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VALIDATING A NUMERICAL ELECTROMAGNETIC SOLVER IN A REVERBERANT ENVIRONMENT

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Abstract

This paper presents some thoughts on how to compare the results from a numerical electromagnetic solver with measured data in a reverberant environment where a large number of resonant modes are present in the data.

1 Introduction

The use of numerical solvers for the solution of electromagnetic fields in reverberant environments such as vehicle bodies and reverberation chambers presents a significant challenge to the solver. The data analysis and validation of results also can be difficult due to the rapid variation of data over a small frequency range. The detailed magnitude and phase of data is also very sensitive to small differences in geometry. This paper presents an example of the use of various techniques to compare the measured and modelled data and their capabilities and limitations.

2 The HY3D Solver

The HY3D code [1] is a hybrid code using the finite difference time-domain (FDTD) method for volume discretisation with a node-based finite element time-domain (FETD) method for boundaries and surfaces. As part of the FLAVIIR research programme the capability to include curved wire geometries has been incorporated. The code has been used and validated for a range of scattering problems but has been used for the first time in the FLAVIIR programme for modelling internal structures and coupling mechanisms.

3 The validation enclosure

In order to provide a basis for a range of validation problems including coupling to wires, shielding materials, and dielectrics, an enclosure of 0.6x0.5x0.3 m with an removable face and a number of coupling ports was built.
In this paper coupling between a monopole antenna and a curved wire is considered. One face of the enclosure is left open.
The (closed) enclosure has its first resonance at 390 MHz. Above 1200 MHz it is likely to be reverberant. We found that even with one face open many high Q resonances are present in the coupling.

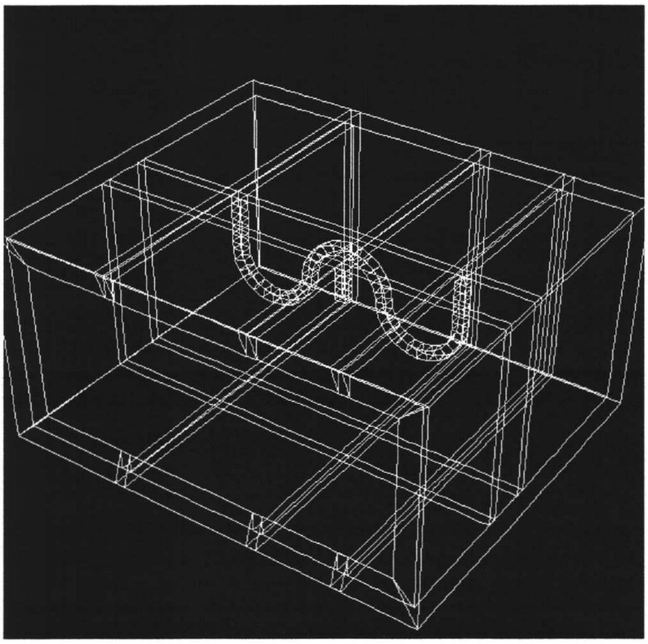

Figure 1: Geometry of the validation enclosure

4 Comparing the data

When there are many resonances in the geometry being considered comparing the data in an objective manner by plotting raw results is difficult as small frequency offsets give rise to large amplitude differences around resonant features.

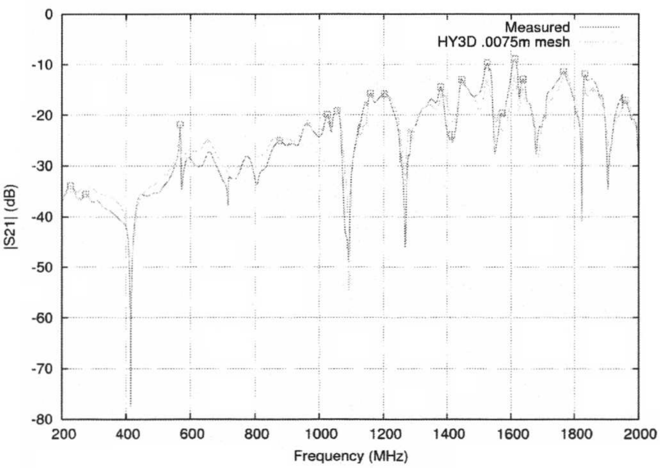

Figure 2: Coupling between a wire and a monopole in the enclosure showing peaks for Q check.

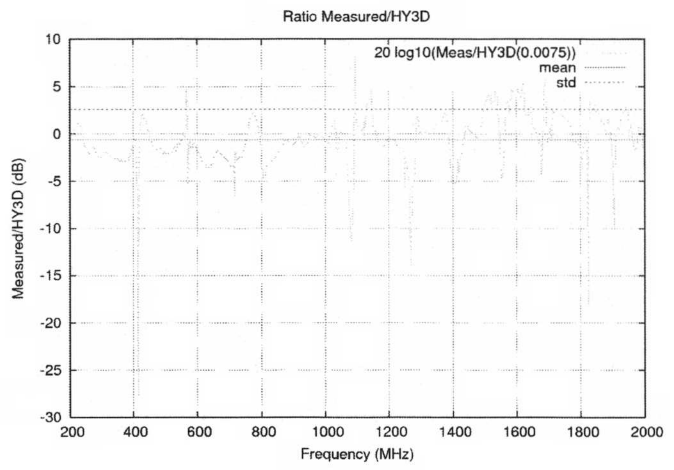

Figure 3: Ratio of measured/HY3D coupling showing mean (-0.6 dB) and std. dev. (2.6 dB) of the ratio.

Figure 2 shows the raw coupling data between one end of a curved wire and the monopole. The two curves have many features in common and one can compare the relative amplitudes of the features by looking at Figure 3 which shows the ratio of the amplitudes in decibels along with mean and standard deviation. It can be seen that the amplitude error is, on average, quite small but tends to be large near peaks due to mis-alignment in frequency of the features.

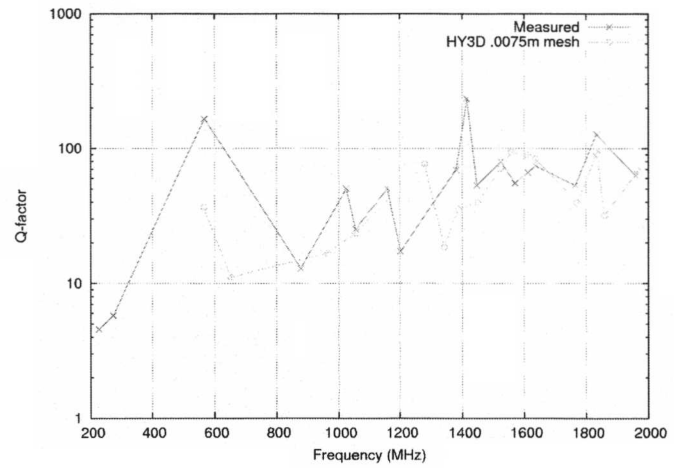

Figure 4: Q-factor of peaks the coupling between a wire and a monopole in the enclosure.

In a reverberant environment the coupled power is directly proportional to the Q-factor. Figure 4 shows that the measured data exhibits, on average, higher Q-factors than found in the model.

5 Conclusions

The curves can be seen to have a good amplitude match by looking directly at the graphs, but it is rather more difficult to estimate how closely the Q-factors correspond. The feature selective validation (FSV) method [3] (Figures 5 and 6) indicates a broad spread in feature agreement (fair) – it does not consider Q-factor directly. FSV indicates a good amplitude agreement.

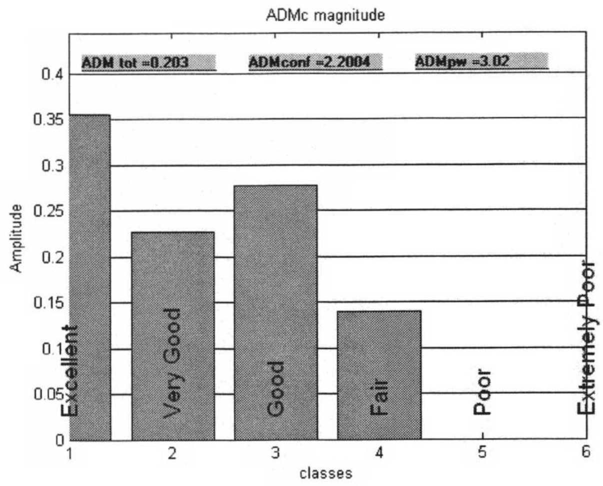

Figure 5: FSV Amplitude difference histogram

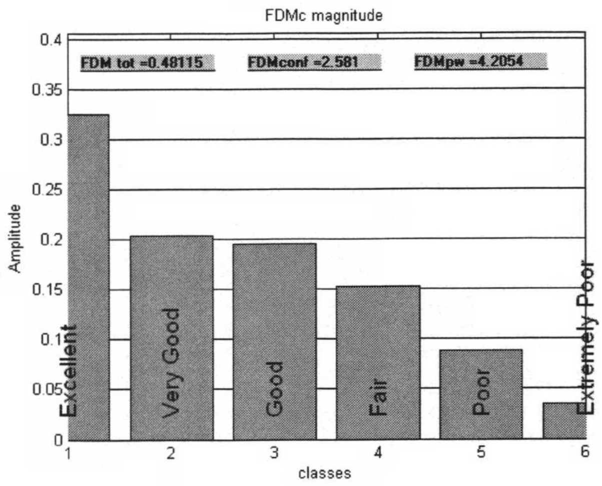

Figure 6: FSV Feature difference histogram

Acknowledgements

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