A CMOS Self-Powered Front-End Architecture for Subcutaneous Event-Detector Devices

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Three-Electrodes Amperometric Biosensor Approach

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Preface

This book presents the conception and prototype realization of a Self-Powered architecture for subcutaneous detector devices. The architecture is designed to work as an event detector or threshold level alarm of some substances, ions, etc ... that are detected through three-electrodes amperometric Biosensor approach.

In this book, the final device is envisaged as a Low-Power subcutaneous implantable application powered by an inductive link, one emitter antenna at the external side of the skin and the receiver antenna under the skin.

The sensor is controlled with a potentiostat circuit and then, a post-processing unit detects the desired levels and activates the transmission via a backscattering method using the inductive link. All the instrumentation, except the power module, is implemented in the BioChip ASIC.

Following the idea of the powering link to harvest energy of the magnetic induced link at the implanted device, a Multi-Harvesting Power Chip (MHPC) has been also designed. This power management unit, able to collect energy from three different sources, solar, mechanical vibrations and magnetically induced energy, converts the energy of the environment into usable electrical energy. In that way, any type of Low-Voltage Low-Power electronics can be powered. This MHPC is used as a supply unit in the designed subcutaneous device.

This book is based on the research carried out in the Smart Self-Powered BioInspired Systems (S^2PBS) of the SIC – BIO Group at the Universitat de Barcelona, Spain, focused on developing discrete-to-integrate electronics for specific instrumentation.

This book is divided in five chapters:

- In Chapter 1, an overview of the state of the art of energy harvesting is done. Several ambient power sources and human body-centered sources are commented. Then, a general introduction to Biosensors and electronics for three electrodes sensors is provided.
- Chapter 2 discuses the design of an ASIC able to recollect energy from several different energy harvesting power sources. All circuits are theoretically and experimentally described and validated. The final IC, called MHPC, is tested and validated.

- Chapter 3 focuses on the design of the integrated instrumentation IC (BioChip) to work with the three electrodes amperometric sensor. The potentiostat amplifier is described in detail and validated through experimental results using a real electrochemical substance. Furthermore, the conception of a Lock-In amplifier is also introduced in this chapter as well as the transcutaneous link data transmission.
- Finally, the Self-Powered front-end architecture for subcutaneous detector devices is presented in Chapter 4. The device combines the MHPC, BioChip, communication antenna, etc… in the same substrate that is fully validated through different test.
- Chapter 5 summarizes the main contributions presented in this book. Moreover, some possible future aspects that may arise from this work are presented.

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Contents

Abbreviations

AC	Alternating current
AM	Amplitude modulation
CGC	Clock generation circuit
CMOS	Complementary metal-oxide semiconductor
CV	Cyclic voltammetry
DC	Direct current
EIS	Electrochemical impedance spectroscopy
ESR	Equivalent series resistor
LDO	Low dropout
LPF	Low-pass filter
MOSFET	Metal-oxide-semiconductor field-effect transistor
MSD	Multiple storage device
OTA	Operational transconductance amplifier
PCB	Printed circuit board
POR	Power-On-Reset
RF	Radio frequency
RFID	Radio frequency identifier
SDG	Synchronous demodulated channel
SMD	Surface mount device
SSD	Single storage device
TG	Transmission gate
TIA	Transimpedance amplifier