An Application of Optimisation for Passive RF Component Design

Andrew Lewis, Seppo A. Saario, David Abramson* and Jun W. Lu
Griffith University, Brisbane QLD 4111, Australia
*Monash University, Melbourne VIC 3168, Australia

***Abstract*—The solution of computational electromagnetic simulations is integral to the design process. As higher performance computers become more available, the application of optimisation techniques to reduce design times becomes more feasible. This paper presents the application of Parallel BFGS and Adaptive Simulated Annealing in minimising the transmission through a ceramic bead suppressor on a straight wire transmission line.**

I. Introduction

A high permittivity ceramic bead on a straight wire transmision line can be used to suppress propagating cable currents at RF frequencies [1]. In our application, we wish to have minimum transmission S_{21} through the bead at 1.0GHz. The FDTD method is used to perform a full-wave analysis of the cable structure. We present the application of an Adaptive Simulated Annealing (ASA) algorithm implemented by Lester Ingber [2] and a parallel implementation of the quasi-Newton BFGS algorithm (P-BFGS) [3] developed at the Queensland Parallel Supercomputing Facility (QPSF) in the design of such beads.

In the optimisation process, the convergence rate and susceptibility to local minima determine the effectiveness of a technique. It is well known that ASA is very good at finding a global minimum in complex problems. However, ASA is generally computationally intensive and requires careful selection of optimisation parameters to guarantee finding a global minimum.

For continuous functions, gradient descent methods can be particularly effective. The algorithm selected is based on the quasi-Newton BFGS method. Because of the computationally intensive nature of the FDTD simulation a parallel implementation of the BFGS algorithm was utilised.

II. Results

Both ASA and P-BFGS algorithms were used to optimise the ceramic bead dimensions (thickness, length) and permittivity. A cost function to drive the optimisation algorithms was defined as the average S_{21} over the 990-1010MHz band, subtracted from 50. The cost function is defined as: $C(p_k) = Avg(S_{21}) - 50$. An isosurface of the cost function is shown in Figure 1.

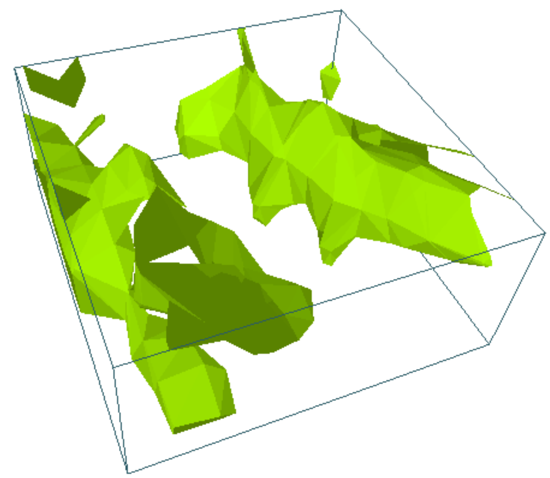

Fig. 1. Cost function isosurface at 25 (S_{21} = -25dB)

Optimisation results from both algortithms were not identical. After 143 function evaluations, the ASA solution defined a bead of $\varepsilon_r = 52$, $O.D. = 20mm$ and $length = 57.5mm$ to have an S_{11} of -10.3dB and S_{21} of -49dB. P-BFGS yielded a bead of $\varepsilon_r = 41.8$, $O.D. = 40mm$ and $length = 102mm$ to have an S_{11} of -14.7 dB and S_{21} of -56.6 dB after 44 steps on an 8 processor machine.

III. Conclusion

The effectiveness of two types of optimisation algorithms was investigated for the optimisation of the high permittivity ceramic suppression beads. Both ASA and P-BFGS provided workable solutions. Further investigations are proceeding into problems with each type of optimisation algorithm. Based on the observed behaviour with a relatively complex problem, possible hybrid schemes are being considered.

References

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