Versatile Innovations
School of Engineering Science
Simon Fraser University
V5A 1S6
versatile-innovations@sfu.ca

February 12, 1999

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 370 Project – Physiological Signal Data Logger Functional Specifications

Dear Dr. Rawicz,

The attached document, Physiological Signal Data Logger Functional Specifications, outlines the requirements of our 16 channel signal data logger for physiological system that is to be used by the Living Lab, a joint venture between SFU and BCIT. This project will provide researchers at the Living Lab a lightweight portable data logger that is capable of monitoring and recording 16 different input physiological signals captured by already available biomedical sensors.

The functionality of the various aspects of the signal data logger and its overall system will be described in detail in this document. The signal data logger will have three modes of operation: Configuration, Logging, and Uploading. There will also be a software control program running on a Windows9x personal computer to program the signal data logger.

Versatile Innovations consists of four innovative and enthusiastic third-year engineering students – Fiona Chan, Karen Chan, Andy Jien, and Sean Shieh. If you have any questions or concerns, please feel free to contact Andy Jien at versatile-innovations@sfu.ca

Sincerely,

Andy Jien, Chairperson
Versatile Innovations

Enclosure: Functional specification for our 16-channel physiological signal data logger

VERSATILE INNOVATIONS

Functional Specifications for a Physiological Data Signal Logger

Submitted by: Versatile Innovations
Fiona Chan, Karen Chan, Andy Jien, Sean Shieh

Contact: Andy Jien
School of Engineering Science
Simon Fraser University
versatile-innovations@sfu.ca

Submitted to: Andrew Rawicz
School of Engineering Science
Simon Fraser University

Ivan Li
Project Leader
Health Applied Research and Development
Technology Centre

Steve Whitmore
School of Engineering Science
Simon Fraser University

Date: February 15, 1999

Table of Content

List of Figures and Tables

Executive Summary

Data is the key to any scientific research. Today, many data-recording devices for obtaining raw data are available in the market. Versatile Innovations is developing such a data-recording device that is portable, lightweight and capable of capturing and recording 16 different channels of physiological signals simultaneously. This device would help researchers at the Living Laboratory to conduct research activities that improve the "fit" between people and their daily living and working environments by studying people's interaction with devices, assistive technology, and environmental features.

Our 16-channel physiological signal data logger allows monitoring and recording of electrical activities of the heart, muscle and brain, the arterial oxygen saturation level in the blood stream, and body temperature. It also records data collected from force, acceleration, and pressure sensors to monitor physical activities.

This document is a functional specification outlining different functions of our 16-channel physiological signal data logger and its different operation modes. Background of each of the physiological signals that is to be acquired by the signal data logger is also discussed.

Introduction

The Living Laboratory concentrates on human factors research. Currently, the Living Laboratory is having difficulties collecting physiological signals for further research. Our lightweight portable 16-channel physiological signal data logger is targeted to assist physiological research at the Living Laboratory. Our device will capture and store physiological signal collected from the sensors. Then, the physiological data can be uploaded to a computer for data analysis.

This document is a functional specification to describe detailed functional requirements of the 16-channel signal data logger system.

Background

Biomedical sensors are available in the market for monitoring conditions of a human body. Some sensors are designed to monitor electrical activities that take place within the human body. Some sensors are targeted to transform specific conditions of a human body into electrical signals. In general, these electrical signals or waveforms are referred to as physiological signals. Medical researchers study the patterns of these physiological signals to identify potential health problems and to conduct further investigation on the intricate human body.

Many electrical activities take place within the human body every minute. Such electrical activities can be detected from the brain, heart, nerves and muscles. These streams of electrical signals are analyzed using different techniques, and they are done using available electrodes. Electrical potential of the heart during contraction are detected and recorded by electrocardiogram (ECG). Electrical signals from the brain, or brain waves, are captured by electroencephalogram (EEG). Electromyography (EMG) is a test that measures muscle response due to nerve stimulation. Table 1 provides some characteristics of the electrical signals mentioned.

Some examples of human body conditions that are of research or medical interest are body temperature, arterial oxygen saturation level in the blood, pressure, force and acceleration due to movement of limbs. Pulse oximetry is a method of monitoring the arterial oxygen saturation level in a patient's blood (SpO_2) and pulse oximeter is used to monitor pulse oximetry. Force sensors and pressure sensors are used to measure the force and pressure exerted by the human body. Accelerometer is used to measure acceleration results from movement of limbs. Our signal data logger is to be able to record these data.

Table 1 Physiological Signals

Physiological Signal	Frequency (Hz)	Amplitude (V)	Occurrence
EEG, Brain Wave			
Delta	0.5 – 4	100µ – 200µ	Slow-wave sleep
Theta	4 – 8	20µ	Light sleep, stress in adults
Beta	>13	< 20µ	Awake, intense, mental activities
Alpha	8 – 13	5 – 150µ	Awake, quiet, eye closed
EMG			
Skeletal	2 – 500	50µ - 5m	Voluntary muscle
Smooth	0.01 – 1	< 10m	Involuntary muscle
ECG	0.02 – 150	<2m	Muscles of the heart

Data obtained from: Joseph D. Bronzion "The Biomedical Engineering Handbook" 1995. 808.

Versatile Innovations is to build a signal data logger that will capture and temporarily store the electrical signals that are listed in Table 1 and output from pulse oximeter, pressure sensor and force sensor.

System Description

Overview

The signal data logger allows users to collect physiological data. It operates in three different modes: Configuration, Logging, and Upload. Users first setup the device in Configuration Mode. After the device is properly configured and tested, it can then start to record data in Logging Mode. Upon the completion of data collection, the data can then be uploaded for further analysis. After the data has been transferred from the signal data logger to a computer, the device is available for a recording session of either the same arrangement or under a new configuration. The following figure illustrates the life cycle of the system under typical usage.

The three operating modes of the signal data logger are introduced in the following sections.

Figure 1 Typical activities of the system

Configuration Mode

In Configuration Mode, the users are able to program the signal data logger through a personal computer. The following block diagram depicts the overview in this mode.

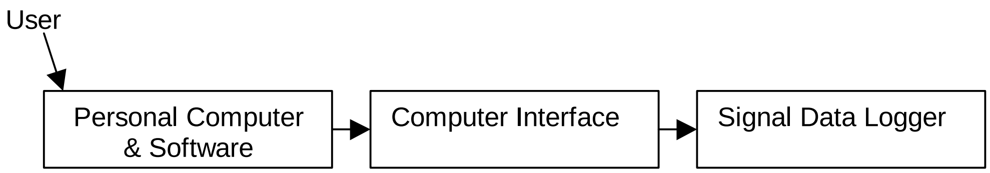

Figure 2 Configuration Mode

Computer Interface

1. The signal data logger will be connected to the computer via RS-232 serial interface.
2. On the data logger, the connection will be made via a 9-pin serial connector. On the personal computer, a 25-pin or 9-pin serial connector is needed to establish the physical connection. Appropriate cable must be used.

Personal Computer

1. The system will be targeted to operate on a 100% IBM® compatible personal computer operating on Windows95®.
2. The software component of the system will reside on the local hard drive of the personal computer.
3. The computer must have one free serial port for connecting to the signal data logger.

Software Control

To avoid mishandling of the signal data logger by the patients, the operation of the device is to be programmed using a control program running in the Windows95 environment on a PC. The control program shall:

1. have a graphical user interface.
2. allow the users to set the type of signals for each channel on the data logger.
3. provide functions to select gains for input channels. The available choices for the gain are 1, 2, 4, 8, or 10.
4. allow the users to set the sampling rate. The rates are at even multiples of 50 and 60 Hz up to the maximum capacity.
5. allow the users to select sampling time from 1 second to 900 seconds at full capacity, or up to a point in time at which the memory is full.
6. allow the users to select the filtering for the signal collected.

The above functions shall be easy to perform. The software will provide wizards and templates to guide the users to configure the logger. Furthermore, the software will allow users to store configuration in profiles for easy future access.

Logger Control

The signal data logger itself shall have several basic controls:
1. An ON/OFF switch to turn the signal data logger on or off.
2. A pause/resume switch to pauses the sampling session or to resume a paused session.
3. A reset switch to resets the current sampling session. It will also clear all data acquired in the memory.

The signal data logger shall also have several indicators as a mean of feedback to the user:
1. A power on indication to show whether the data logger is on or not.
2. A visual warning to indicate the battery is low in power.
3. A memory full warning to indicate the memory is full.
4. A visual indication to show which mode of operation the data logger is currently operating in (i.e. which channel is sampling which type of data).

Logging Mode

In logging mode, signals from the electrodes or sensors are being recorded. The logging mode has two functions: signal conditioning and data acquisition. Figure 3 shows the block diagram for this mode.

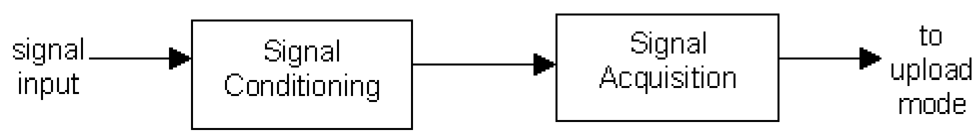

Figure 3 Logging Mode

Signal Conditioning

Raw analog signals from the electrodes and sensors will be filtered to reduce noise. It will also be amplified to improve the accuracy when converted to digital signal. Figure 4 shows the functional block diagram for this stage.

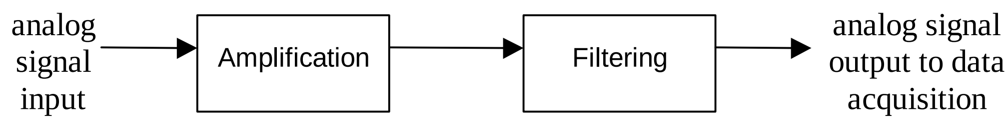

Figure 4 Signal Conditioning

The signal-conditioning block shall:

1. accept input signals specified in the Configuration Mode
2. amplify signals as specified in the Configuration Mode
3. output analog signal to the data acquisition stage
4. reduce the noise in the signals

Signal Acquisition (with Storage)

The signals being processed by the conditioning stage is collected by the signal acquisition stage. Figure … shows the functional block diagram for this stage.

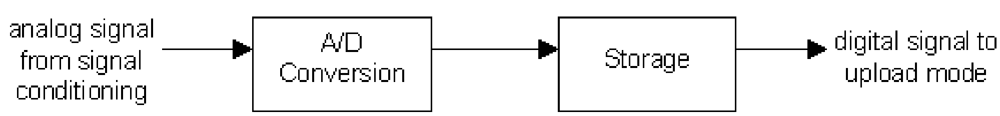

Figure 5 Signal Acquisition

The signal acquisition block shall:

1. accept input analog signal from the signal conditioning stage
2. convert analogue signal to digital signal with a 12-bit resolution
3. sample at the rate set in the Configuration Mode
4. hold 3600 second worth of data
5. digitally filter the data according to the filtering scheme set in the Configuration Mode

Upload mode

The main objective of operation in Upload Mode is to transfer the data stored in experiments onto a personal computer for further examination. The following block diagram represents the key entities for the data logger system under Upload Mode.

Figure 6 Upload Mode

Data Logger

1. In upload mode, users will control the data logger through the control program on a PC.
2. The data logger will display appropriate progress/status indicator.
3. The data logger will also give out indications when errors occur.
4. If the data logger has no sufficient energy for the operation, it will notify the users through the software on the PC.

Computer Interface

3. The Computer Interface is identical to the interface used in Configuration Mode.
4. The time needed for uploading full content from the logger to the computer shall be no longer than 8 minutes.

Computer Software

1. The software will provide a graphical user interface.
2. The software shall provide indication of progress while the data logger is in the upload mode. The indication shall include one or more of the following: estimated time to completion, percentage completed, and number of channels loaded.
3. In case of any error, the software will display proper error messages and provide suggestions for trouble shooting during the upload of data.
4. The software shall provide the users with 2 options of output formats: ASCII or binary.
5. The software will provide a default storage location on the personal computer’s local hard drive if a specific storage device or location is not specified.
6. The users will be able to control the data logger through the software in Logging Mode.

Power requirement

1. The portable physiological data logger is to be battery operated.
2. The battery shall be rechargeable.
3. The standby time shall be at least 24 hours.
4. The minimum operation time shall be 1.5 hours when the data logger is operating at full capacity.
5. The battery will be easy to replace.

I/O requirement

Input

1. The signal data logger will have 16 channels as input in Logging Mode.
2. The signal data logger will allow input from and output to a personal computer via Recommend Standard number 232 (RS-232) Standard. In Configuration Mode and Logging Mode, the link is mandatory.

Output

1. RS-232

See Input item 1 above.

2. Scope output

In order to test the whether the data logger is functioning properly or not, we need a way to examine the output of each channel of the data logger when a test signal is applied. Therefore the data logger shall have an output to the oscilloscope for this purpose.

3. LCD display

The data logger shall have a LCD display to indicate the mode of operation and various other messages.

Physical requirement

The physiological data logger is a portable device; therefore, it needs to be small and easy to carry.

1. The maximum dimensions is $80 \times 120 \times 30$ mm
2. The weight of the data logger is not to exceed 500g.
3. The device has to be impact resistant and waterproof as well to avoid damage to the electronics when the device is used in extreme environments.
4. The I/O connectors on the data logger should be easily accessible.

Safety requirement

1. The signal data logger will present no electrical hazard to users.
2. The battery will not post any danger to the environment under continuous charging.
3. The software will post no threat to the computer it resides on or the data the information the computer holds.

Standards

The signal data logger system shall be CSA approved and CE marked.

System limitations

The Logger will not record the signal from any channel input while it is in Configuration and Upload Mode.
The Logger will retain data for a limited time only.
The rechargeable battery pack will only allow a limited recharge cycle.

Conclusion

Since our 16-channel physiological signal data logger is a join venture between SFU and BCIT, this document acts as a contract binding Versatile Innovations to the specifications above. In the next two months, Versatile Innovations will develop a primitive prototype of this system and hopefully we can continue to refine it during summer.