Postgraduate Course on Radiofrequency Optimization Techniques (MSc)

Instructor Information

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Course Information

Course Description

The analysis and design of radiofrequency circuits and subsystems by means of electromagnetic and circuit simulators requires solving global optimization problems, often of noisy and costly functions. We will review the better-known heuristic methods, such as simulated annealing, genetic algorithms and evolution strategies. The use of surrogate models will be also dealt with, by reviewing the Space Mapping technique. All these topics will be illustrated by practical projects, where students will optimize different radiofrequency subsystems and components.

Prerequisites

Fundamentals of constrained and unconstrained optimization.

Circuit Theory, Matrix representation of multiports, Transmission lines.

Fundamentals of microwave passive and active circuits.

Linear systems, Fourier transform and FFT.

A working knowledge of MATLAB.

Course Goal

The aim of the course is two-fold. On the one hand, to show the significance of optimization as a tool for the analysis and design of RF circuits and subsystems. On the other hand, to provide tools for a more effective use of electromagnetic and circuit simulators.

Summary of intended course outcomes

At the end of the course a student will have used different optimization algorithms for the analysis and design of basic RF circuits, and will be able to:

- Model a problem, by defining a proper objective function for the

analysis/optimization of a circuit or subsystem.

- Select a heuristic optimization algorithm in the case of noisy or costly objective functions.
- Apply the Space Mapping technique for the optimization of complex devices and circuits by means of CPU-time consuming electromagnetic simulators.

Syllabus

Nonlinear microwave network analysis
Linear and nonlinear subnetworks. Parametric description of nonlinear devices.
Harmonic Balance method.
Balance equation. Solution by optimization.
Examples and exercises.

RF and microwave network optimization
Modelling. Definition of the optimization problem.
The size of the search space.
Objective functions. Constraints.
Examples and exercises.

Global optimization. Noisy and costly functions.
Computational effort and numerical error in electromagnetic simulators.
Global optimization.
Simulated annealing.
Genetic algorithms and evolution programs.
Other heuristic techniques.
Examples and exercises.

Surrogate models and the Space Mapping technique
Introduction to surrogate models.
Space mapping for the optimization of microwave circuits.
Examples and exercises.

Suggested readings

1. Maas, Stephen A. *Nonlinear microwave and RF circuits*. Artech House, 2003, Chap 3.
2. Dréo, Johann, et al. *Metaheuristics for hard optimization: methods and case studies*. Springer Science & Business Media, 2006.
3. Michalewicz, Zbigniew. *Genetic algorithms+ data structures= evolution programs*. Springer Science & Business Media, 1996.
4. Michalewicz, Zbigniew, and David B. Fogel. *How to solve it: modern heuristics*. Springer Science & Business Media, 2000.
5. Bandler, John W., and Shao Hua Chen. "Circuit optimization: the state of the

art," IEEE Transactions on Microwave Theory and Techniques, vol. 36, No. 2, 1988, pp. 424-443.
6. Bakr, Mohamed H. "Advances in space mapping optimization of microwave circuits," PhD. Thesis, 2000. https://macsphere.mcmaster.ca/handle/11375/7119

Student Assessment Criteria

A series of short projects will be assigned throughout the semester (to groups or individuals) which involve the development of Matlab computer code to simulate and optimize basic RF circuits or subsystems. Besides, some short quizzes and exercises will be proposed, to be solved individually.

Short quizzes and exercises	30%
Reports on individual projects	40%
Reports on group projects	30%