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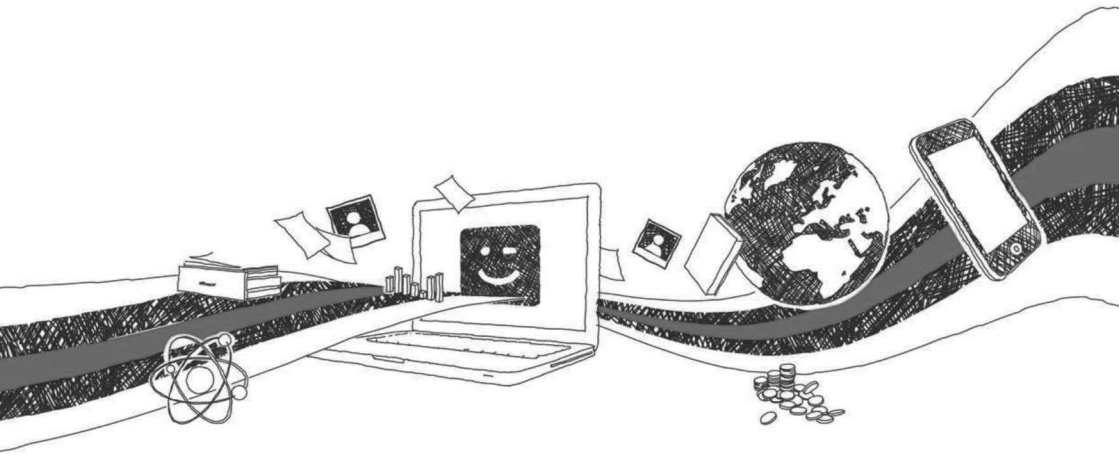

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A LOW-POWER ANALOGUE SC-CMOS FILTER SUITABLE TO IMPLEMENT THE WAVELET ALGORITHM TO ANALYSE ECG SIGNALS IN PACEMAKERS

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This book is the revised and corrected version of the thesis submitted in October 2004 to the faculty of Engineering at University of Pisa, Italy,
in partial fulfilment of the requirements for the degree
Master of Science
in Electronics Engineering.

Contents

Contents ..... **iii**

Acknowledgments ..... **v**

Introduction **1**

Chapter I

Evaluation of the filter expression in s-domain and z-domain **4**

1.1) Laplace transform and Padè approximation 4

1.2) Impulse invariance technique 8

Chapter II

Filter optimization – dynamic range analysis **12**

2.1) State-Space realization 12

2.2) State-Space optimization 15

2.3) Hessenberg and Schur decompositions 18

2.4) Optimal capacitance distribution 20

Chapter III

Comparison of discrete and continuous time approaches **21**

3.1) State-Space realization in continuous time 21

Chapter IV

Circuital realization of the filter **24**

4.1) Synthesis of the state-space filter 24

4.2) Filter settings 26

4.3) First approach to the circuit 28

4.4) Impulse transient response of the circuit with ideal amplifiers 31

4.5) Step transient response of the circuit with ideal amplifiers 33

4.6) Sine transient response of the circuit with ideal amplifiers 34

4.7) Clock feedthrough 35

Chapter V

Two-stage CMOS operational amplifier **37**

5.1) Two-stage CMOS operational amplifier topology 37

5.2) Analysis of the amplifier 38

5.3) Frequency compensation 41

5.4) Integrator bandwidth 43

5.5) Considerations on the amplifier 46

5.6) Calculus of the transconductance by noise-optimisation 48
5.7) Calculus of the biasing current and design of the amplifier 49
Chapter VI
Final schematic of the wavelet filter 51
6.1) Transmission gate and dummy gate 51
6.2) Impulse transient response 54
6.3) Step transient response 55
6.4) Sine transient response 56
6.5) Power consumption 56
6.6) Noise analysis 57
Chapter VII
Considerations on the wavelet filter 59
References 61

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Introduction

The *QRS complex* represents ventricular depolarization and consists of three waveforms. The normal complex begins with a downward deflection known as the Q wave, followed by an upward deflection called the R wave. The next downward deflection will be the S wave. All ventricular complexes are known as QRS complexes even if every wave is not present in all complexes. The normal human QRS complex lasts about 0.04 to 0.11 seconds and its waveform can be seen in Fig. 1, which shows a typical external electrocardiogram (ECG).

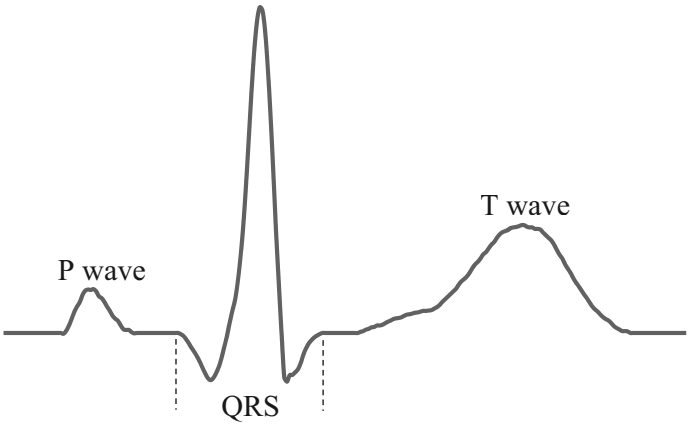

Fig. 1. Example of a typical external electrocardiogram.

The detection of the QRS complex is very important because it is related to different heart dysfunctions such as:

- Nonspecific intraventricular conduction delay
- Some cases of left anterior or posterior fascicular block
- Incomplete right or left bundle branch block
- Ectopic rhythms originating in the ventricles (e.g., ventricular tachycardia, pacemaker rhythm)
- Presence of necrotic heart tissue
- Ventricular hypertrophy

The *wavelet transformation* [1] is a very promising tool to characterize non-stationary signals such as the QRS complex because it gives good estimation of time and frequency localization. In fact, the analysis of the signal is performed at *various resolutions* and accomplished by decomposition