

# Preface

The technology presented in this book has the intention of providing a reliable and efficient bridge between fluctuant ambient energy harvesting supplies and the rather regular but peaking energy demand profiles of small-scale sensor and actuator systems. The envisioned solution is an autonomous and self-sufficient sensor or actuator system that is to be installed and forgotten, i.e., free of maintenance or manual operation control. The developed power processing modules are developed as an efficient, compact, and low-cost solution.

As such, integrated power management circuits are presented for autonomous supply of remotely operating portable and wireless sensors. The focused ambient energy harvesters are AC low-voltage sources, specifically electromagnetic vibration transducers. Besides the power conversion and energy extraction circuits, a major part is on innovative ultra-low voltage circuits and building blocks. These allow full operation at voltages as low as 0.5 V and up to 3.6 V—a key enabler for harvesting energy at various application conditions.

Besides the design and characterization of four CMOS chip prototypes, the book introduces several inventions, models, and as well as circuit and systems. For instance, presented inventions are on a load-matching detector (for fully-analog online detection of the maximum power point), and a coupled active diode for pulse-width modulation at a lower power level.

As energy harvesting is usually very application-specific, design rules are introduced and the limiting mechanisms of the operation ranges are analyzed. This is seen as important for the scaling, design modifications, and adaptation of the presented subsystems. It makes it easy and attractive for designers to reuse and adapt the presented work, but may also help to improve their systems in regards of lowering power consumption substantially.

The Part I starts with a general overview, used to derive apparent needs and challenges. Since the realization of these interfaces requires particular circuit constraints, the Part II of this book concentrates on the device and circuit design level. Then, Part III explains the interfaces at a circuit to system level basis. Basic design rules, operation limits, their architecture, as well as presenting the chip-integrated prototypes.

For preparing the presented research in the following chapters, I had the great opportunity working with quite a list of fantastic persons. It is my pleasure to express my thanks and very great appreciation to all of them. This work would not have been possible without their kindness, support, guidance, and inspiration.

First and foremost it is my pleasure to thank Prof. Dr.-Ing. Yiannos Manoli for not only giving me the opportunity to work in his laboratories for many years, but also became the coauthor of this book. From his diversified research know-how and expertise as well as his marvelous teaching skill gave me immense flexibility, pleasure, and comfort during my research work.

Needless to say, that I am grateful to all of my colleagues of both, the Fritz-Huettinger Chair of Microelectronics and the 'Energieautonome Systeme' group at HSG-IMIT with Bernd Folkmer. I am grateful to thank Dr.-Ing. Joachim Becker and Prof. Dr.-Ing. Maurits Ortmanns for supporting this work during its infant period, as well as Prof. Dr.-Ing. Eduard Alarcon for his valuable support. Further thanks I would like to express to Dr.-Ing. Dirk Spreemann who introduced me to the secrets of electromagnetic transducers and the many inspiring discussions with him.

Moreover, I am indebted to Markus Kuderer and Stanis Trendelenburg for their IT support. Thanks and appreciation go also to my dear colleagues from IMTEK, in particular Thorsten Hehn, Christian Peters, Niklas Lotze, Joachim Leicht, Fabian Henrici, Fridolin Michel, as well as Matthias Keller for their vibrant and enlightening discussions.

Last but not the least, I thank my parents and brother for their valuable support—emotional, moral, and of course financial. This book would certainly not exist without them. Thank you.

Freiburg (Germany), Singapore

Dominic Maurath  
Yiannos Manoli

CMOS Circuits for Electromagnetic Vibration  
Transducers

Interfaces for Ultra-Low Voltage Energy Harvesting

Maurath, D.; Manoli, Y.

2015, XXIII, 300 p. 155 illus., Hardcover

ISBN: 978-94-017-9271-4