field computations involving objects of arbitrary shape

FEKO

QUARTERLY: March 2006

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Comments, queries or suggestions?

The FEKO Quarterly team wants to hear from you! Contact us at:

quarterly@emss.co.za

S-Parameter Calculation in FEKO

S-parameter characterized 'black boxes' are commonly used during system design to simplify subsystem interactions. S-parameters characterize the interactions between ports within the subsystem. The coupling between the ports could be very complicated, including electromagnetically coupled input and output ports.

FEKO can be used to calculate the S-parameters of a complex subsystem whose ports are electromagnetically coupled. This article explains how FEKO computes the scattering parameters and provides some handy hints for making the most of your S-parameter calculations in FEKO.

Student Competition 2006

Its that time of the year again! The FEKO student competition is open for entry. The competition is open to all currently enrolled students. Last years winning entry can be seen at:

http://students.ee.sun.ac.za/~sjmarais/

The winning participant will receive a laptop. The most participative University also wins free Maintenance and Support for one year on all FEKO licences purchased by them.

The closing date for entries is the 29th September 2005. Please email queries to

student_comp@emss.co.za

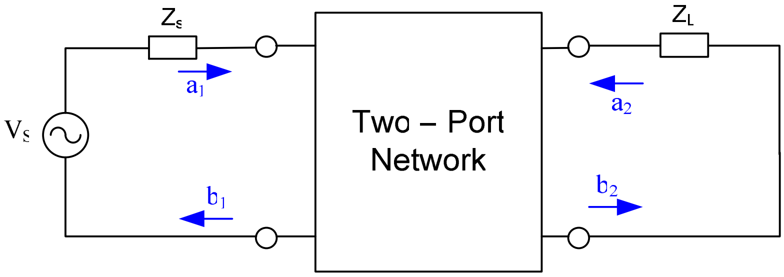


Figure 1: A generic two port representation, with load and source impedances. The incident and reflected waves are as indicated.

Definition of S-parameters

For the recap of S-parameter definition, only a 2-port network is considered. The generic two port sub-system in Figure 1 has 4 waves defined at the ports. The first two are incident on each port and are named a1 and a2 respectively. The second two are the corresponding reflected wave at each port, named b1 and b2. The S-parameters are described by the ratios between the reflected and incident waves.

The linear equations (in terms of the reflected and incident waves) describing the two-port network are:

$$b_1 = S_{11}a_1 + S_{12}a_2$$

$$b_2 = S_{21}a_1 + S_{22}a_2$$

The S-parameters can be derived from these linear equations. S_{11} and S_{21} are obtained by setting a_2=0. In order to set a_2=0, Z_L=Z_0. We then have:

$$S_{11} = \left.\frac{b_1}{a_1}\right|_{a_2=0}$$

$$S_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0}$$

Special FEKO session at ACES

The first FEKO session at the Applied Computational Electromagnetics Society (ACES) conference last year was a phenomenal success. We are happy to announce that there will be 2 FEKO sessions at this years' conference in Miami, Florida from 12-16 March 2006.

A complete list of the papers that will be presented during the sessions is on the last page of this Quarterly.

For further information about this event, please contact Dr. CJ Reddy at:

cjreddy@emssusa.com.

S-Parameter Calculation in FEKO ...continued

Similarly, by setting a_1=0, we get:

$$S_{12} = \left.\frac{b_1}{a_2}\right|_{a_1=0}$$

$$S_{22} = \left.\frac{b_2}{a_2}\right|_{a_1=0}$$

How FEKO computes S-parameters

FEKO can be used to compute the S-parameters of a structure. In order to compute S-parameters more than one port is needed in the model. For a single port sub-system, the input reflection coefficient (S_{11}) is usually calculated by a post-processing step in POSTFEKO (S_{11} is calculated from the input impedance). The exception to this is for the waveguide feed (AW card), where the SP card must be used.

When calculating S-parameters, all ports must have an active excitation. This means that for a 4 port network, there will be 4 excitation definitions in the control section. Note that the first excitation must have the 'New source' option selected, and all following sources must have the 'Add to Sources' option selected.

Handy hint: If you know that your S-parameters will be symmetrical, you can reduce computation time by defining certain ports to be 'receiving only'. To do this, simply make the voltage on the excitation 0V.

After all source definitions, and all model information cards (dielectric parameter specification, lumped elements etc.) the SP card should be added. The SP card contains only one input field – the system impedance. Note that each port can optionally have its own reference impedance – the value specified at the SP card will only be used if the impedance hasn't been specified on the excitation definition.

FEKO then adds loads to each port equal to the impedance as specified for that port. Each port is then 'turned on' and corresponding S-parameters are calculated. Consider the following set of instructions in a pseudo pre file:

EG – End geometry input
AE – specify the edge for port 1
  – 50 Ohm port impedance
AE – specify the edge for port 2
  – 75 Ohm port impedance
FR – frequency sweep
SP – Calculate the S-parameters
EN

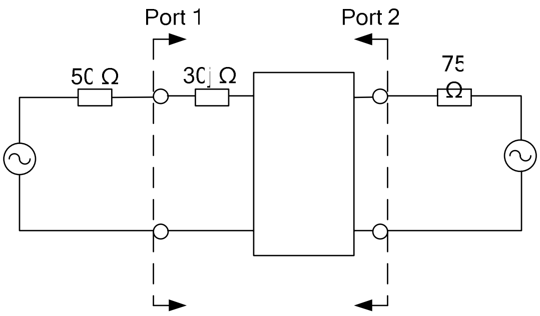
With this structure for the input file, FEKO will load port 1 with a 50 Ohm series load and port 2 with a 75 Ohm series load prior to any computation. It will then add an active source to port 1 (in series with the impedance) and leave port 2 with the impedance load across the terminals. Note that port 2 is loaded with its characteristic impedance, which is the condition under which S11 and S21 can be computed, since a2 is zero. FEKO then solves this system, calculating S-parameters from the current through both ports.

FEKO then 'turns off' the source on port 1 and adds a source to Port 2. Note that Port 1 is terminated with its characteristic impedance. The system is then solved for S21 and S22.

Pitfalls to beware of:

Pitfall 1: Overwriting of Lumped elements

Inappropriate results are sometimes calculated when a user models lumped elements in series with a port. Consider an example where an inductor is added in series to the two port network as a matching element. Assume that at the frequency in question the inductor has an impedance of 30j Ω. For the purposes of S-parameter analysis, this matching element should be considered to be part of the network.



In this case, a series 30j Ω impedance is in series with the first port, but inside the 'black box'. In FEKO, all these series discrete elements (the two impedances and the generator) are added at the same physical location (they are infinitely small, so this is not a problem). A user may try to represent this model in FEKO using the following lines of pseudo pre file:

EG – End geometry input
A1 – Specify the segment for port 1
  – 50 Ohm port impedance
A1 – Specify the segment for port 2
  – 75 Ohm port impedance
LZ – add an additional series 30j Ω load at port 1
FR – frequency sweep
SP – Calculate the S-parameters
EN

This will however not give the desired results. The reason is that when FEKO sets up the problem internally, the LZ load on the segment will

S-Parameter Calculation in FEKO ...continued

get overwritten by the automatic addition of the system impedance. So how to go about setting this problem up then?

The suggested strategy is to physically separate the Source from the series impedance. So, in this case, one segment should be used to define the excitation, and the segment next to it for the series impedance.

Pitfall 2: Importance of the order in which the SP card is placed in the control section

Consider the situation of an array antenna. In one FEKO run, it is desirable to calculate mutual coupling between two driven elements, as well as the radiation pattern of the array. Consider the following section of pseudo code to get this right:

EG – End geometry input
AE – specify the edge for element 1
AE – specify the edge for element 2
FR – Three frequencies (f1,f2,f3)
FF – Calculate the radiation pattern
SP – Calculate the S-parameters
EN

With this control section, the first radiation pattern will be calculated with the excitation connected directly to the elements (without the 50 Ohm internal resistance). The second and third patterns will both be calculated with the series resistance, changing the magnitude of the gain. You should therefore put the FF card after the SP card to get consistent answers. If elements are being driven by a 50 Ohm system, then these impedances need to be taken into account when calculating gain. The control section will now be structured like this:

EG – End geometry input
AE – specify the edge for element 1
AE – specify the edge for element 2
FR – Three frequencies (f1,f2,f3)
SP – Calculate the S-parameters
FF – Calculate the radiation pattern
EN

Conclusion

The S-parameter computation in FEKO can be used to characterize a subsystem with electromagnetic interaction between ports. The results of this computation can be exported and used as a black box element in later system design. FEKO supports saving S-parameter data to a Touchstone file. Care should be taken when inserting an SP card, to ensure that intended series loads are not omitted, and that the calculation of other items in the loop are not affected. The S-parameter functionality in FEKO is applicable to a variety of subsystems, from inter-element mutual coupling to microwave devices. These results can then be used as inputs to further system analysis.

Taiwanese Distributor for FEKO appointed

We welcome CADMEN from Taiwan to the growing list of FEKO distributors! Troy Huang and his team can be contacted at troy.huang@cadmen.com.tw

EMSS USA Inc. appoints two new applications engineers

We are pleased to announce appointment of Dr. Rensheng (Ray) Sun as Senior Application Engineer and Brian Woods as an Application Development Engineer, to support FEKO customers in North America. Dr. Sun has the M.S. degree from Villanova University, Villanova, PA, and Ph.D. degree from Michigan State University, East Lansing, MI, both in electrical engineering. He served as a Visiting Assistant Professor in the Department of Electrical and Computer Engineering at Michigan State University during Fall Semester, 2005. Dr. Sun has experience in computational electromagnetics as well as in antenna design and development. Dr. Sun is a member of IEEE, Eta Kappa Nu, and Tau Beta Pi.

Brian holds B.Eng and MScEng degrees from the University of Stellenbosch in electrical and electronic Engineering. He has worked as a full-time researcher at the University of Stellenbosch, where he was involved with system specification and development of specialized ground penetrating radar technology. He was active in all aspects of system engineering, including antenna and electronics design and simulation, as well as product commercialisation.

We welcome Ray and Brian to the growing EMSS team!

List of Papers to be presented at ACES 2006

The following papers were accepted for presentation in the FEKO sessions at the ACES conference:

- " Recent extensions in FEKO: Parallel MLFMM and waveguide excitations" Ulrich Jakobus, Marianne Bingle, and Johann J. van Tonder
- " Optimizing Salisbury Screens Using FEKO" Randy L. Haupt
- "Simulations of Wing Mockup Sizes for EMI Measurements using FEKO" Praveen Anumolu, Ronald Pirich, and Danielle Schefer
- "Simulation of a Dual-Band Dual-Polarization Radiator Using FEKO" Amir I. Zaghloul and C.B. Ravipati
- "Meshing Silicon Valley - An HF Antenna over Finite Curved Earth" Keith Snyder
- "Analysis and design of a multiband, multipolarized two arm sinuous antenna" Michael C. Buck and Dejan S. Filipović
- "Coupling between spiral antenna elements of a conformal wideband array" François Chauvet 1, Régis Guinvarc'h 1 and Marc Hélier
- "Method of Simulation of Closely Spaced, Finite, Periodic, Radiating or Reflecting Structures, Including Metamaterials " Steven J. Franson,and Richard W. Ziolkowski
- "Modeling Large Finite Frequency-Selective Surfaces with FEKO" Rensheng Sun and C. J. Reddy
- "Self-Adjoint Sensitivity Analysis of High-Frequency Structures with FEKO" Jiang Zhu, Natalia K. Nikolova, and John W. Bandler
- "Using FEKO Software for Analysis of Radiated Electric Field " Y. Rousset, V. Arnautovski-Toseva, C. Pasquier, K. El Khamlichi Drissi, and L. Grcev
- "Numerical Simulation of the Generation of Synchrotron Radiation in a Vacuum Chamber with FEKO" Andreas Paech, Thomas Weiland

Upcoming exhibitions

Mar 7-9	**Int. Conf and Workshop on EMC, EMV, Düsseldorf, Germany**
Mar 12-16	**ACES 2006, Miami Florida**
Apr 4-7	**CEM 2006, St. Malo, France**
May 1-4	**AMTA European Symposium, Munich, Germany**