Faculty of Sciences and Technology of the University of Coimbra

Master Thesis

Development of a blood pressure device with wireless communication

by
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Under the supervision of

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Carlos Correia, University of Coimbra
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A thesis submitted in fulfilment of the requirements
for the degree of Master of Science of Biomedical Engineering

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This work was developed in collaboration with:

Exatronic Insight Innovation — Aveiro, Portugal

Electronics and Instrumentation Group (GEI)
Department of Physics, University of Coimbra
Coimbra, Portugal

"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

Abstract

1st - The problem

NEED - At the same time we have an increase quality of life and consequently on life expectancy and on aging population. More diseases. Cardiovascular diseases are the number one worldwide cause of death. No Infraestructure

APPROACH - To meet the need (growing number of diseases) evidenced by this population medical devices sector is developing solutions with integrated electronics in order to improve quality of life in all periods of life and preferred living environment. This is called Ambient Assisted Living (AAL). area and integrated (módulos)

"Ambient Assisted Living" (AAL) are concepts, products and services which combine new technologies and the social environment in order to improve quality of life in all periods of life and preferred living environment

BENEFITS - Thus, increasingly arise of portable solutions allow quick monitorization of vital parameters with the purpose of diagnosing diseases earlier and prevent emergency situations.

This project has as main goal the development hardware, firmware and software for a blood pressure measurement device.

2nd

WHAT - This thesis details the development of a blood pressure device prototype with wireless communication of their readings that will be part of a multi-module device with oxymetery, ECG, etc .

HOW - The work includes the creation schmetics and a Printed Circuit Board (PCB) which integrate all the selected components for this device. The system was programmed using an Atmel debugger, AVR Dragon, and a development board with a microcontroller (MCU), ATxmega 384C3, for whom all the firmware was developed

3rd

The main goal was to have a fiable device. Even thought factors like electric consumption of all the components were studied having in mind a a portable prototype.

System tests Interface (HMI) - web/Android How did you stored that?

Keywords: *Blood Pressure, Medical Devices, Ambient Assisted Living (AAL), Internet of Things (IoT), ATmega2560/AVR Dragon, Bluetooth, Wireless Communication, Printed Circuit Board (PCB), ATxmega 384C3, Hardware, Altium Designer, Firmware, C Language, Signal Aquisition, C Language*

Resumo

Currently, Portugal displays indicators to be an aging population. In this light, the medical devices sector has been developing solutions [1] that try to meet the needs evidenced by this population. Thus, increasingly arise mobile solutions such as solutions for monitoring vital parameters with the purpose of diagnosing diseases earlier and prevent emergency situations. These devices are part of the Ambient Assisted Living area [2].

The Exa4Life is also very attentive to this market sector and the Ambient Assisted Living solutions. As such, you want to see the emergence of solutions with electronic able to monitor vital parameters in a simple way so they can be used by the target audience in their preferred environment.

It is intended, then the students to develop a prototype device which is a 7medidor blood pressure with wireless communication of their readings....

Palavras-Chave: *Pressão Arterial, Dispositivos Médicos, Ambient Assisted Living (AAL), Bluetooth, Comunicação Wireless, ATmega2560/AVR Dragon, Printed Circuit Board (PCB), ATxmega 384C3, Hardware, Altium Designer, Firmware, Linguagem C, Aquisição de Sinal, Linguagem C*

Acknowledgements

Thanks!

Contents

List of Figures

List of Tables

Abbreviations

LAH **L**ist **A**bbreviations **H**ere

Physical Constants

Speed of Light $c = 2.997\ 924\ 58 \times 10^8\ \mathrm{ms}^{-\mathrm{S}}$ (exact)

Symbols

a	distance	m
P	power	W (Js^{-1})
ω	angular frequency	$rads^{-1}$

For/Dedicated to/To my...

Chapter 1

Introduction

1.1 Motivation

1.1.1 Need

Compared to 45 years ago we have an increase quality of life and consequently on life expectancy (6 to 8 years) and on aging population.

(28 mil idosos vivem sozinhos ou isolados [3] +NUMBERS)

Limited health infraestructure to attend to their needs.

Among all this problems cardiovascular diseases are the number one worldwide cause of death.

1.1.2 Approach

To meet the need evidenced by this population medical devices sector has been developing (portable) solutions with integrated electronics that monitor vital parameters in the preferred living environment with the purpose of diagnosing diseases earlier and prevent emergency situations. These devices are part of the Ambient Assisted Living (AAL) area [2].

As said by the European Commision: "Ambient Assisted Living as a concept aims to prolongate the time people can live in a decent way in their own home by increasing their autonomy and self-confidence, the discharge of monotonously everyday activities, to monitor and care for the elderly or ill person, to enhance the security and to save resources."

It can be used in clinics, eldery houses, etc.

AAL concept leads to another one called Internet of Things (IoT). With IoT technology healthcare providers computer can be directly connected and constantly receiving data from all their patient's devices. The analysis of this data may lead to a more consider decision and make better use of the appointments.(more productive)

An ABI Research research says by 2020 there will be 30.000 million devices connected using this tecnology. [4]

The bigger medical devices players such as iHealth, Omron ISA and Exatronic already created some solutions that are being used by hypertenses. Specially with the ill population sensibility and accuracy is extremelly important

This project has as main goal the development hardware, firmware and software for a blood pressure measurement device with wireless communication of its readings.

What diseases does it cure?

1.2 Contribution

Exatronic

Modular medical device: oxymetry, electrotherapy, ultra-sounds, ECG

Nice engineering work

The Exa4Life is also very attentive to this market sector and the Ambient Assisted Living solutions. As such, you want to see the emergence of solutions with electronic able to monitor vital parameters in a simple way so they can be used by the target audience in their preferred environment.

It is intended, then the students to develop a prototype device which is a 7medidor blood pressure with wireless communication of their readings.

1.3 Goals

The main goals for this project are: Development of a blood pressure device prototype with wireless communication of its readings

Focus: hardware, firmware, software

design an electronic configuration that, given the relative performance vs. consumption, get a sign of heart Heart potential with good qualitative indices.

Com accuracy of X, dimmensions

Before/During - State of the Art, Electronic Configuration, System Tests

- **State of the Art Study** study of the blood pressure measurement devices, embedded systems and integrated circuits for medical area.
- escolher os componentes: analisar as caraterísticas técnicas e a configuração e o desenho do hardware. Posteriormente, proceder-se-á ao estudo das caraterísticas do sinal que se pretende medir e das normas existentes na conceção de dispositivos médicos. Os componentes a utilizar e a sua disposição irão ser detalhadamente estudados, e serão definidos em função dos objetivos delineados pela Exatronic para o produto a desenvolver.
- **Design** the Printed Circuit Boards
- **Harware Development** Após esta parte inicial, e depois de definido o esquemático do módulo de aquisição, haverá uma fase de aprendizagem de uma ferramenta CAD (software Altium Designer®) e o desenvolvimento do circuito impresso (PCB, Printed Circuit Board).
- **Firmware Development** programming the microcontroller for proper operation/ C programming language
- **Software**Web APP bla bla bla
- **Software**Android APP bla bla bla
- **Test** the developed system that should be compared with a standard bla bla bla Por fim, serão feitos os testes à placa durante os quais será avaliada a sua funcionalidade e procurar-se-á otimizar o sinal obtido.

Figure 2 represents the tasks that had the ultimate goal of achieving the prototype generating plate signals.

1.4 Thesis Outline

This thesis is divided in 9 chapters.

Chapter 1 defines the problem and the contribution of this Master Thesis to solve it, the main goals to be achieved at the end of the project and finally the report structure is presented for a better understanding of the topics covered during this work.

Chapter 2 portrays the stakeholders that made this project possible and illustrates the project scheduling.

Chapter 3 details the physiolofical processes/most important concepts around blood pressure, its signal characteristics, the important components. Plus, it also points out the solutions refered in the litterature and the ones already in the market.

Chapter 4: Acquisition System refers

Chapter 5: Hardware describes

Chapter 6: Firmware presents

Chapter 7: System Tests makes sense of

Chapter 8: Data Storage specifies

Chapter 9: Conclusion recalls

Chapter 2

Project Management

The first section of this chapter introduces the people that made this project possible whereas the following two describe the organizations they represent, Exatronic Innovation Insight and Electronics and Instrumentation Group (GEI).

The last section regards the forseen and final project scheduling.

2.1 Context

This document is intended to report the project developed within the discipline of Project in the school year 2012/2013, which will be submitted to the Faculty of Science and Technologies of the University of Coimbra (FCTUC) to obtain a Master's degree in Biomedical Engineering.

Apart from the FCTUC, where the student was during the first semester, the project was developed along with a portuguese company, Exatronic Insight Innovation, where the student was during the second semester.

The stakeholders responsible for implementation of the project are described in Table 2.1.

2.2 Exatronic Innovation Insight

Exatronic Innovation Insight is a leading Portuguese company in integrated electronics products and solutions.

Name	Function	Contact
André Carvalheira	Student responsible for the execution of the project	andre.carvalheira1@gmail.com
Prof. Carlos Correia	Supervisor of the project at FCTUC	correia@fis.uc.pt
Eng. André Santos	Supervisor of the project at Exatronic Innovation Insight	asantos@exatronic.pt
Eng. Manuel Loureiro	Supervisor of the project at Exatronic Innovation Insight	mloureiro@exatronic.pt
Prof. Miguel Morgado	Coordinator of the projects of the Integrated Masters in Biomedical Engineering	miguel@fis.uc.pt

Table 2.1: Stakeholders responsible for implementation of the project

With 20 years of experience it also creates solutions in product certification and engineering, raw material procurement, sub-contracting production automation and automotive section.

Since 2010 a new business area was created, Exa4Life, which fits this project through an established protocol with the University of Coimbra, the University of Aveiro and Instituto Superior Técnico.

Experience - electrotherapy, ECG

2.3 Electronics and Instrumentation Group (GEI)

Thr Electronics and Instrumentation Group (Grupo de Electrónica e Instrumentação, GEI) is based in the Physics Department of the University of Coimbra.

The research areas of the Electronics and Instrumentation Group (GEI) are Atomic and Nuclear Instrumentation, Biomedical Instrumentation, Plasma Physics Instrumentation, Microelectronics, Optical Signal Processing and Telemetry and Industrial Control.

The GEI keeps a close cooperation with several national and international institutions that develop work in common research areas with unquestionable scientific results.

Concerning the teaching practice, GEI strongly supports the Instrumentation branch of the Physics Engineering degree and Biomedical Engineering degree with all its specialization branches.

This center has great deal of concern with the community services promoted during the last years by regular cooperation with several national companies, consulting services, conference participation, symposia as well as the coordination of several Ciência Viva projects promoted by the National Science and Technology National Ministry.

2.4 Schedule

The project schedule was done using a Gantt diagram.

Figure 2.1 shows the Gantt diagram with the macro tasks proposed by Exatronic and their expected timing.

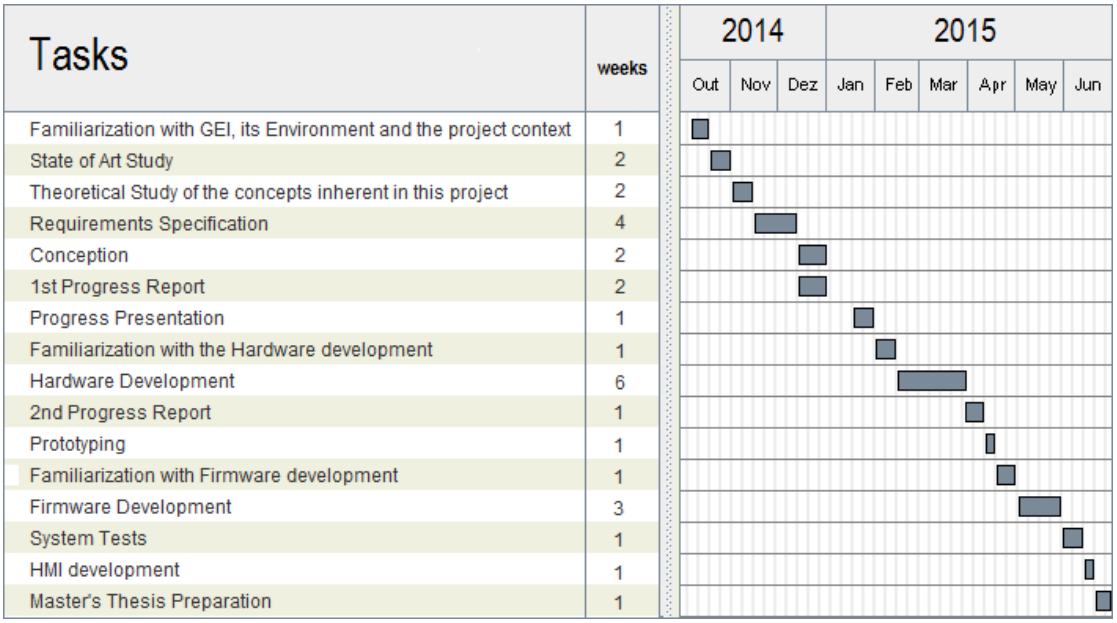

FIGURE 2.1: Gantt Diagram of the project.

Chapter 3

Blood Pressure Measurment

why blood pressure measurment is important? most used because

3.1 Physiological Process

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3.2 Signal Characteristics

Onda

Pressão sistolica

Pressão diastolica

Pressão média

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3.3 Components

Solenoid pneumatic valve external diammeter of 3 mm

Pressure Bomb external diammeter of 4.3 mm

Patient Monitor NIBP connector external diammeter of 3,97 mm

Pressure Sensor external diammeter of 3.04 mm

T connector external diammeter of 3 mm

Optocoupler

Tube external diammeter of 4 mm and internal diammeter of 2.5 mm

3.4 State of the Art

The former cenas whilst the latter cenas

Introduction to SoA (numbers)

3.4.1 Litterature

For over a century the technique of blood pressure measurement developed by Riva-Rocci and Korotkoff has provided most of the data on hypertension diagnosis and treatment. Its limitations, however, are becoming increasingly evident and therefore alternative solutions are under investigation. [5]

3.4.2 Solutions

Braço

Fixo

Sensitivity etc

Normas de Segurança (Europeias, Americanas, etc)

3.4.2.1 One Care Sensing

One Care Sensing - http://www.onecare.pt/pt/pagina/2/

- ISA não avançou porque o financiamento parou (4 anos), apitava muito/má qualidade (FALAR COM A ISA)

O OneCare Sensing é um kit de fácil utilização que permite monitorizar a tensão arterial, frequência cardíaca, peso e glicemia, no domicílio do utilizador. Oferece ainda a possibilidade de um prestador de cuidados ou profissionais de saúde acompanharem o estado de saúde do utilizador, à distância, contactando-o sempre que ocorram alterações relevantes nos parametros avaliados[24].

Medições são feitas pelo utilizador, no conforto da sua casa e ficam automaticamente disponíveis online no portal OneCare. Freq ajustável, comunicação bluetooth

Envio de alertas quando ha desvios (registados no portal, SMS ou mail)

GLouzada

3.4.2.2 iHealth

In 2012 iHealth launched the first wireless blood pressure monitor, and in 2013, the first wireless blood glucose monitor. iHealth made the first health devices to be carried in Apple retail stores. Its products are now sold in shops like Walgreens, Best Buy, and Amazon.

25M Xiaomi

3.4.2.3 Omron

Omron

3.4.2.4 Plux BioSignals

Pressão de Volume Sanguíneo (BVP do inglês Blood Volume Pressure): O sensor de Pressão de Volume Sanguíneo é um sensor ótico não-invasivo que mede variações do volume sanguíneo numa extremidade arterial, baseado na técnica de fotopletismografia. Este sensor possui uma sonda para ser colocada na ponta do dedo com uma fonte de luz vermelha e um fotodetetor. Estes dois componentes estão em modo de deteção de transmissão, e devido à sua configuração permitem assinalar as duas fases do ciclo

cardíaco (sístole e diástole). A aplicação mais comum deste tipo de sensor é a medição da frequência cardíaca e da variabilidade de frequência cardíaca. No entanto, pode ser utilizado para outro tipo de estudos, como a avaliação da

3.4.2.5 Software

iRythm Zio Patch Convertis AVIVO Mobile Patient Management System Toumaz SensiumVitals

3.5 Overview

Aplicações: Pacotes de turismo sénior, farmácias, clínicas, lares, IPSS A table resuming everything

Chapter 4

Acquisition System

4.1 YOLO

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Chapter 5

Hardware

5.1 YOLO

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Chapter 6

Firmware

6.1 YOLO

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Chapter 7

System Tests

7.1 YOLO

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7.2 YOLO

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Chapter 8

Data Storage

8.1 YOLO

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8.2 YOLO

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Chapter 9

Conclusion

9.1 Final Result

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9.2 Future Work

- minuterize - portable (I had that in mind when creating the algorithm) - better system/Big Data (new communication protocol and new data storage) - Tese GLouzada

Appendix A

Appendix Title Here

Write your Appendix content here.

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