DESIGN AND IMPLEMENTATION OF WIRELESS DIGITAL STETHOSCOPE

By

Sandy Rio Rara Meha
14310065

A thesis submitted to the Faculty of

LIFE SCIENCES AND TECHNOLOGY

in partial fulfillment of the requirements
for the
BACHELOR'S DEGREE
in

BIOMEDICAL ENGINEERING

SWISS GERMAN UNIVERSITY

SWISS GERMAN UNIVERSITY
EduTown BSD City
Tangerang 15339
Indonesia

August 2014
Revision after the Thesis Defense on 19 July 2014

STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Sandy Rio Rara Meha

Student Date

Approved by:

SWISS GERMAN UNIVERSITY

Ir. Arko M. Sc., Ph. D

Thesis Advisor Date

Fuad Ughi, MT.

Thesis Co-Advisor Date

Irvan S. Kartawira. ST. MSc Date

ABSTRACT

DESIGN AND IMPLEMENTATION OF WIRELESS DIGITAL STETHOSCOPE

By

Sandy Rio Rara Meha
Ir. Arko M. Sc.,Ph. D, Advisor
Fuad Ughi, MT., Co-Advisor

SWISS GERMAN UNIVERSITY
Bumi Serpong Damai

Telemedicine is growing steadily in clinical medicine, especially now when the medical information can be transferred digitally though the internet or other transmission method for medical consultation and medical diseases detection. Since the rural areas in Indonesia have limited number of medical practitioners, telemedicine offers solution for the problem. The device that is being developed to enable telemedicine is wireless digital stethoscope with emphasis on functional development. Measurement results using wireless digital stethoscope are proven to be playable on other compatible devices, can be displayed as a graph, and stored for further analysis by medical experts either locally or from remote location. For real field usage, more extensive development and testing are still required to this initial work to make the system more robust.

Keywords: Telemedicine, Data Transmission, Digital Stethoscope, Patient Monitoring, Audio

© Copyright 2014
by Sandy Rio Rara Meha
All rights reserved

SGU®
SWISS GERMAN UNIVERSITY

DEDICATION

This thesis is dedicated to:

God for his bestowment of knowledge to me

My family for always supporting me during the good and bad times

My friends for encouraging me to be better

Myself for never giving up

SGU®
SWISS GERMAN UNIVERSITY

ACKNOWLEDGEMENTS

I want to express greatest gratitude to God for His guidance and blessing throughout the process of making this thesis. Thank you for the advice and continuous support of my advisor Ir. Arko M. Sc. Ph. D, who always patiently guides me and keeps me motivated even when the solution seems to be impossible. Thank you to my co advisor Fuad Ughi, MT who always gives me directions in this thesis. Thank you for my family who is always been there through the good and hard times in my life. And lastly thank you to all my friends who always support me for four years, especially Gerald Justin Goenawan and Irene Alina Yohanes.

SGU®
SWISS GERMAN UNIVERSITY

TABLE OF CONTENTS

Page

STATEMENT BY THE AUTHOR 2

ABSTRACT 3

DEDICATION 5

ACKNOWLEDGEMENTS 6

TABLE OF CONTENTS 7

LIST OF FIGURES 10

CHAPTER 1 - INTRODUCTION 12

1.1 Background 12

1.2 Research Problems 14

1.3 Research Objectives 14

1.4 Significance of Study 15

1.5 Research Questions 15

1.6 Hypothesis 15

CHAPTER 2 - LITERATURE REVIEW 16

2.1 Telemedicine 16

2.2 Heart & Heart Sound 17

2.3 Stethoscope 19

2.4 Arduino Microcontoller Board 20

2.5 Bluetooth 22

2.6 NI Elvis 25

2.7 Microphone 26

2.8 MATLAB 28

2.9 Adafruit WAV Shield 29

SGU SWISS GERMAN UNIVERSITY

CHAPTER 3 – RESEARCH METHODS 30

3.1 Overall System Design 30

3.2 First System Specification and Design 30

3.2.1 System Specification 30

3.2.2 System Design 30

3.2.2.1 Analog System 32

3.2.2.2 Digital System 33

3.2.2.3 Microphone 34

3.2.2.4 Amplifier 35

3.2.2.4.1 Pre Amplifier Gain Calculation 37

3.2.2.4.2 Amplifier Gain Calculation 39

3.2.2.5 Arduino 40

3.2.2.6 Xoscillo 41

3.2.2.7 MATLAB 41

3.2.2.8 Wireless Transmission of Data 41

3.2.2.9 Analytical Method 43

3.3 Second System Specification and Design 44

3.3.1 Second System Specification 45

3.3.2 Second System Design 45

CHAPTER 4 – RESULTS AND DISCUSSIONS 47

4.1 Analog Design Result 47

4.2 First Digital Design Result 48

4.3 Performance Test Result 49

4.4 Second Digital Design Result 55

CHAPTER 5 – CONCLUSIONS AND RECCOMENDATIONS 57

5.1 Conclusions 57

SWISS GERMAN UNIVERSITY

5.2 Recommendations 58

GLOSSARY 59

REFERENCES 60

APPENDICES 62

CURRICULUM VITAE 81

SWISS GERMAN UNIVERSITY

LIST OF FIGURES

Figures Page

Figure 1 Analog Stethoscope (Nurse Learning) 12
Figure 2 Digital Stethoscope (Earinc) 13
Figure 3 Human heart (Webster, 2010) 17
Figure 4 Heart Sound (Richard E. Klabunde, 2007) 18
Figure 5 Example of Wired Stethoscope 19
Figure 6 Arduino Uno Board (Arduino, 2014) 22
Figure 7 Two piconets connected to one another (scatternet). (Daryatmo, 2007) 23
Figure 8 Connection of Bluetooth across Several Devices (Mahatma Gandhi Institute of Technology, 2010) 24
Figure 9 NI Elvis Instruments (National Instruments, 2013) 25
Figure 10 Cross Section of Dynamic Microphone (Media College) 26
Figure 11 Cross Section of Condenser Microphone (Media College) 27
Figure 12 Example of MATLAB User Interface 28
Figure 13 Arduino WAV Shield 29
Figure 14 Block diagram of the radio frequency stethoscope. 30
Figure 15 Flow Chart of Digital Stethoscope 31
Figure 16 The stethoscope head that used in this research research 32
Figure 17 Block Diagram of Digital Stethoscope 33
Figure 18 Electret Microphone 34
Figure 19 Block Diagram of Sound Detection 34
Figure 20 2N3904 Transistor 35
Figure 21 LM386 Amplifier 36
Figure 22 Original Circuit 37
Figure 23 Simplified Circuit for Analysis Purpose 37
Figure 24 Amplifier Circuit (Swagatam, 2011) 39
Figure 25 Block Diagram of Arduino Data Capture 40
Figure 26 HC-05 Bluetooth Module 42
Figure 27 NI Elvis Oscilloscope User Interface 44

SWISS GERMAN UNIVERSITY

Figure 28 Second Design Flowchart 45
Figure 29 Rechargeable FM Transmitter 46
Figure 30 Designed Digital Stethoscope 47
Figure 31 Digital Design Result 48
Figure 32 Connection with Arduino 48
Figure 33 Result of Microphone with Pre Amplifier 2N3904 49
Figure 34 Result of Microphone with applied Signal of Function Generator 50
Figure 35 Microphone Direct Oscilloscope Reading compared to Arduino Analog Reading 50
Figure 36 Sketch of Code That Used to Detect the Analog Reading 51
Figure 37 Microphone with Amplifier 51
Figure 38 Result After Connecting Signal to Xoscillo 52
Figure 39 Xoscillo Program with 2kHz Emulated From Function Generator 53
Figure 40 XML Result Of Xoscillo 54
Figure 41 MATLAB Matrix from Analog Input 54
Figure 42 List of commands in the Arduino software 55
Figure 43 Result of Heartbeat Before Filtered 56
Figure 44 Result of Heartbeat Sound After Filtered Filtered 56
Figure 45 Final system design 58

SWISS GERMAN UNIVERSITY