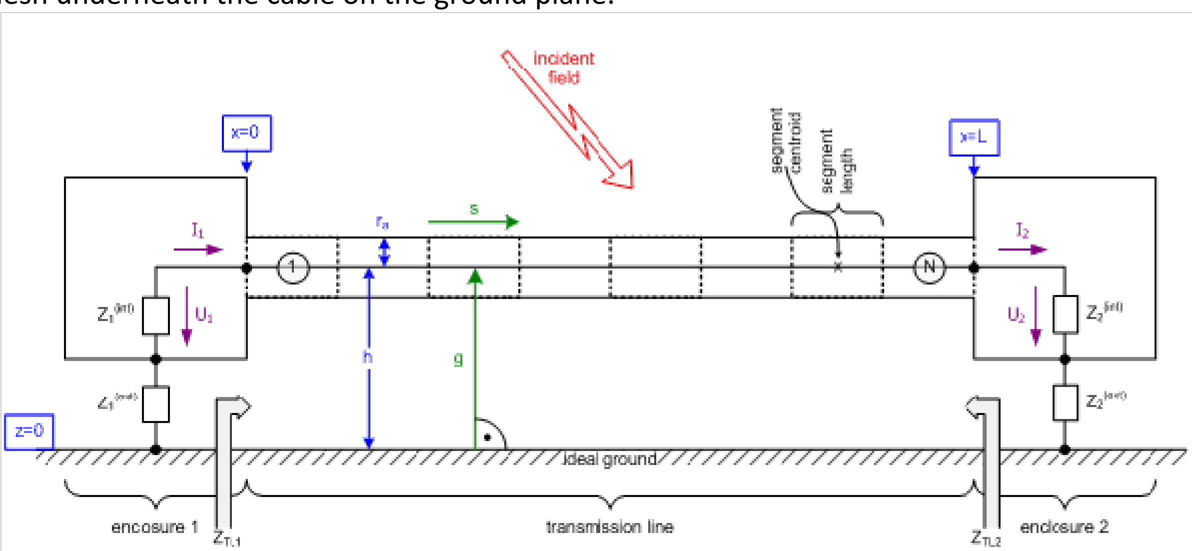

Figure 1: Side view of the simplified cable path scenario

Terminology

Cable Path(CP): This represents one complete cable from the start point with the terminating impedance up to the end point with the other termination impedance.

Cable Path Section (CPS): This is the part of the cable path defined by a single poly-line cable section in CADFEKO. A cable path must consist of at least one or more cable path sections where the first and last cable path sections of each cable path must have termination impedances defined.

Segments: Each cable path section is internally subdivided into an integer number of segments for computation. The maximum length of the segments may be specified by the user or automatically determined at computation time.

Capabilities

In the current implementation cable modeling can be used to compute the induced voltage (measured over the termination loads) in shielded single-conductor cables (over a conducting ground plane) that are exposed to an arbitrary external field. The cable path is only restricted by the fact that only straight cable path sections are currently supported. Within this restriction the cable path can follow any path in 3D space and use any number of cable path sections.

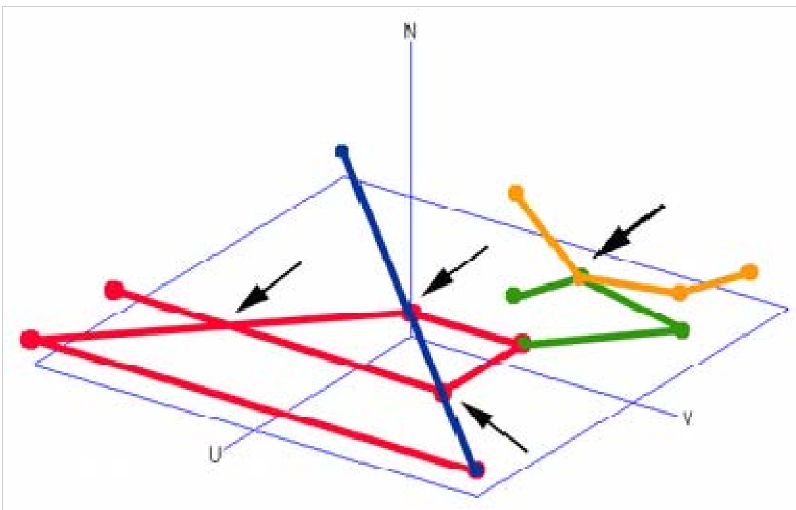

Figure 2: Examples of allowable cable paths

Cable properties can be selected from a predefined database of commonly used cables (22 cables currently in database) or can be specified by the user. The user specified cable properties should be valid for the frequency of interest in the current simulation. Predefined cable properties are frequency dependent and are valid for the frequency range 10 kHz to 500 MHz.

CADFEKO features a new dialog to request cable analysis. This dialog consists of three tabs for:

- Specification of the cable path as a polyline.
- Setting of cable properties from the database or manually.
- Specification of terminating impedances.

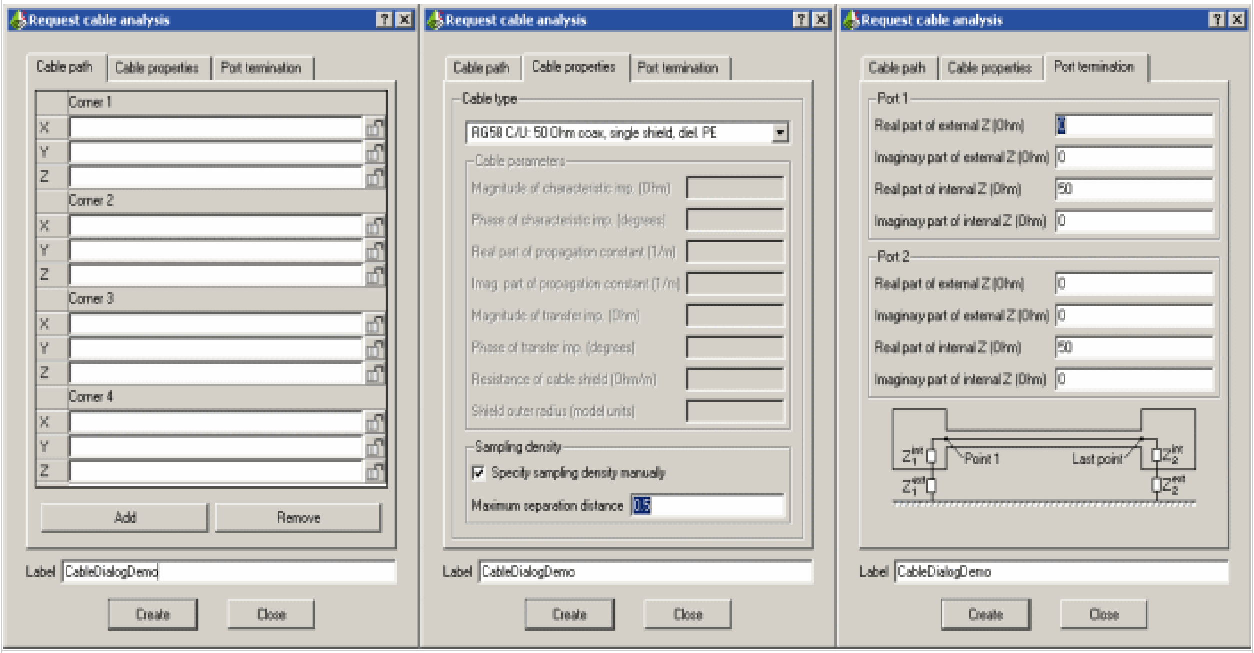

Figure 3: Dialogs for defining cable paths in CADFEKO

Limitations

There are some limitations to the current implementation that the user should take note of. These include:

- Cable junctions are not supported. In practice this means that connecting nodes always have only two cable path sections connected to them, unless this node specifies the end of a cable path in which case terminating impedance replaces one cable path section.
- Crossing cables are not interconnected, even though it is possible for cables to cross each other geometrically.
- Cables must be homogeneous meaning that all cable path sections must have the same electric properties.
- Unshielded and multi conductor cables are not currently supported.
- Cables are decoupled from each other and do not radiate energy from the currents on the cable's shielding.

Example

The example that is presented here was chosen as it enables comparison with results reported in open literature, [1]. It consists of an RG-58 cable loop close to a monopole antenna. The monopole is fed with a voltage source at its base and the radiated power scaled to 10 W. The cable is terminated at both ends in 50 Ω impedance, with the cable shield directly connected to the PEC ground plane (implying a shield terminating impedance of 0 Ω). The maximum segment length is set to 0.5 m for a frequency range 1 MHz to 35 MHz.

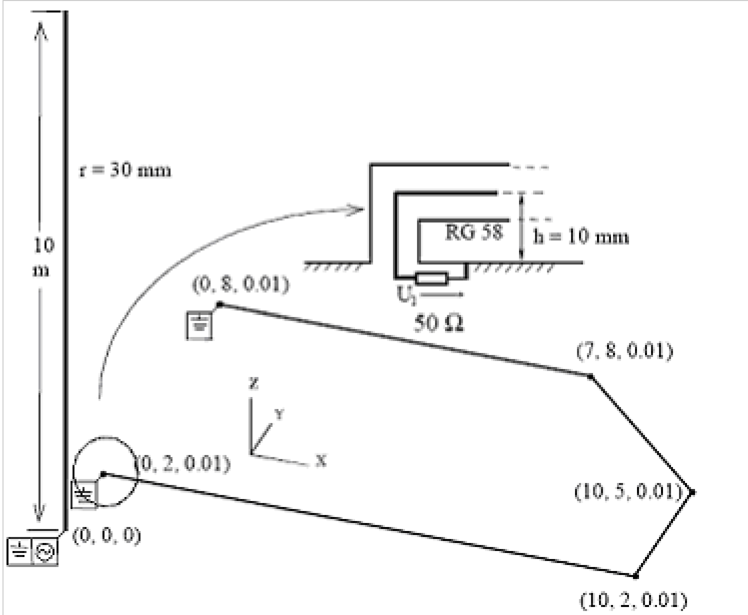

Figure 4: Monopole and RG-58 cable loop geometry setup

A comparison is drawn between the FEKO results and results published in [1] for the same problem. The agreement between FEKO values and the published data is very good for both magnitude and the position of the sharp resonances in the magnitude.

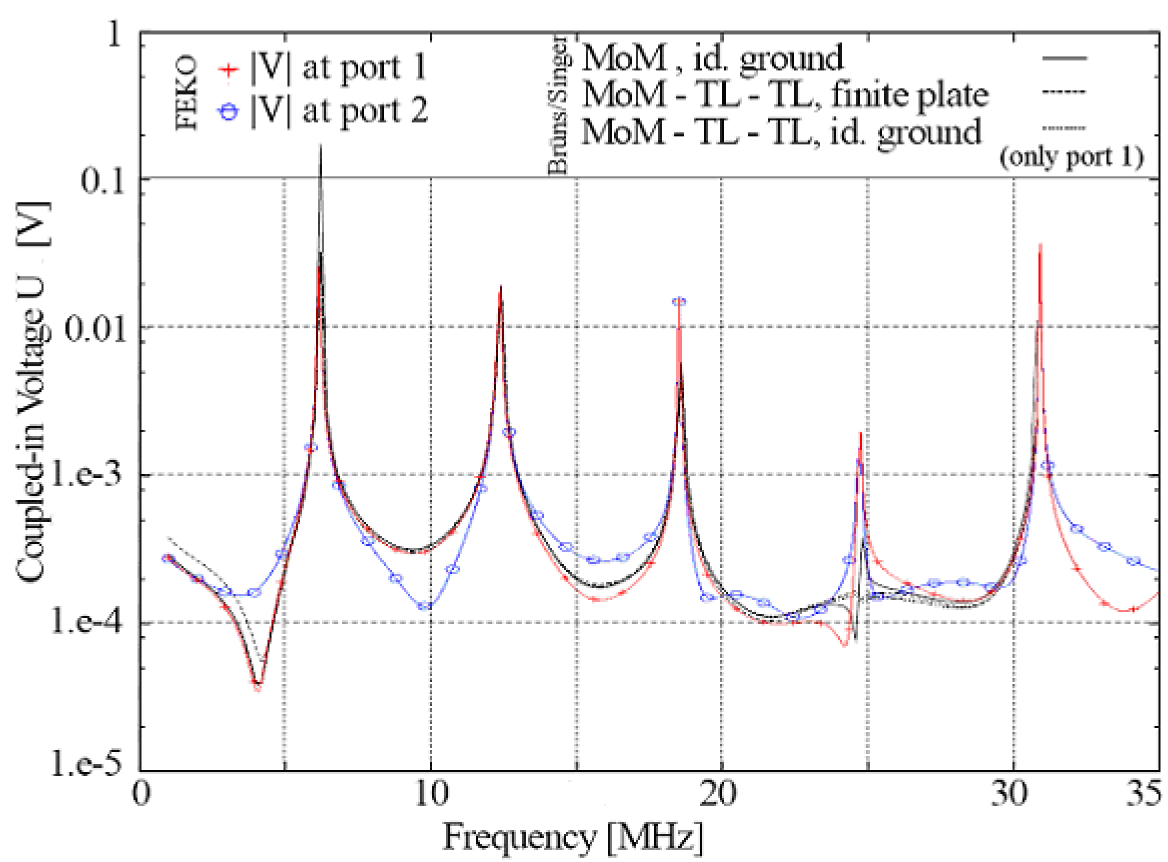

Figure 5: Comparison of results from FEKO (red, blue) with those from [1] (black)

References

[1] H.-D. Brüns, H. Singer, "Computation of Interference in Cables Close to Metal Surfaces," *IEEE Int. Symposium on EMC, Denver*, 1998, pp 981-986