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Review of the PhD Thesis

Real-time Digital Simulation of Guitar Amplifiers as Audio Effects

by Jaromir Macak

The PhD thesis by Mr Macak is a contribution to the field of mathematical modeling of analog nonlinear circuits. The thesis presents the analysis of these original analog circuits and synthesis by new flexible digital simulations. Modeling and simulation of the behavior of analog circuits plays an important role in commercial audio applications like sound processing and recording, and audio communication devices, but also mathematical models of such analog devices play an important role in research fields like human acoustical perception. Another important class of simulation models for analog circuits has already been realized by several commercial offline circuit simulators. Mr Macak's thesis extends these analog circuit simulators towards real-time digital simulators which are suited to simulate the circuit behavior by discrete-time processing means.

The PhD thesis consists of seven chapters, the author's publications, a bibliography, an appendix and a DVD. The first chapter covers the basics of algorithms for the simulation of audio effects and introduces the state of the art approximation and simulation methods for nonlinear signal processing. The second chapter introduces the goals of simulating a guitar amplifier and gives an outlook towards the contributions of Mr Macak in the following chapters. In Chapter 3 Mr Macak presents his own contributions to a Discrete Kirchhoff state space model. He derives and extends simulation models for circuits with a transformer and operational amplifiers. Simulation results confirm the validity of the approach and the functionality. Chapter 4 covers approximation techniques for nonlinear functions under the special real-time requirement and computational complexity constraints. In Chapter 5 Mr Macak introduces new techniques for the simulation of more complex circuits by decomposing the entire circuit into smaller systems which are connected by three different techniques. All three techniques are derived and evaluated by case studies and convincing simulation results. Chapter 6 then introduces a specific simulation of a guitar preamp and shows real-

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time measurements and conducted informal listening test. In Chapter 7 a conclusion and a summary of the main contributions are presented.

The topic of the thesis is of great interest for the field of multimedia and audio processing. The development of the general framework for a digital circuit simulator presented by Mr Macak shows several original and important contributions. He has proposed new modeling techniques based on a state space modeling approach and has presented his work with several publications at conferences and a journal publication. This reflects the significance and acceptance of his scientific contributions.

Besides his research activities Mr Macak shows excellent skills of bringing innovative ideas into working algorithms and products.

I hereby state, that the thesis meets the standard for the awarding of an academic degree. I rate the thesis as "very good"

Udo Zölzer   Hamburg, November 16, 2012

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