SAND2007-0212C

EIGER an Open Source Frequency Domain Electromagnetics Code

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Introduction

EIGER[TM] is a general-purpose, 3D electromagnetics (EM) modeling tool for modeling system response to EM environments. In order to better enable collaborative development, EIGER version 2.0 has been approved for release as open source software under a Gnu Public License. A web site, www.code-eiger.org, has been created for this collaborative development.

EIGER[TM] is primarily an integral equation code for both frequency-domain electromagnetics and electrostatics. In the frequency-domain version there are different Green's functions in the code, 2D,3D free space, symmetry-plane Green's functions, periodic Green's functions for layered media, and layered media Green's functions. There are thin wire algorithm as well as junction basis functions for attachment of a wire to a conducting surface, and also thin slot models for coupling into cavities. The code is written in Fortran 90 using object-oriented design. The code has the capability to run both in parallel and serial modes. The code is a suite consisting of pre-processor (Jungfrau), the physics code (EIGER), and post processor (Moench).

The original development of EIGER began in the early 90's as a collaborative effort between University of Houston, Sandia,Lawrence Livermore(LLNL) labs and the U. S. Navy [1]. However, due to different customer bases the two codes diverged. Applications at Sandia were geared towards EMC and EMI problems for which the thin-slot coupling algorithms were developed. Other Sandia applications that drove the development of this code were the modeling of periodic diffraction gratings for a petawatt laser, photonic band-gaps made by use of photoinic crystals, plasmon optics, frequency selective surfaces, and electro- and magneto- static problems for pulsed power and micro-machines. The layered media work of Nathan Champagne developed at the University of Houston and LLNL has been incorporated into this version of the code. The major change in this version of EIGER is that it uses singularity cancellation techniques [2] rather than the traditional singularity subtraction techniques. These techniques have greatly simplified the implementation of the new EIGER[TM] . The main computational part of the code has been reduced to numerical evaluation of the inner product $<\mathbf{\Lambda}_m^{test},\mathbf{O}\mathbf{\Lambda}_i^{source}>$ where $\mathbf{\Lambda}_m^{test}$ and $\mathbf{\Lambda}_i^{source}$ are the Rao, Wilton,Glisson basis functions and is $\mathbf{O}$ and differential-integral operator. (There is a version of the code with higher-order basis functions which we hope will be available in a future release.)

Sample Problems

In the early 1980's I had the privilege of working with Ricard W. Ziolkowski and Kendall F. Casey who was our group leader. We made a run at solving electromagnetic coupling problems using Rieman Hilbert [2] and dual series techniques. Kendal had shared his notes on quasi-static coupling to a thin spherical shell with a circular hole (Fig. 1) with Rick and myself and the solution of that problem then occupied our free time for the next three years [3]. Fig. 2 gives the solution, since EIGER used inner and outer regions with a dielectric interface it has much greater dynamic range than the predecessor code Patch.

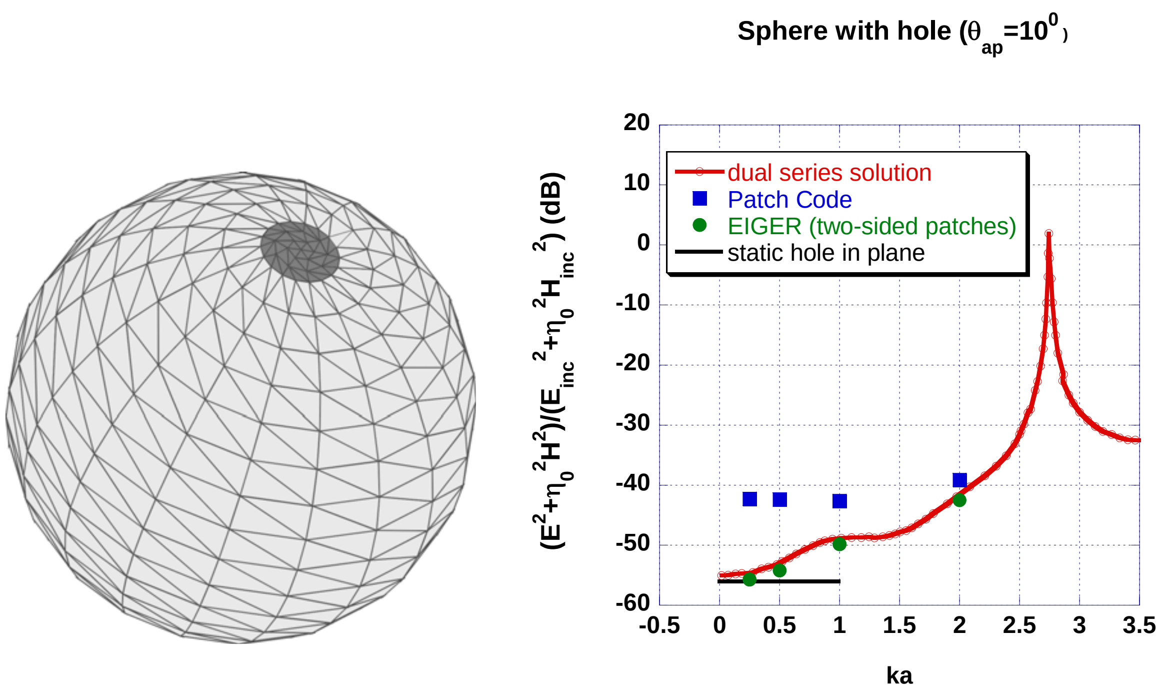


Figure 1. (a) Plane wave coupling to a thin spherical shell with a circular hole ;(b) the solution by dual series, Patch, EIGER, and statics.

I was involved in solving the problem of a wire penetrating the air-earth interface (Fig. 2) while working for Kendall in order to check the NEC code. This work utilized the evaluation of sommerfeld integrals presented in [5]. In [6] I made the mistake of setting the tangential D to zero rather than tangential E. This was the reason why the large number of unknows on the water side of the interface had to be used. (This is answer to the question that Kendal asked me at that time) This no longer has to be done with the EIGER code as illustrated in Fig. 2c.

Fig. 3 illustrates the use of the thin-slot subell modeling capability in EIGER as applied to a cavity backed aperture. The glitch in the EIGER result at about 574.5 M-hertz is due to numerical noise coupling to a high Q mode that would not be excited in an ideal problem.

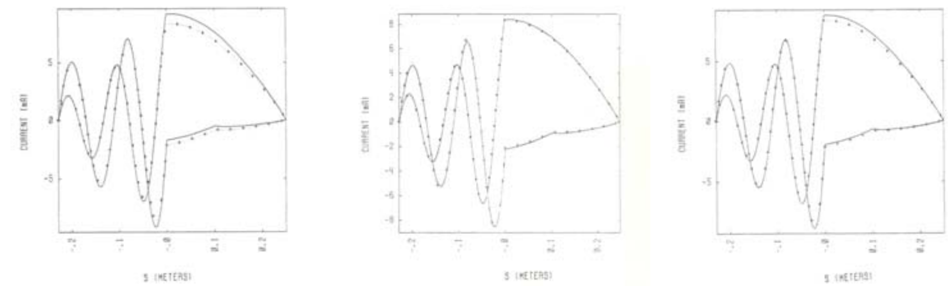


Figure 2. a) A comparison of the NEC code with currents on the the ground stake generated from; [6] b) results from [6] with extrapolation of the number of unknowns in the water side of the interface to infinity; c) EIGER results for the same problem

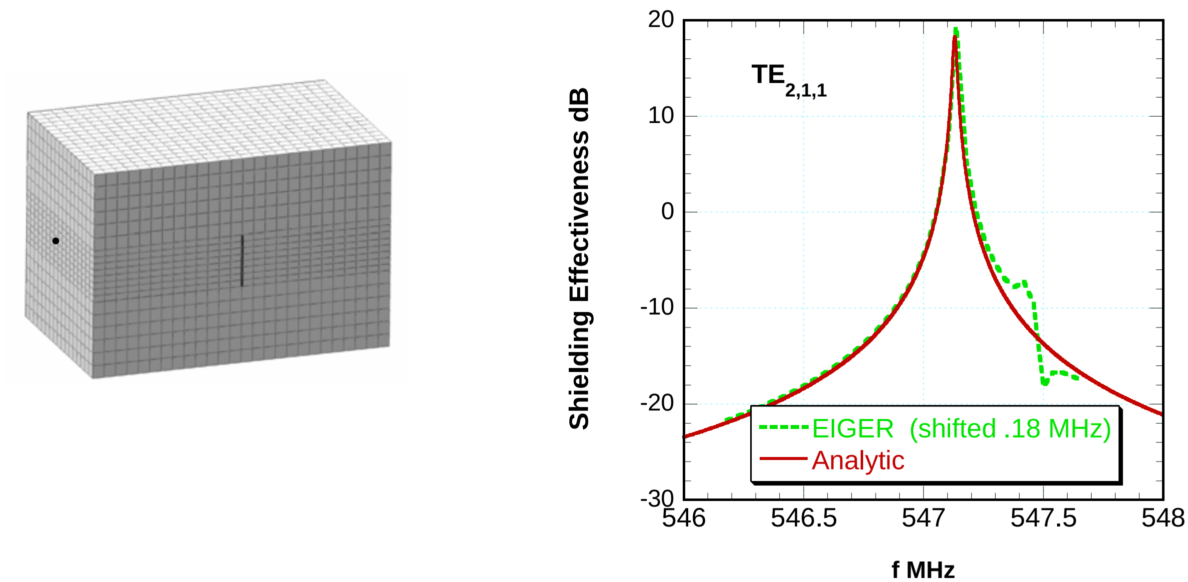
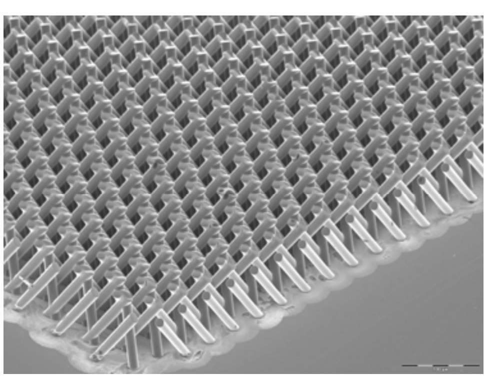


Figure 3. (a) Plane wave coupling to a cavity backed aperture. The dot represents the point where the electric field was measured.



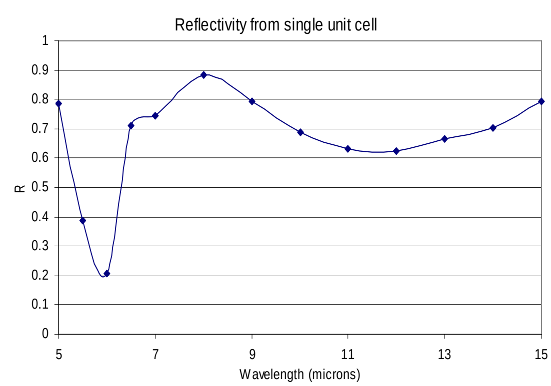


Fig.4 (a. Photonic crystal (LIGA te[illegible]) ([illegible] Reflectivity as a function of wavelength for infinite photonic crystal array.

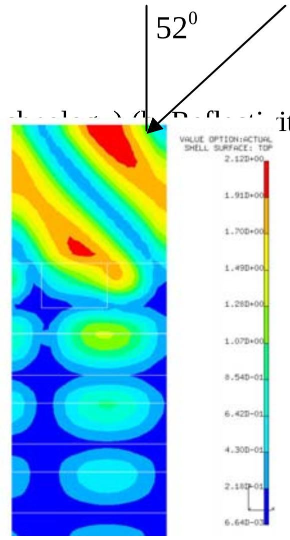


Fig. 5 Electric field magnitude in an infinite periodic-diffraction grating. The grating is periodic along the horizontal direction.

Conclusion

We have illustrated a few of the features of the EIGER^{TM} code. Some problems have been chosen to look back at the time when W. A. Johnson was working for Kendall F. Casey and to illustrate some of the impact Kendall had on that authors career. Kendall’s standard of his technical excellence and kind and ethical way of treating younger staff has been a model that I have tried to follow throughout my career.

Acknowledgements

The authors would like to thank David W. Peters of Sandia National Laboratories for providing the results for the photonic crystal.

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