



## Features in this Issue

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- Student competition winners 2006
- 8th German FEKO users meeting

In this issue we focus on the cable coupling modelling feature that was released in FEKO 5.2. We explain its intended use, what technology the formulation is based on, some new terminology and present an example of this new feature's functionality.

We also highlight the new receiving antenna feature of FEKO and conclude the technical articles with some interesting facts about single vs. double precision computation in FEKO.

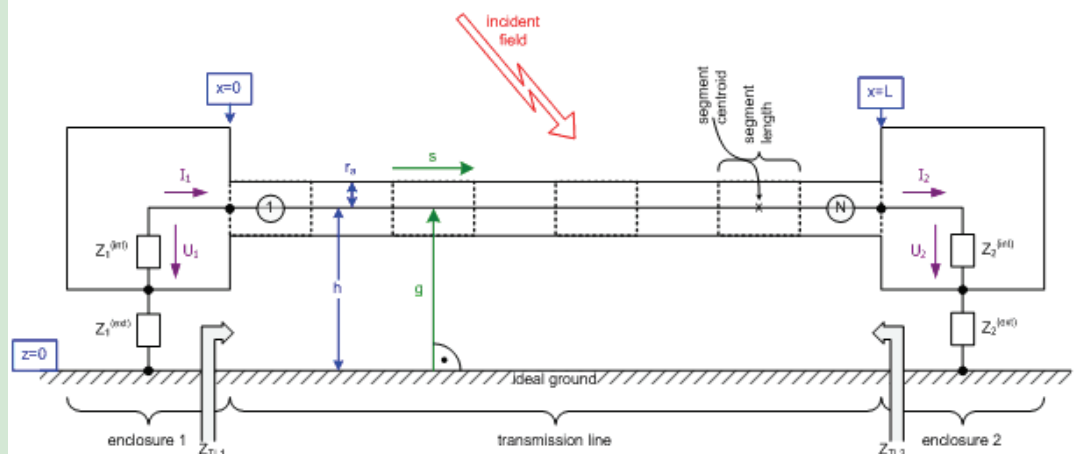
The winner of our student competition and educational institute prize for 2006 is announced and we report on the 8th annual German FEKO users meeting.

As always, your comments on the quarterly are welcomed. If you would like to make suggestions or comments or contribute an article, please send it to [quarterly@emss.co.za](mailto:quarterly@emss.co.za).

## Cable Coupling Modelling

**Application.** The release of FEKO 5.2 introduces the possibility to compute field coupling into cables in simple cabling scenarios directly in FEKO without using additional tools. It 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 modelled in FEKO. Up to now only wires (i.e. simple wires without any shielding) could be modelled, but with the new technique shielded cables can be included in the simulation. This is achieved by 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 modelling 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 modelled 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.



Side view of the simplified cable path scenario

### New 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

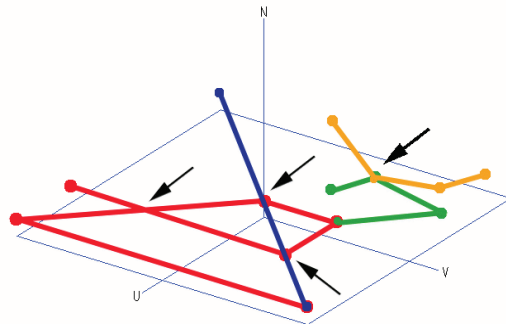
## Cable Modelling continued...

“Cable properties can be selected from a predefined database of commonly used cables or can be specified by the user.”

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 modelling 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. 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.



Examples of allowable cable paths.

Cable properties can be selected from a predefined database of commonly used cables (22 cables currently in the 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:

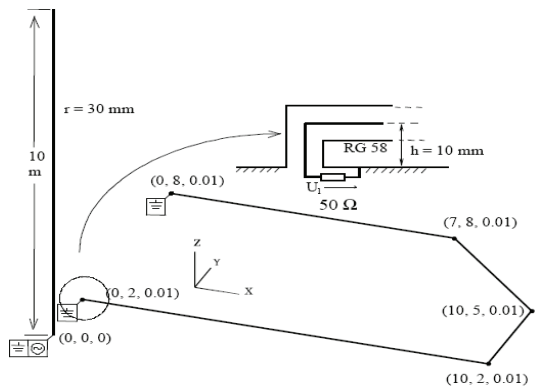
- Specification of the cable path as a polyline.
- Setting of cable properties from the database or manually.
- Specification of terminating impedances.

**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 a terminating impedance replaces one cable path section.
- Crossing cables are not interconnected, even though it is possible for cables to cross each other geometrically.

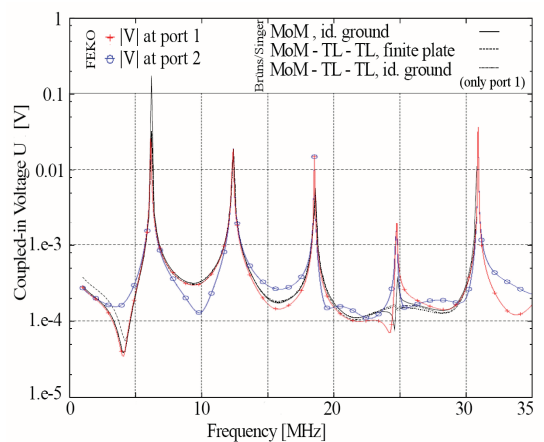
- Cables must be homogeneous meaning that all cable path sections must have the same electric properties.
- Unshielded and multiconductor cables are not currently supported.
- Cables are decoupled from each other and do not radiate energy from the currents on the cable's shielding.

**Example** The example that is presented here was chosen as it enables comparison with results reported in open literature. 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 a 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.



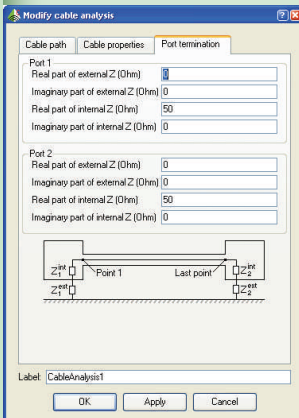
Test example: Monopole and RG-58 cable loop

A comparison is drawn between FEKO results and results published in [1] for the same problem. Good agreement is evident for both magnitude and the position of the sharp resonances in the magnitude.



Test example: Comparison of results from FEKO (red, blue) with those from open literature (black)

[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



Specifying cable termination in CADFEKO

## The Ideal Receiving Antenna

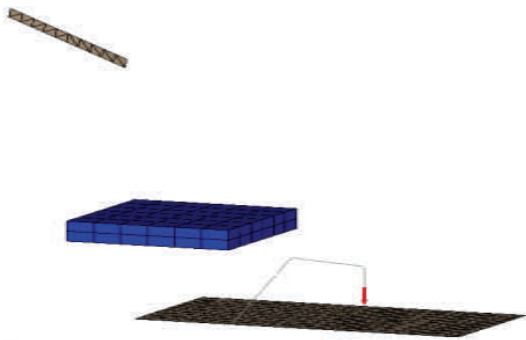
One of the features released in FEKO 5.2 is the ideal receiving antenna. The ideal receiving antenna is analogous to the ideal transmitting antenna in that no physical structure is needed to model the antenna. It is modelled as a point in space, with a predefined far-field radiation pattern attributed to it and can be rotated into any required orientation.

What is the purpose of the ideal receiving antenna? The ideal receiving antenna is an efficient method for analysing received power of an antenna in complex geometries without adding additional unknowns to the problem. It is also the ideal solution for determining the received power of an antenna that is only characterized by its far-field radiation pattern, rather than a detailed geometrical model

The antenna is assumed to be ideally matched and the output quantity is the received power in Watt. It is important to note that the ideal receiving antenna is assumed to be operating in the far-field and is therefore decoupled from all sources, other receiving antennas and MoM, PO or UTD elements. It is also not valid in models with infinite ground planes or special Green's functions.

### Solution accuracy?

Consider the model shown below. A wire with excitation indicated is placed above a metal plate, with a dielectric block in close proximity and a strip dipole hovering over the construction. It will be shown that the strip dipole may be replaced with an ideal physical receiving antenna if the strip dipole is far enough from the transmitting wire segment. The construction shown here was used as a reference solution with the power received by the strip dipole being compared to the corresponding ideal antenna solution. A summary of the difference between the reference solution and the ideal receiving antenna solution in relation to distance from the transmitter is shown below. Due to weaker coupling solution accuracy improves significantly with distance from the transmitter.



Receiving antenna accuracy test model

Distance from radiating element	Solution difference
5 $\lambda$	7.0 %
15 $\lambda$	3.9 %
45 $\lambda$	1.7 %

Receiving antenna solution error vs. distance from radiating structure

## Single vs. Double Precision Storage

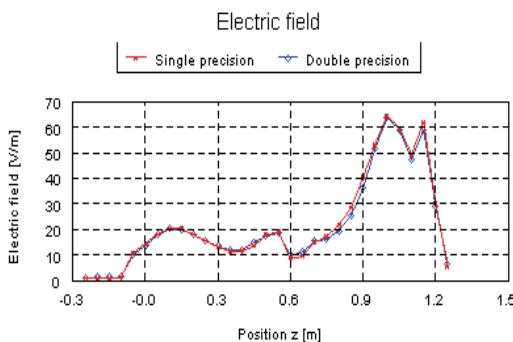
It is quite obvious that single precision floating point storage will result in significantly reduced memory requirements. The question will arise as to whether single precision solutions are accurate. Tests were done in this regard during a recent SAR project. The tests were for the inner metal shell of a car (MoM) with a human phantom (FEM) seated in the car with a mobile phone next to the phantom's ear as radiation source.

Results show that the 10 g cube localised SAR results compare very well in position, with only a 2.9% difference in magnitude. Comparisons were also drawn for E-field lines that were selected to pass through free space, the FEM phantom and the MoM mobile phone in the test. Comparative results for these tests show good agreement between the single and double precision solutions.

These tests show that single precision FEKO solutions are accurate. The confidence in the single precision solution has led the development team to select single precision as the default solution method for FEKO. FEKO will automatically check the solution and issue a warning if the single precision solution may be inaccurate. Double precision computation is selectable via the solution settings dialog in CADFEKO or the EG-card in EDITFEKO.

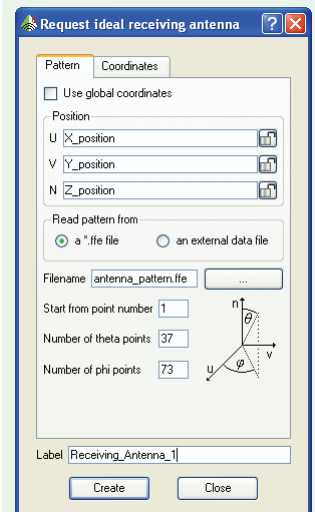
	Single	Double
10g cube SAR	0.276 W/kg	0.268 W/kg
Position	X = -0.287 Y = 1.586 Z = 1.103	X = -0.288 Y = 1.580 Z = 1.109
Memory	3.8 GB	7.1 GB

Single vs. double precision: Localised peak SAR comparison



Single vs. double precision: E-field comparison

**“The ideal receiving antenna is an efficient method for analysing received power of an antenna in complex geometries without adding additional unknowns to the problem.”**



Ideal receiving antenna dialog in CADFEKO

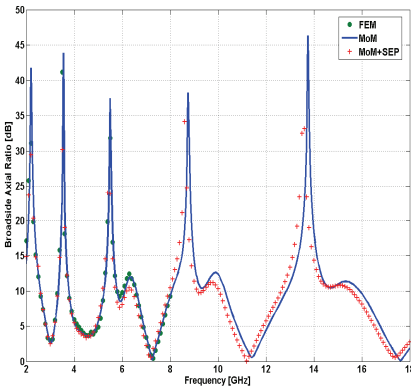
**“The question will arise as to whether single precision solutions are accurate.”**

## Student Competition Winner 2006: Michael Buck – Two Arm Sinuous Antennas

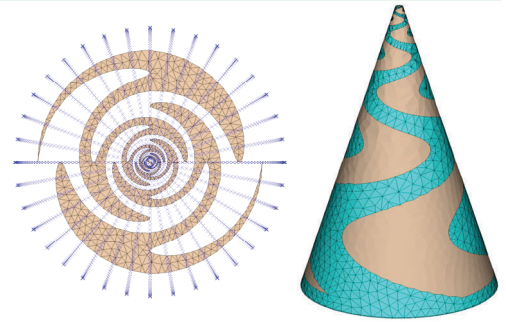
Sinuous antennas are designed with  $N$  arms to result in  $(N-1)/2$  co-polarized broad-band modes. This means that such antennas typically have at least three arms. Michael investigated the possibility of designing a two arm variant and evaluated the performance that is to be expected from such designs with FEKO.

His work varied growth rate, total number of cells, self-complimentary and non-self-complimentary structures and dielectric parameters and results in recommendations for optimization of axial ratio and impedance bandwidth.

Designs were verified by comparing the MoM and SEP-MoM formulations in FEKO with FEM results from HFSS and measurements from prototype antennas. Michael's sinuous antenna development forms part of his PhD research at the University of Colorado, Boulder. The educational institute prize has been awarded to prof Jim Breakall in support of his educational program in the Antenna and Radio Engineering group at the Communications and Space Sciences Laboratory, Pennsylvania State University.



Axial ratio comparisons between FEKO's MoM, MoM+SEP and HFSS's FEM.



FEKO models for planar and conical two arm sinuous antenna.

### Exhibitions

FEKO will be exhibited at several conferences this quarter.

- 12-15 Dec APMC – Yokohama, Japan
- 14-15 Feb 10th Australian Symposium on Antennas - Sydney, Australia
- 6-8 Mar EMV 2007 - Stuttgart, Germany
- 19-23 Mar ACES 2007 - Verona, Italy
- 21-23 Mar iWAT 2007 - Cambridge, U.K.

### 8th Annual German FEKO Users Meeting

35 Customers attended the 8th annual German FEKO user meeting that was recently held in Stuttgart. FEKO users contributed presentations on how FEKO is used in their companies for a wide range of applications, e.g. keyless go systems for automobiles, modeling of satellite antennas, development and design of a dual-polarized dielectric near-field probe, etc.

The latest FEKO features were highlighted and attendees had the opportunity to create a wish-list of features for further development of FEKO.



## Comprehensive Electromagnetic Solutions

### APPLICATIONS

- Antenna Design
- Antenna Placement
- EMC Analysis
- Scattering Analysis
- Biomedical
- Microwave Circuits

### SOLUTION TECHNIQUES

- Method of Moments (MoM)
- Physical Optics (PO)
- Uniform Theory of Diffraction (UTD)
- True hybridisation of MoM/PO and MoM/UTD

- MoM with Surface and Volume Equivalence Principle for Multiple Dielectric Bodies

- Planar Green's Functions

### FAST SOLUTIONS

- Parallel Processing
- Out-of-Core Solving
- Multi-Level Fast Multipole Method (MLFMM)

### MODEL IMPORT FORMATS

- Solid models (Parasolid, ACIS, CATIA, Pro-E, IGES, STEP, Unigraphics)
- Meshes (CADFEKO, FEMAP, NASTRAN, AutoCAD DXF, STL, PATRAN, ANSYS CDB, ABAQUS, ASCII data format)

### SERVICES

- Extended Service Contract
- On-site Training (Short Course)

- CAD Preparation
- Runtime Solutions
- Engineering Consulting Services



[www.feko.info](http://www.feko.info)

