School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, BC
V5A 1S6

February 11th, 2013

Dr. Andrew Rawicz
School of Engineering Science
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specifications for Personal Electronic Stethoscope

Dear Dr. Rawicz,

Attached to this letter is our team's functional specification for a Personal Electronic Stethoscope (PES), as per our class: Engineering Science 440. This device is designed for users to monitor the condition of their heart by connecting to a smart phone directly. Any abnormal behavior detected, an automatic instantaneous message will be sent to the individual's pediatrician.

In our functional specification, we will break-down our project into three distinctive components: electronic stethoscope hardware, user interface and visual display, and hardware packaging. Each section discusses the testing methodology that will be used. This document will later be used as a guide for design and development of our device.

Better Lift Technology is consisted with five-member team who are confident, skilled and motivated. Real Yuen, Guntae Park, Jungioo Lee, Seven Yao, and Jesse Yang are all fifth-year engineering students majoring in electronics or systems engineering. Should you have any concerns or question about our proposal, please feel free to contact me by phone (604) 773-3766 or by email at yky1@sfu.ca.

Sincerely,

Real Yuen
President and CEO
Better Life Technology

Enclosure: *PES –Functional Specification for Personal Electronic Stethoscope*

Better Life Technology

Functional Spec.

- Personal Electronic Stethoscope

Project Team: Real Yuen
Chao Yang
Guntae Park
Jungjoo Lee
Seven Yao

Contact Person: Real Yuen
yky1@sfu.ca

Submitted to: Dr. Andrew Rawicz - ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

Issued date: February 11, 2013

Revision: 1.1

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

Executive Summary

At Better Life Technology, we aim to develop the Personal Electronic Stethoscope (PES) to help patients and people who want to know the status of their heart condition without seeing a doctor. There are other ways to detect heartbeats such as electrocardiography (ECG) which is very popular in the market, but it is hard to find any stethoscope for patients. The electrical heart activity is detected based on depolarization and re-polarization of myocardial cells for ECG. However, our product is focused on portable and actual heartbeat sounds. The portable device will have a long enough length to put on one's chest and connect to their iPhone.

By detecting heartbeat sounds and analyzing the data in the iPhone App, customers can see the status of their heart conditions or heartbeat rate on the display of their iPhone. Specifically, the system is divided into hardware parts and software parts. First of all, hardware PCB is designed for electronic stethoscope. There is an electronic stethoscope in the market with mechanical support to cover the electrets microphone. In our hardware, we will use band-pass filter or low-pass filter dependent on heartbeat sound in audible condition. And we will send this sound signal to the iPhone to diagnose and analyze heart conditions. This is the main distinct function of existing electronic stethoscopes in the market. We don't need to use huge rubber cover for the stethoscope for our device in order to make it portable. Once the heartbeat sound goes though the electrets microphone, the sound will be filtered out using a band-pass filter or low-pass filter, and the output sound from the filter will be amplified though the sound amplifier design. Second, the software is designed for collecting data and transferring into visual forms such as graphs and numbers. In the software, there will be more filtering processes because actual original sound signals will have noise and will look like random signals. To make this smooth and natural, the filtering processes are needed. For the software part, transferred audible heartbeat signals will be filtered more and the Fast Fourier Transform will be used to get the heartbeat onto the screen of the iPhone. Third, the hardware packaging will be performed for the PCB package. Our hardware should be protected by hard cover.

Better Life Technology aims to use PES as a patient's self-detector of heartbeat rate to save more lives and manage health. When compared to current products in the market, our PES is uniquely designed for patients and people who want or need to use it. The design, implementation, and debugging of our product will be done by April 12, 2013.

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

Table of Contents

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

List of Figures

Glossary

CSA	Canadian Electrical Standards
ECG	Electrocardiography
EMC	Electromagnetic Compatibility
FCC	Federal Communications Commission
ICES	Information Technology Equipments
PCB	Printed Circuit Board
PES	Personal Electronic Stethoscope
SMD	Surface Mount Device
UI	User Interface

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

1. Introduction

Nowadays, people are busy with their work, relationships, and other activities. People rarely realize or pay attention to physical warnings. According to these reasons, Better Life Technology is going to create a device for people that can monitor their heart conditions by themselves. Once there are any abnormal activities happening on the user's heart, a message will be sent to the user's phone and provide advices.

1.1 Scope

This document describes the functional requirements for the Personal Electronic Stethoscope (PES). The requirements are prioritized according to functional importance. This document also dictates the current design tasks as well as future development, though minor modifications may be needed during development or after testing.

1.2 Intended Audience

The functional specification document is intended to be used by the members of the Better Life Technology team throughout the design and development stages to ensure that the design adheres to the required specifications. The President and CEO, Real Yuen, will use this as a measure of compliance and progress of our project and direct future tasks. This document will also be used to measure project progress and to aid in user documentation and test plan creation.

1.3 Classification

This document uses the following convention to number and prioritize the functional requirements:

[Rn-p] A specific functional requirement.

Where *n* denotes the requirement number
Where *p* denotes the priority of the specification and can have one of the following values:

1 - These requirements are high priority and are necessary for the function of our device.
2 - These requirements are medium priority and are important for making a marketable device.
3 - These requirements are low priority and are not planned for prototype. Mostly for the future development.

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

2. System Requirements

2.1 Overview

Heart disease or heart attack is the number one killer in the world. However, not everyone can afford or have time for a body check every year. According to these reason, Better Life Technology is going to create a device that the users are able to monitor their heart condition without any guide from doctor or specialist. Below has shown the basic block diagram of functions of the product we are aiming for.

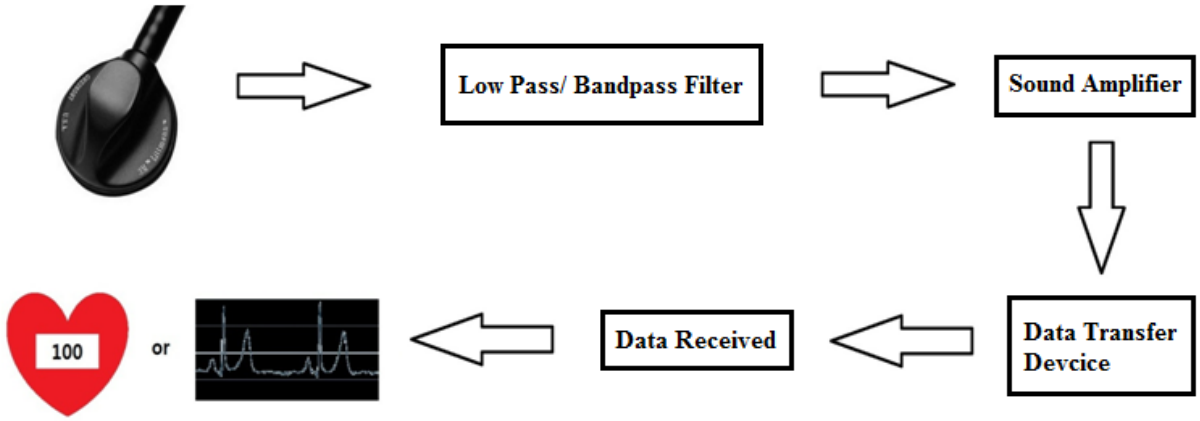

Figure 1: Block diagram of functions for PES

The project design consists of three different systems: the electronic stethoscope, a data transfer device to the mobile and a mobile user interface. Although the electronic stethoscope already exists on the market, they are made for doctors or any other specialists. They are also not able to transfer data. To implement this device, Better Life Technologies are going to apply the software and hardware techniques so that the electronic stethoscope will be able to capture data from the user and transfer the signal to the user's mobile.

The circuit part of the electronic stethoscope will contain a low pass or bandpass filter to reduce the noise from the surroundings. The filter is designed to capture signal within 20Hz to 2k Hz range (Which is the heartbeat frequency). [1] Then the filtered signal will be amplified and ready to transfer via the data transfer device.

The data transfer device will convert the captured signal into digital form, and then analyze the signal and process to the mobile interface.

The mobile user interface will provide the heart condition and a beating graph to the user. If there is any abnormal behaviour, a message will be sent to the user.

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

Baseband Circuit

The circuit will generate a filtered and amplified signal. User is able to listen their heartbeat while they are using the device.

2.2 General Requirements

[R1-1] Must not have loose or cold-soldered wires.
[R2-1] The system must be easily assembled and disassembled.
[R3-3] The device will be able to transfer data via Bluetooth or Wi-Fi.
[R4-3] The device will be turned off after 15 minutes not in use.
[R5-2] The retail price of the device must not exceed $400.
[R6-1] The device can be use after the user downloads the apps. No further installation is needed.

2.3 Physical Requirements

[R7-1] The device must have a width not exceeding 8cm.
[R8-1] The device must have a length not exceeding 4cm.
[R9-1] The device must have a height not exceeding 1cm.
[R10-2] The outer case of the device will be smooth.
[R11-2] The device should be easy to carry around.

2.4 Electrical Requirements

[R12-1] The device will have a battery life sufficient to give at least 50 hours continuously operation.
[R13-2] The device will comply with part 15 of the FCC rules. [2]
[R14-2] The device will comply with the EMC requirements of the IEC 60601-1-2. [3]
[R15-2] The device will comply with ICES-003 rules. [4]
[R16-1] The device should powered by a battery in range of 3V to 6V.
[R17-1] The circuit should work normal within the temperature range of -5ºC to 70ºC.

2.5 Mechanical Requirements

[R18-1] The power button should be on the side way.
[R19-2] A lock button should be supply so the device cannot accidently turn on by the user.

2.6 Standards

R[20-3] The device will meet all CSA Electrical standards. [5]
R[21-3] The device will meet all FCC regulations on Wi-Fi.

2.7 Environment Requirements

[R22-1] The device can be used both indoor and outdoor.
[R23-3] All the components should be recyclable.
[R24-3] All the components should be reusable.

2.8 Performance Requirements

[R25-1] The device must able to detect the heartbeat accurately.
[R26-1] The signal must able to display on the iPhone.
[R27-1] The software must analyze the result and data from the analog signal.
[R28-2] The result should be able to display on the iPhone within 5 seconds.
[R29-3] The signal should be able to transfer via Bluetooth or Wi-Fi.

2.9 Safety Requirements

[R30-1] All electronic components must be enclose inside the case.
[R31-1] All components must not cause any harmful interference with any other devices or components.
[R32-1] The power requirements must lie within human safety limits.
[R33-2] The electrical components must not melt or emit toxic fumes.
[R34-3] Apply epoxy to fill up gaps to avoid short circuit.

2.10 Usability Requirements

[R35-1] The system must be user friendly.
[R36-1] The system does not require technical training.
[R37-2] The device should receiving signal all the time

2.11 Reliability and Durability

[R38-3] All components should work without any failure at least 1 year.
[R39-3] The apps can be automatically updated.
[R40-3] All the device should be tested before is published.
[R41-3] Protection on the case and circuit in case any drop from the user.

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

3. Sound Amplifier

The sound amplifier is the most important hardware part, the purpose of the sound amplifier is sending the correct and accurate signals to the iPhone App. Heartbeat sounds are very small, and it is sometimes difficult to hear it without sound amplifier when it goes though microphone. Also, the sound amplifier will include a low-noise filter inside the circuit before we amplify the input signal. Therefore, the sound amplifier is the key device for PES.

3.1 General Requirements

[R42-1] Must send amplified sound signal to iPhone though AUX output from the device.
[R43-2] Must cost less than $200 per sound amplifier (PCB version) including all components such as Op-amp, resistors, capacitors etc.
[R44-2] Must include low-pass or band-pass filter to filter out noise from original signal.

3.2 Electrical Requirements

[R45-2] Filter noise outside of range from 20Hz to 2 kHz.
[R46-2] Use 3V battery for SMD version and use inverter to provide -3V (alternative way possible).

3.3 Physical Requirements

[R47-3] Must be portable and small enough (PCB).
[R48-3] Must be light, not exceeding 25g weight.
[R49-3] Might be covered by hard case if possible (might be designed).
[R50-3] Must use a switch (push switch or slide switch).

3.4 Safety Requirements

[R51-2] Power source must match with components limit for input of circuit and different Op-amps.
[R52-3] Spike protection might be required if voltage regulator is used in order to supply different voltages into different Op-amps.

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

4. Hardware Packaging

The hardware packaging of the sound amplifier is the most important and main part of Personal Electronic Stethoscope, and must have a proper case to cover the PCB including the components, audio output port to send an amplified sound signal to the iPhone App, and a suitable battery size and spot to provide power to the device. The enclosure will contain PCB, either band-pass or low-pass filter circuitry, all components required, and battery supply. Hardware packaging should be compact and tiny enough in order to make it portable.

4.1 General Requirements

[R53-1] Weigh less than 50g total.
[R54-1] Must pass 70cm height drop test.
[R55-1] All electrical components must be placed in right position and any circuit traces and components are not shorted.
[R56-2] Must be as compact as possible, not exceeding 10cmx6cmx3cm (hand-hold size).
[R57-2] Audio output from sound amplifier case must be held in right position and audio jack length should be not too short and not too long.
[R58-3] Cover can be opened easily by hands.

4.2 Mechanical Requirements

[R59-1] On/Off switch mounted on the surface of case.
[R60-2] Audio jack must be long enough, but not too long for convenient.
[R61-2] Rubber cover for microphone should be proper size to prevent just electrical effect from human body and to gather heartbeat sound, not too large and too small.
[R62-3] LED power notification is option.

4.3 Physical Requirements

[R63-1] Physical damage must be minimized, so drop test needed.
[R64-1] Casing and electrical components can be operating in extreme condition of temperature between -5°C and 70°C.
[R65-2] Case surface and fasteners should not weather.

5. Software Requirements

In software, the function of PES is that the iPhone App receives the signal from the PES hardware and displays the status of the heart condition on the screen. There may be graphical and numerical values on display, and there may also be a sound function from the iPhone speaker. The loudness of the sound can be manipulated by the iPhone volume controller. The range of the heartbeat for each age and personal preferences can be set manually. Once the heartbeat is out of range, the phone will text a message to a family member you set earlier. The error probability will be minimized by testing the many different cases of emergency situation in the software and debugging the errors.

5.1 General Requirements

[R66-1] Must include start/stop buttons in user interface to collect data.
[R67-1] Rendering the results in graphic and numeric properly.
[R68-1] Sending emergency message to a family member.
[R69-2] Selecting a range of heat beat per time and dependent on personal condition.
[R70-2] Must run on any iOS6 or later version.
[R71-2] Should not have any error during operations.
[R72-3] Speaker of iPhone can be used to hear heartbeat sound after amplified.
[R73-3] More specified setting options can be added for users.

6. User Interface

The UI contains the options to support that users can decide the settings of device. Basically, there should be a start/stop button and personalized setting options in the UI. Our device is for patients who have heart diseases already and people who want to prevent a heart attack or any heart disease that can suddenly happen. Personalized settings will include a heartbeat range for different ages or conditions.

6.1 General Requirements

[R74-1] User can start and stop the program to see the data graphically and numerically.
[R75-1] User can choose many different options dependent on the personal condition.
[R76-1] Must have an emergency message sent to family member when user is in emergency situation.
[R77-3] Might have a button to control the speaker to hear heat beat sound.

6.2 Usability Requirements

[R78-2] The manual adjustment interface will be intuitive and easy to use.

7. User Documentation

[R79-3] User documentation shall include the explanation of purpose of the product and user manual for options in English/French.

[R80-3] Provide electronic version online for user.

School of Engineering Science
Simon Fraser University
8888 university Drive
Burnaby, BC
V5A 1S6

8. System Test Plan

The general approach to system testing consists of separately testing each part in prototype, complete hardware device, and a combination of hardware and software. Better Life Technology intends to implement a test plan in order for both individual modules and the final product. The individual module tests will be done on prototype and hardware device. Once the prototype passes, then the hardware device in PCB can be made and tested. Software tests can be conducted separately by using microphone with 3.5 inch audio jack, but the tests cannot be correct because our purpose is testing the heartbeat in a specific frequency range. The rest of the frequency ranges will be filtered out. Therefore, software tests can be performed with a complete hardware device. So, once the audio signal from the sound amplifier device is confirmed, the sound signal can be converted to data format in graphs and numbers. Also, an emergency situation can be tested only if the heartbeat rate is out of range. For example, we can set up the range of the heartbeat manually and test it with our normal heartbeat. It will show abnormal result, and will generate a text message to a family member. These can be tested once the hardware and software are completely created. Typical usage scenarios and test plan are discussed below.

First of all, individual module testing will be performed on each aspect of the project as they are completed. The testing contents are as follows:

- Making prototype by using breadboard with common components which are used in school
- Making sure that heartbeat sound is detected by microphone with rubber cover
- Making sure that all the components working fine (not burn or malfunctioning) and sound signal amplified properly
- Designing PCB and testing this SMD condition
- Making sure that all the components working fine (not burn or malfunctioning) and sound signal amplified properly in PCB mode
- With case, drop test can be performed to inspect the durability of the case in about 70cm height because popular height when people seat on chair is close to 70 cm

Second, combination testing will be performed after the hardware testing passes. The testing contents are as follows:

- Opening the App will be tested
- Once the amplified sound signal is supplied into iPhone through audio jack, then start/stop button in UI can be tested

- Options of personal setting can be manipulated and tested
- Sound from iPhone speaker might be tested if this function is added
- While portable stethoscope is put on chest and move around, check that user can still see the status of the heart condition
- Graph and number is displayed properly
- Make sure that emergency text message is sent properly when the heartbeat is out of range

The functional specifications include requirements for operational safety and error handling. To test these requirements, the error conditions will be simulated and the system response will be verified. There should be different scenarios in different conditions and setting dependent on different ages etc. Initial tests can be conducted in a normal range of settings for healthy people. But, more accurate tests will be conducted for patients who have heart diseases. To do this, we need to do more research on many heart disease cases and improve the system to prevent most of the cases. The most important functions can be conducted and modified if there are problems.

10. Conclusion

The functional specification clearly and concisely defines the capabilities and requirements of the PES. All requirements and details are prioritized by three importances. Our products have mainly three phases. The hardware (PCB) and software are the top priorities to make this functionally working. When the higher priority requirements are completed, the device can be developed and be evolved more to reduce error and create more functions on it. The first prototype is built and tested already and we are confident in the completion of the final product by April 12, 2013.

11. References

[1] D.Balasubramanuam and D. Nedumaran (2010, August) Efficient Computation of Phonocardiographic Signal Analysis in Digital Signal Processor Based System. [Online] http://www.ijcte.org/papers/219-H304.pdf

[2] FCC (Federal Communications Commission (2010, October) Rules and Regulation. [Online]
http://transition.fcc.gov/oet/info/rules/

[3] Roland Gubisch and Bill Holz (2007) The Engineer's Guide to Global EMC Requirements: [Online]
http://www.ieee.li/pdf/essay/guide_to_global_emc_requirements_2007.pdf

[4] Information Technology Equipment (2012, August) ICES-003. [Online]
http://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/ICES-003-issue5-2012.pdf/$FILE/ICES-003-issue5-2012.pdf

[5] The CSA Group (2013) C22.1 Canadian Electrical Code. [Online]
http://shop.csa.ca/en/canada/electrical/c221-canadian-electrical-codes/icat/cec