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Text Is Comprehensive Guide To Converter Circuit Transfer Functions

Transfer Functions of Switching Converters: Fast Analytical Techniques at Work with Small-Signal Analysis, Christophe Basso, Faraday Press, ISBN: 978 1 949267 51 8, glossy 8.5 × 11-inch color hardback, 685 numbered pages + index, 2021.

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Christophe Basso is an engineer who has designed various integrated converter controller circuits at ON Semiconductor in Toulouse, France, is an IEEE senior member, and is also a major contributor to How2Power Today. This latest and sixth book by Basso draws on his previous book (also reviewed in this newsletter), *Linear Circuit Transfer Functions: An Introduction to Fast Analytical Techniques*, published in 2016.[1]

The new book is easy to summarize; it begins with a chapter on small-signal (incremental) modeling. These are the basic principles of how to linearize very nonlinear devices such as power switches by averaging voltages and currents over switching cycles or across sampling intervals. Basso's style is to not gloss over the mathematics, but carry it out so that the reader understands where the design equations came from and how they are derived. The reader interested in a less complete coverage can skip over derivations and apply the design formulas. They are illustrated by multiple examples throughout the book.

Basso's style of presentation is to present the power circuits, derive design equations, and then simulate some examples with SIMPLIS. The large 8.5- × 11-in. book size makes equations large enough to be easily read, and the book is good exercise for an outstretched arm of a sedentary person to pull off a shelf and hold.

The first chapter includes the basic linear system principles, in large, color illustrations, needed to analyze circuits appearing in the succeeding chapters. The mathematics of reducing total-variable circuit equations to incremental equations is explained in some detail for those not ordinarily proficient at mathematics.

For instance, partial differentiation is a central concept and has its own entire section (1.1.5). Readers are encouraged to engage the math because it is a major aspect of what is required to understand how power-circuit transfer functions are derived, and Basso is more than patient in explaining the details for the willing reader. This book is an opportunity for engineers "rusty" at math to do sufficient refreshing to handle the involved analytic modeling of power circuits.

In the first opening chapter, various familiar topics about converters are included, such as ripple at power ports, conduction modes, flux and charge equilibrium, converter transfer ratios (perhaps a better name than *transfer functions*, though both apply), isolation, PWM function modeling, feedforward, voltage and current control, resonant power transfer, and hysteresis control. Two additional sections in part 1 are about modeling the PWM for both voltage and current control loops.

The three parts 2 through 4 each cover variants on both circuit topology and methods of control of the three basic PWM-switch configurations (buck, boost and buck-boost). Basso systematically derives the transfer functions of the broad spectrum of PWM-switch transfer-circuit variants, a gigantic task that is not equaled even by the monumental work of Erickson and Macsimović (E&M) in *Fundamentals of Power Electronics*.[2]

In this way, the book serves as a kind of handbook of the compendium of power-transfer circuits likely to be encountered in engineering practice. Not only are the equations worked out with intermediate steps to show progression in the derivations, example circuits are then simulated and the results compared graphically to the results from the derived equations, to provide a check on the math.

As each category of circuits is completed, the design formulas are tabulated, as E&M do in their book. Transfer functions are derived by finding the open- and short-circuit time-constants which are substituted into a general formula for expressing the transfer function. These methods are an outgrowth of R.D. Middlebrook's refined form of the Cochrun-Grabel method of finding transfer-function poles, but include zeros for a complete transfer function. Vatché Vorpérian has also written a book on these higher-level methods of circuit analysis[3] referred to by Basso.

A final chapter on "High-Order Converters" covers four power-transfer circuits: two configurations of the Ćuk-switch, the Ćuk-circuit (common-switch, CS) and zeta (common-active, CA) and a four-terminal Ćuk-switch configuration, the SEPIC. The fourth is the series-resonant "LLC circuit". These circuits are part of the larger

repertoire of topologies in power transfer and have not one but two inductor windings. Open- and short-circuit time-constants are found in the circuit analysis, drawing on the methods developed in the previous book.

Appendix A summarizes some of what is in the previous book, on higher-level methods ("fast analytical techniques") of circuit analysis. The book includes a four-page "token" index. However, the table of contents at the front of the book is equally useful in finding one's way around in the book, and the systematic progression of topics through it should make it easy enough to find where topics are covered.

References

1. *Linear Circuit Transfer Functions: An Introduction to Fast Analytical Techniques* by Christophe P. Basso, Wiley, 2016. To read Dennis Feucht's review of this book see "Circuit Analysis Book Makes It Easier To Derive Transfer Functions".

2. *Fundamentals of Power Electronics*, *Third Edition* by Robert W. Erickson and Dragan Maksimović, Springer, 2020. To read Dennis Feucht's review of this book see "Classic Power Electronics Text—Updated, But Further Refinement Is Possible".

3. *Fast Analytical Techniques for Electrical and Electronic Circuits* by Vatché Vorpérian, Cambridge University Press, 2002.

About The Author

Dennis Feucht has been involved in power electronics for 40 years, designing motor-drives and power converters. He has an instrument background from Tektronix, where he designed test and measurement equipment and did research in Tek Labs. He has lately been working on projects in theoretical magnetics and power converter research.

To read Dennis' reviews of other texts on power supply design, magnetics design and related topics, see How2Power's Power Electronics Book Reviews.