CEM833 Task 3:
The RWG element
&
Exploring CEM methods with FEKO, for metallic antenna analysis

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This task is based on the following material:

- [3, §6.5 – 6.11]
- Microstrip patch antenna theory: [4, §5.8]
- Axisymmetric parabolic reflector theory: [4, §7.6.1 – 7.6.2]
- Horn antenna phase center: [2, §13.10]

FEKO [1] is presently installed in FIRGA and on the 4th floor lab computers. Should you wish to work with the latest version (Suite 6.1) and/or on your own machine, then you should install FEKO on a machine connected to the faculty network, in order to be able to check out a floating license. Licence file and installation disk can be obtained from prof. Botha.

The latest evaluation version of the antenna synthesis software, Antenna Magus is also required. The installation can be downloaded from the FEKO website [1], or obtained from prof. Botha.

1 Visualise and analyse the RWG, triangle basis functions

1.1 Visualisation

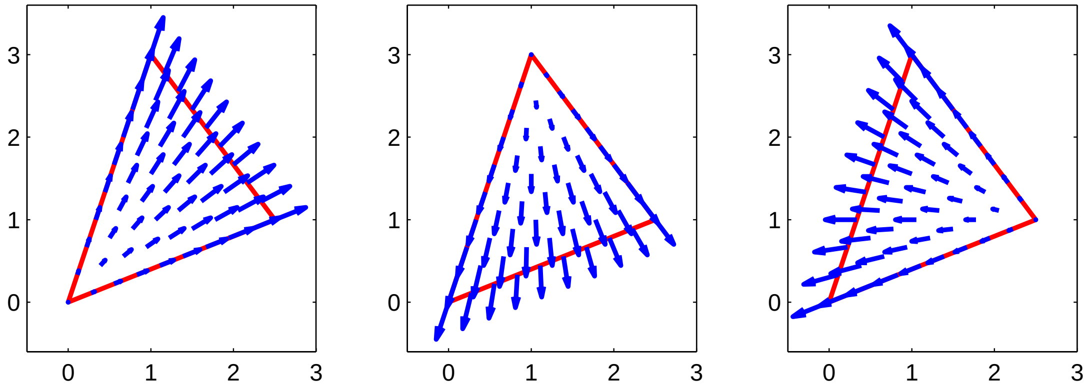
- Write a MATLAB script that plots the three RWG basis functions, given the coordinates of the three vertices of a triangle element. Use the quiver function. See the figure below, as an example of the expected result. Note that the field evaluation points are defined at regular intervals in terms of simplex coordinates. This ensures that the points on the actual element are always spaced in the same relation to the boundaries and each other, no matter the actual element shape. Please work in the same way — this will familiarise you well, with simplex coordinates.

1.2 Analysis

Note that the tasks below are considerably easier, with the right choice of coordinate system (hint: locate one of the triangle nodes at the origin, etc.).

- Prove that an RWG basis function, spanning two triangle elements (this is called the *support* of the basis function), that lie in a plane, has normal continuity at the shared edge.

- Prove that in the above case, the normal component is constant along the shared edge.
- Derive the expression for the divergence of the basis function [3, eq.(6.14)], from its definition [3, eq.(6.6)].



2 Parabolic reflector with rectangular horn feed: design and modelling

2.1 Design

Use Antenna Magus to design a waveguide-fed, pyramidal horn antenna. Export the antenna to FEKO and based on its radiation pattern properties, design an axisymmetric parabolic reflector to be fed by it, based on the material in [4]. Note the following specifications:

- Operating frequency: 9 GHz
- Horn gain: 12 dBi
- Diameter of reflector: $8\lambda_0$
- Calculate focal length such that the reflector covers the main beam of the horn up to 10dB down, in the E-plane.

2.2 FEKO modelling

- First analyse the horn on its own. Experiment with refining the mesh to insure you have a convergent result. This result will be required to design the reflector.
- Note: the reflector focus must coincide with the E-plane pattern phase center of the horn. Regard the phase center as being located at the E-plane apex [2].
- Analyse the complete antenna with the MLFMM. You might have to mesh the model quite coarsely to fit into RAM. Experiment. The reflector can likely be more coarsely meshed than the horn, without compromising on accuracy...why?
- Next, analyse the complete antenna with the MoM-PO hybrid method. Consider both coupled and decoupled MoM-PO approaches.
- Next, calculate the radiation pattern of the horn on its own (shifted so that phase center is appropriately located!) and then analyse the reflector with MLFMM and PO in turn, being excited with the horn radiation pattern imported as a point source at the focus.

- Compare your results w.r.t. radiation pattern cut(s). Explain discrepancies.
- Explain the pros and cons of the various analysis methods used.

3 In conclusion

- Based on your experience during this task, what would you in future regard as important points to keep in mind, when engaging in numerical electromagnetic modelling of antennas or other structures?

References

[1] FEKO User's Manual Suite 6.1, July 2011. `http://www.feko.info`.
[2] C. A. Balanis. *Antenna Theory.* John Wiley and Sons, New York, 3rd edition, 2005.
[3] D. B. Davidson. *Computational Electromagnetics for RF and Microwave Engineering.* Cambridge University Press, Cambridge, UK, 2nd edition, 2011.
[4] W. L. Stutzman and G. A. Thiele. *Antenna Theory and Design.* John Wiley and Sons, New York, 2nd edition, 1998.