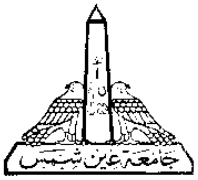


AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics Engineering and Electrical Communications

Implantable Biomedical Recording System

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

by

Nader Sherif Kassem Fathy

Bachelor of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

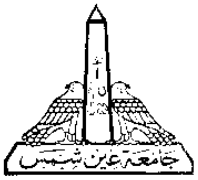
Faculty of Engineering, University, 2013

Supervised By

Prof. Emad Hegazi

Dr. Mohamed Ahmed Mohamed El-Nozahi

Cairo - (2018)



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Date: 30 July 2018

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Electrical Engineering Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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July 2018

ABSTRACT

Faculty of Engineering - Ain Shams University

Electronics and Communication Engineering Department

Thesis title: “Implantable Biomedical Recording System”

Submitted by: Nader Sherif Kassem Fathy

Degree: Master of Science in Electrical Engineering

Implanting a tiny biomedical integrated circuit transceiver inside the human brain is quite challenging, especially when it is powered wirelessly to transmit the neural signal outside the brain. The power, area and noise constraints are quite difficult to achieve especially when considering the biomedical safety constraints. This thesis investigates the design of a low power, low noise and small size neural channel to support high density neural implant system.

Various neural recording systems were studied prior to the beginning of this work. A classification of the recording systems is presented along with the advantages and disadvantages of each. The main contribution of this thesis is the design of a very small size neural channel that can be integrated with high density. A novel technique in autozeroing is presented to reduce the overall channel size. In addition, a digital system is presented to recover the neural signals that are affected by the autozeroing technique.

To lower the noise of the neural amplifier, a chopper stabilized technique is considered. However, this technique causes the degradation of the input impedance. Accordingly, this work proposed a novel digitally calibrated impedance boosting circuit that is robust against process variations.

The achieved neural recording channel area is 0.004 mm^2; each consuming 0.7 µW from a 1V DC supply. The proposed system integrates 86,956 neural recording channels on a 20×20 mm^2.

All simulation results were done by Cadence Virtuoso and Mentor Graphics Eldo-RF using UMC 130 nm CMOS technology.

THESIS SUMMARY

Faculty of Engineering - Ain Shams University

Electronics and Communication Engineering Department

Thesis title: “Implantable Biomedical Recording System”

Submitted by: Nader Sherif Kassem Fathy

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The realization of a state-of-the-art wireless biomedical implantable interface system puts strict requirements on the design of the biomedical recording system. Since there is a massive number of biomedical signal sources inside the human body, the recording system should be capable of sensing these signals. Each signal requires its own recording channel. Accordingly, the channel design should be of an exceptionally small size and consumes ultra-low power; this will make it scalable for multiple channels. This thesis aims to design a low-power wireless implantable biomedical recording system. The focus will be on the design of the main building blocks of the system, implemented in CMOS technology.

This thesis is divided into six chapters including table of contents, list of tables and figures as well as list of references and the appendices. A brief summary of each chapter is discussed below:

Chapter 1

This chapter introduces the main motivations of researching in the field of biomedical neural recording systems. A brief outline of various neural recording system applications is presented. In addition, the chapter clarifies the main challenges imposed on the recording system design regarding power and area constraints to be able to satisfy all human safety factors.

Chapter 2

This chapter provides a detailed literature survey on the existing state-of-the-art neural recording systems. It goes further with discussing the limitations and drawbacks of each system and the opportunities of improvements. Finally, it compares some of the existing state-of-the-art neural recording system.

Chapter 3

This chapter discusses the proposed implantable neural recording system that tackles most of the limitations of the existing state-of-the-art systems. It illustrates the theory behind solving the area and size issues in the system. Finally, it discusses the functionality of each building block in the system and the coexistence if each block.

Chapter 4

This chapters illustrates the theory behind the digital signal correction of the neural electrode DC-offset cancellation applied in the receiver part to restore the original neural signal. In addition, it summarizes the system limitations and achieved signal restoration percentages.

Chapter 5

This chapter introduces the idea behind the neural recording system input impedance boosting techniques. It summarizes the existing techniques in the literature that solve the input impedance boosting mechanisms in addition to the performance limitations existing in each system.

Chapter 6

This chapter presents the summary for the thesis in addition to some proposed future work.

Key words: Implantable Neural Recording Systems, Biomedical CMOS ICs, Impedance Boosting Systems, Neural Electrode DC Offset Cancellation.

TABLE OF CONTENTS

1. Chapter 1: Introduction 1
   1.1 Introduction 1
   1.2 Biology of Neurons and Neural Signal Types 2
   1.3 Neural Signal Electrical Interface 3
   1.4 Neural Electrodes and Characteristics 5
   1.5 Motivation for High Density Neural Implants 10
   1.6 Thesis Contribution 11
   1.7 Thesis Organization 12
2. Chapter 2: Neural Recording System Topologies 13
   2.1 Introduction 13
   2.2 Existing Neural Recording Techniques 14
   2.3 High Density Neural Implants Systems 18
   2.4 Comparison of State-of-the-Art Recording Systems 23
   2.5 Summary 24
3. Chapter 3: Proposed Neural Recording System 25
   3.1 Proposed Neural Recording System 25
   3.2 Neural Recording System Requirements 28
   3.3 Building Blocks of the Proposed System 30
   3.4 System Layout and Simulation Results 57
   3.5 Summary 62
4. Chapter 4: Signal Recovery Module 63
   4.1 Introduction 63
   4.2 FIR VS IIR Digital Filters 64
   4.3 Filter Design and Signal Recovery Trials 66
   4.4 Proposed Signal Recovery Algorithm 70
   4.5 Conclusion 74
5. Chapter 5: Impedance Boosting Circuit 75
   5.1 Introduction 75
   5.2 Existing Impedance Boosting Techniques 76
   5.3 Proposed Impedance Boosting System 80
   5.4 Simulation Results of the Proposed System 88
   5.5 Conclusion 91
6. Chapter 6: Summary and Future Work 93
   6.1 Conclusion 93
   6.2 Future Work 95