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Theory of Power Matching

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To Mrs. Gabriella Reeves, My Cello Teacher

Preface

The reader has been invited now for a grandiose trip. One of the most important concepts during the history of circuit theory will be overviewed: power matching. This concept has a great impact on various areas such as foundation, broadband matching, and game theory.

The eBook consists of 12 chapters. We present an overview in Chap. 1. In Chap. 2, a completely derivative-free approach is shown for proving the globality of the maximum power in case of linear time invariant one-ports. In Chap. 3, nonlinear resistive case has been treated: the well-known solar cell example. Topic of Chap. 4 is competitive power matching. That means a multiport case when the ports have been optimized consecutively. This way leads to very different solution than the simultaneous optimization. The big Chap. 5 deals with the scattering matrix as the measure from the power matched status. Broadband matching applications have been touched as classical and real frequency methods for broadband matching. In Chap. 6, we prove that a linear, passive one-port is always causal and that causality can be hurt in case of large nonlinear circuits. Chap. 7 is intended for our own results: power matching with describing functions and weakly nonlinear circuits . In Chap. 8, the most general case has been solved: nonlinear dynamic sources. Importance of the Gateaux derivative has been pointed out. This work has been concluded in Chap. 9.

Technically, main units are called as chapters, while sub-chapters are called sections. Figures and equations are numbered by the chapter and section number and the consecutive serial number. In the references chapter, literature has been grouped according to the chapters.

For those who are less familiar with circuit theory, we suggest studying the references for this chapter before reading this work. Suggested order of reading is: [Dieudonné60, Gantmacher59, Papoulis77, Valkenburg74, Belevitch68, Chua87].

Budapest, Hungary — János Ladvánszky

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The three persons who influenced this work the most are Dr. A. Baranyi, Professor T. Berceli, and Dr. E. K. Simonyi. Dr. A. Baranyi was my first master. My first work in this topic was supervised by him: the reversal of the nonlinear resistive maximum power theorem. Later I learnt microwaves and optics from Professor T. Berceli. More recently, he sent talented students to me whom I could consult in their diploma works. Dr. E. K. Simonyi was the advisor of my D.Sc. work. He combined rigorous criticism with friendly approach.

Basic influences were made by my teachers at the Budapest University of Technology and Economics: Professor K. Simonyi, Professor L. Pap, Professor V. Székely, Professor S. Csibi, and Professor K. Géher. I learnt from them the basics of electrical engineering. Without this knowledge, this eBook could not be imagined.

In 1976, one of my problems at the closing exam from Electromagnetic Theory was power matching. I admit it is not intentional that the present eBook has been written in the same topic. I would like to mention my examiners, Professor Gy. Veszely, still active, and Dr. S. Takács. I still remember the constructive atmosphere of this exam. Dr. S. Takács taught the subject Electromagnetic Theory to our university group, and I clearly remember his thorough explanations and his beautiful handwriting on the blackboard.

It is my special honor mentioning here the long-term communications at conferences with Professor L. O. Chua whose works are frequently referred here. He is among the professionals in electrical engineering to whom I look up.

From the history of this eBook, personal meeting with Professor M. Hasler at the European Conference on Circuit Theory and Design in 1987 (and several times since then) was significant. Professor M. Hasler was one of the reviewers of the work about power matching using my describing functions. The encouragement that I received from him helped my work in this topic very much.

In this eBook, the computer program AWR is frequently used. The parent of AWR is APLAC by Professor M. Valtonen. My pleasant stay with him and his group at Helsinki University of Technology in 1992, now Aalto University, was a significant event in my career.

Describing function approach to the problem of power matching was a part of my Ph.D. thesis. Now, the opponents of this work are acknowledged, Professor I. Frigyes and Dr. I. Schmideg. Their constructive criticisms and long-term communications with them helped me a lot.

When this eBook was born I imagined that I explained to my students or young colleagues. I am grateful to all of them for keeping me mentally young: Zoltán Szalontai, Dr. Attila Hilt, Dr. Gábor Kovács, Gergely Mészáros, Bence Erdei, Tibor Gál, Kristóf Máté Osbáth, András Surman, Tamás Szili, Lajos Budai, and Ádám Kristóf Ónodi.

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Abstract

Power matching is one of the most important concepts in the history of circuits and systems theory. In this eBook, the most significant results and the impact of power matching on other concepts have been presented.

Reasons of writing about power matching are the rich impact on other areas and the vast amount of applications. From impacts, basis of today's microwave industry, the scattering matrix should be emphasized first. The scattering matrix also appears in digital circuits, for example, the wave digital filters to be included in the next edition. As far as the applications are considered, our results in describing functions and Volterra series are mentioned. From this sample palette, applications in numerical solution for the Nash equilibrium should not be left out, which is intended to be detailed later. The most distant application that we can still see is quantum communications, also detailed in a latter edition.

Contents

About the Author

János Ladvánszky (member, IEEE) is an electrical engineer at Ericsson Hungary (M.Sc. in 1978, "Modelling of a microwave transistor," from the Budapest University of Technology and Economics; Ph.D. in 1988, "Nonlinear, microwave circuit design," from the Hungarian Academy of Sciences; D.Sc. defense, forthcoming, "Integrated systems for optical communications," at the Hungarian Academy of Sciences). His career can be followed at ResearchGate, LinkedIn, and Facebook. He has got 180 conference and journal papers and 14 patents, 52 independent citations, and above 3400 reads at ResearchGate.