January 18, 2010

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

Re: ENSC 440 Project Proposals for Biomedical Monitoring System

Dear Dr. Rawicz:

Please see attached for *Project Proposal for Biomedical Monitoring System*, a document which describes our proposed project for ENSC 440. The proposal outlines our solution to a data acquisition system to monitor patients' cardiovascular health. The monitoring can be done via two options: USB cable or through a wireless protocol.

The proposal presents the outline of our project, the problem and the possible solutions, the estimated costs, and the timeline for the project development. This document also outlines the advantages and market potential of our product, named Biomedical Monitoring System (BMS).

Biomedical Embedded Systems Technology (BEST) is a group innovative engineering students from diverse backgrounds. The team consists of Sam Seyfollahi and Alireza Rahbar (Electronics Engineers), Farzad Abasi (Computer Engineer), Parna Niksirat (Systems Engineer), and Shaghayegh Hosseinpour (Biomedical Engineer).

For any further information please feel free to contact me.

Yours truly,

Alireza Rahbar

Alireza Rahbar
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Enclosure: *Proposal for a Biomedical Monitoring System*

Proposal for: Biomedical Monitoring System

Project Team: Alireza Rahbar
Farzad Abasi
Parna Niksirat
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Sam Seyfollahi

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

Due date: January 18, 2010
Revision: 1.0

Executive Summary

Cardiovascular diseases (CVDs) affect many lives throughout the world. According to the World Health Organization:

- "CVDs are the number one cause of death globally; more people die annually from CVDs than from any other cause.
- An estimated 17.1 million people died from CVDs in 2004, representing 29% of all global deaths. Of these deaths, an estimated 7.2 million were due to coronary heart disease and 5.7 million were due to stroke.
- Low- and middle-income countries are disproportionally affected: 82% of CVD deaths take place in low- and middle-income countries and occur almost equally in men and women.
- By 2030, almost 23.6 million people will die from CVDs, mainly from heart disease and stroke. These are projected to remain the single leading causes of death. The largest percentage increase will occur in the Eastern Mediterranean Region. The largest increase in number of deaths will occur in the South-East Asia Region. " [1]

Prevention is the key to curbing this global epidemic. A healthy diet and exercise may reduce the risk of CVD. However, some people who exhibit no physical signs of heart problems (such as professional athletes and people with a history of heart disease in their family) may also suffer from CVD. Patients in a high risk category of heart disease should be routinely monitored by their physician. One of the best ways that doctors can detect signs of CVD is to monitor their patients for signs of abnormalities and erratic heartbeat.

Biomedical Embedded Systems Technology (BEST) is planning to develop a portable, real time data acquisition system that is capable of acquiring the electrocardiograph, heart rate, and body temperature of a patient. The device is to be small and comfortable enough to be worn for long periods of time which allows for long term patient monitoring. The system will be designed to remotely alert the doctor in case the heart shows symptoms of an abnormality. The system will also be capable of both displaying the data in real time and logging the information to its onboard memory for later analysis.

BEST consists of a diverse group of engineering students from Electronics, Computing, Systems, and Biomedical engineering backgrounds. This wide range of disciplines combine to provide an excellent variety of skills and knowledge such as digital and analog circuit design, embedded programming, materials, and the medical background needed to design a product that will be safe to use.

We estimate that this project should take until Aril of 2010 to complete. This time will be used for planning, research, programming and testing our product. The initial budget has been estimated at $500 but may increase depending on the implementation and availability of parts. We have applied for funding through the ESSS and other sources.

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1. Introduction

Throughout history, humans have been constantly trying to find ways to increase their lifespan. From the early days of crude medicine to today's sophisticated medical science, the objective has been the same: longevity. As science advances, we are constantly striving to find new ways of accomplishing this goal. Our project falls in line with this same goal.

The objective of our project is to develop a portable, real time data acquisition system that is capable of being used as a preventative tool in diagnosing heart disease. This tool allows physicians to constantly monitor at risk individuals and provides early warning of possible heart problems.

2. System Overview

The following **(Figure 1)** shows the system overview. The core of the system is the Atmel microcontroller which will connect to multiple sensors. These sensors will collect raw data for the controller to interpret and convert to a more user readable format (such as a graph). This data can be retrieved to a computer using either a USB cable or wirelessly.

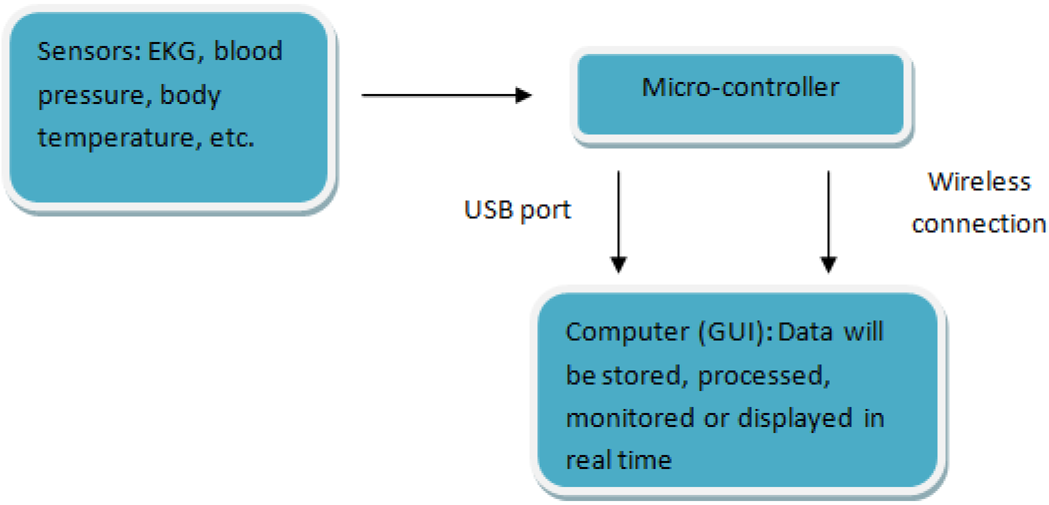


Figure 1: System Overview

The following flow charts **(Figures 2 and 3)** show the data acquisition and overall function of the system. These flow charts have been simplified to provide the general overview of our system.

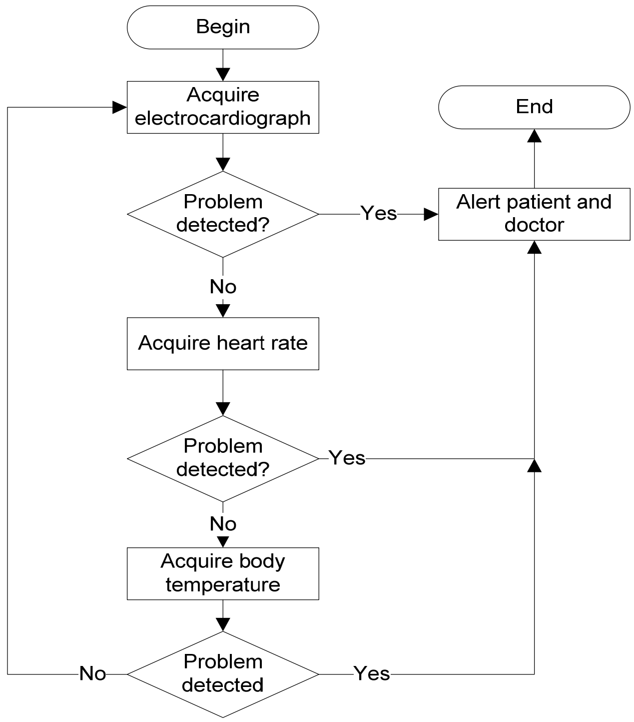


Figure 2: Sensor Acquisition flowchart

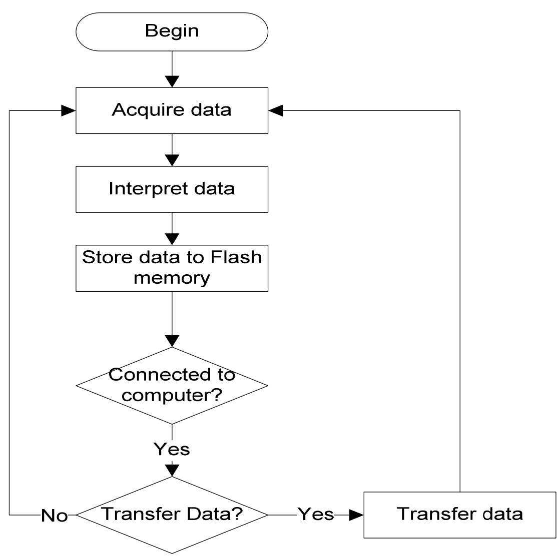


Figure 3: Overall system flowchart

3. Existing Design Solutions

Currently, with the help of new technologies, there are many systems available to monitor heart rates. Hospitals use electrocardiographs (EKG) but these machines require experts to use them and to interpret their data. Other companies have introduced devices, such as the Vital Positioning System and the Alive Heart Monitor, to carry out similar tasks. These devices are much smaller and easier to use, however suffer from other problems. Two of these existing solutions are presented below.

3.1. Vital Positioning System (VPS)

"The VPS is a wireless Bluetooth-based cardiac alert system that is integrated into a cell phone or PDA and is linked to GPS" [2].

This system can notify emergency services as soon as it detects any sign of a heart attack. The Quebec based company, which introduced the product in 2004, claims that their product uses artificial intelligence to detect a potential heart attack between eight to twenty minutes before its occurrence. Although this device seems to be the perfect solution to our design problem, we could not find any further information regarding the product or its price.

3.2. Alive Heart and Activity Monitor

This device is a health monitoring system that uses Bluetooth technology to transfer the data wirelessly. The product is designed for use in doctors' offices, homes, and gyms. The product immediately transmits EKG and accelerometer data to a mobile phone, computer, or central monitoring centre.

Figure 4: Alive Heart Monitor

The disadvantage associated with this product is the need for the consumer to carry the Alive Heart Monitor along with a Bluetooth GPS and a cell phone. This makes it an impractical for the consumer.

4. Proposed Design Solution

Our proposed project is to develop a real time data acquisition system to measure and monitor several factors such as heart rate, body temperature, blood pressure, etc. We intend to design a home monitoring system that will alert the user, or a doctor, if any of the measurements have exceeded a predefined threshold. The system will also alert users if the heart rate displays any anomaly.

We will be using an existing embedded microcontroller to program a data logger. The final product will have the ability to store the data on to flash memory or to transfer the data to a computer for real-time monitoring. This can be done through a USB cable or wirelessly. Stored data can be converted to a graph for analysis at a later time.

If the information is to be used in real time, the raw data will be transferred to a computer (via USB or wireless) and converted to meaningful values to be graphed. In case of an anomaly or problem, an alarm will sound to notify the user. The computer will also backup the data frequently.

This product would be used in doctors' offices, homes or gyms, to wirelessly monitor the performance of the heart. This device will allow the doctors or coaches to track and monitor heart rate and EKG in real time. As the final cost of this product will be significantly less than existing products, it will increase its availability to the general public.

As the core of this project is a data logger, it has the potential for a variety of applications in other fields. The microcontroller will have between 6 to 8 channels that different sensors can be attached to. With a slight modification to the software, this data logger can be altered to serve in different applications. For example, by attaching a throttle position sensor, it can be used as a device to monitor race car acceleration and performance.

Major constrains that we face in completing this project are lack of funding and time. As we are only given 13 weeks to finish the project, we are forced to use pre-made modules for our controller and wireless device. However, a better approach would be to design and tailor a microcontroller along with a wireless interface on a single board to perfectly fit the characteristics that are required for the system. This would also reduce the size significantly and therefore be more practical for the consumer.

We should also note that a full 12-lead EKG requires 12 analog channels to detect a variety of heart problems. In developing this product, we will be using a 3-lead EKG system. The main reason for this is the cost of the EKG sensors. The micro controller that we will be using will only have 8 analog channels (also due to cost) and this will limit the other number of sensors that we can attach to the system.

5. Sources of Information:

To gain a better understanding of how an EKG works, we will consult with one of group members, Shaghayegh Hosseinpour, who has a Bachelor's degree in Biomedical Engineering. Our goal is to familiarize ourselves with the basic features of the electrode sensors and the process of monitoring heart rate.

We will also use the embedded and real time systems programming skills we have acquired throughout our degrees. Additionally, three members of the group have gained embedded systems programming experience through co-operative education work terms.

The Internet is a great source of information for researching similar projects and potential safety concerns. In addition, we will use engineering literature to familiarize ourselves with different types of EKG sensors, minimum required sample rates, possible errors in reading the sensor values, etc.
Finally, for technical design problems, we will consult with SFU professors. As Dr. Rawicz and Dr. Kaminska have years of research experience in the field of biomedical engineering, they can provide us with any feedback we require.

6. Budget and Funding

6.1. Budget

The table below indicates the estimated budget for the Biomedical Monitoring System. As the details of the device are still under investigation, the prices presented in the table are tentative. In order to keep the table brief, the components have been grouped into categories that represent their general functional group. The budget breakdown has been overestimated by 15% in order to allow for the increased cost per part for orders that are placed in small quantities, and for the potential need for ordering replacement parts (in case of unpredicted loss of equipment). Moreover, the approximated budget does not include any development or manufacturing costs.

Table 1: Tentative Budget

EQUIPMENT	Estimated Cost
Micro-Controller- WASP	$40
Daughter Board Module for USB connection: USB 10	$40
Connector Module for micro-controller and relates wires	$10
Compiler for programming the AVR micro-controller (ICCV7)	$90
Heart beat sensor	$250
One wire Digital Temperature sensor-DS18B20	$5
Graphic LCD 128X64 STN LED Backlight (LCD-00710)	$25
Shipping cost	$40
Total Cost	**$500**

6.2. Funding

As per the budget for the production of this prototype, different sources of funding are being considered by BEST. The cost for the developing a prototype of our product is much higher than mass producing it. Therefore, the above estimated cost does not correctly reflect the final production costs.

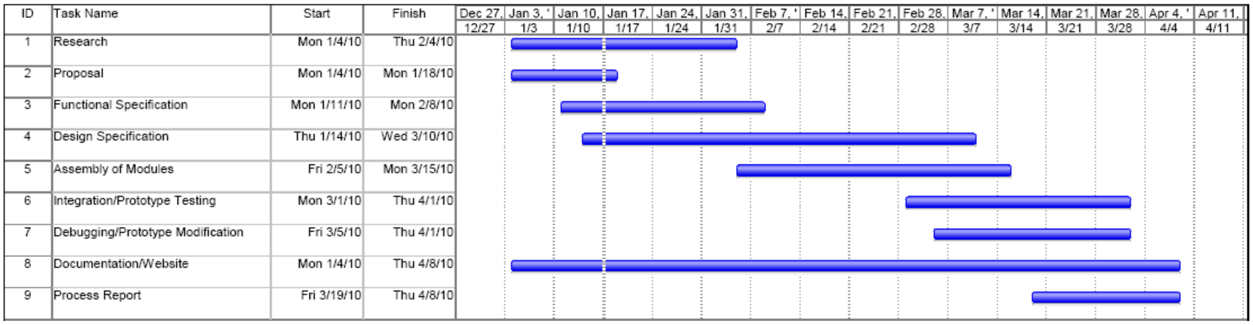
One potential source of funding is the Engineering Science Student Endowment Fund. Another possible source is funding from the ENSC 440 course. In addition to these, Dr. Andrew Rawicz has offered to contribute financially to our project.

We are also considering approaching Dr. Bozena Kaminska for financial donations. However, if there is still a lack funding, the team members agree to share the remaining financial costs of the project equally. An accurate account of all financial transactions will be kept to ensure proper reimbursement to the members of the group. We are planning to introduce and develop this product to the market after completion.

7. Schedule

Table 2 shows the Gantt chart and our tentative time to accomplish various part of the project. In addition, figure 5 representing the milestone diagram for the project.

Table 2: Gantt Chart



ID	Task Name	Start	Finish
1	Research	Mon 1/4/10	Thu 2/4/10
2	Proposal	Mon 1/4/10	Mon 1/18/10
3	Functional Specification	Mon 1/11/10	Mon 2/8/10
4	Design Specification	Thu 1/14/10	Wed 3/10/10
5	Assembly of Modules	Fri 2/5/10	Mon 3/15/10
6	Integration/Prototype Testing	Mon 3/1/10	Thu 4/1/10
7	Debugging/Prototype Modification	Fri 3/5/10	Thu 4/1/10
8	Documentation/Website	Mon 1/4/10	Thu 4/8/10
9	Process Report	Fri 3/19/10	Thu 4/8/10

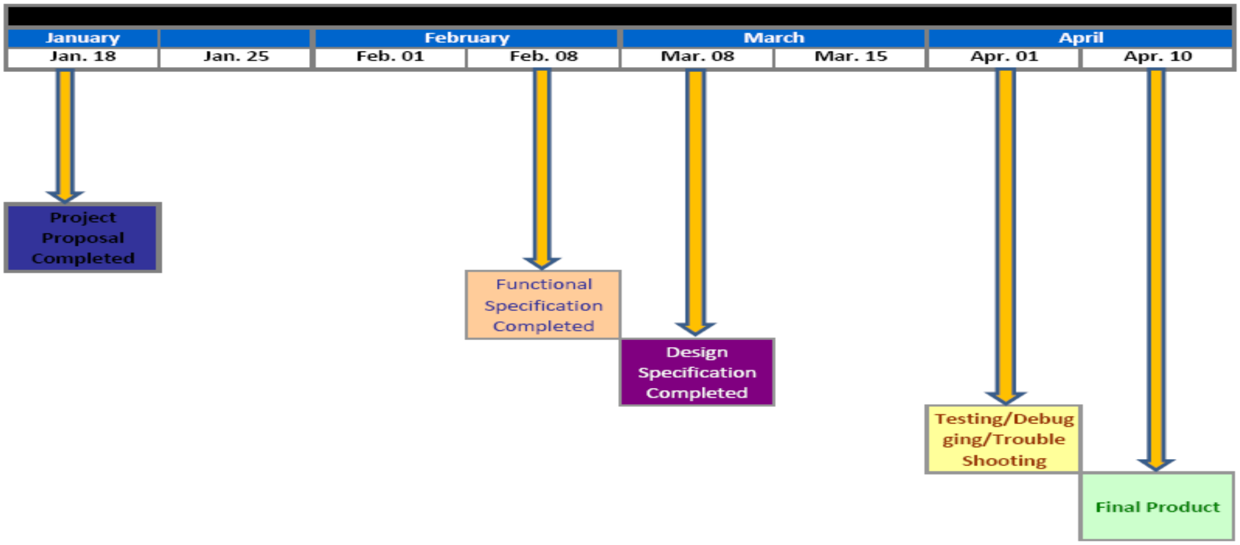


Figure 5: Milestone Schedule

8. Team organization

BEST consists of five skilled and creative engineers: Sam Seyfollahi, Alireza Rahbar, Farzad Abasi, Shaghayegh Hosseinpour, and Parna Niksirat. Four of the members are fourth-year engineering undergraduate students. One of the members, Shaghayegh Hosseinpour, is a first year Master's student. As the members have diverse experiences, each offers a unique perspective which allows the team to approach the problem with wider vision. Our team will consist of two electronics engineers, one computer engineer, one biomedical engineer, and one systems engineer. The members' interests and skills are briefly described in the Company Profile.

BEST tries to exercise an interactive environment and tasks will be assigned based on interest, experience, and skills. In order to maximize the project development efficiency, as well as the performance of the group, the supervision and responsibility of each part is assigned to one member. Alireza Rahbar, President and Chief Executive Officer, is in charge of the progress of the project and addressing any potential problems. He is also responsible for assessing the group and individual performances. Sam Seyfollahi, Vice President of Marketing and Finance, is responsible for evaluating the market value of the product, product promotion, and managing the source of funds. Farzad Abasi, Chief Technical Officer, will focus on the scientific and technical issues. In addition, he will concentrate on the operational integrity, system support, and maintenance of the project. Shaghayegh Hosseinpour, Vice President of Research and Development, is responsible for all the research and analysis to increase the design productivity. Parna Niksirat, Vice President of Operations and Software, is in charge of the technical operations of the project on a day by day basis and will concentrate on the development of the software.

To minimize the frustration due to the technical difficulties and/or malfunctions, the team plans to devote two hours every week to finding solutions to any technical problems. Through brainstorming sessions, we hope to come up with solutions to help the team move forward at an accelerate speed. Each member will discuss his/her issues with the other members to take advantage of their experience and skills. Since the main focus of the project is software development, the team has decided to divide it into two smaller parts which will be tackled in groups of two.

The key to success in this project is team work, motivation, and most importantly, a passion for learning and technology. We strongly believe that our motivated team and organized schedule will guarantee the success of this project.

9. Company Profile

Alireza Rahbar- Chief Executive Officer (CEO):

Alireza is fourth year Electronics Engineering student at Simon Fraser University. He has recent co-operative education experience working with embedded systems that has not only allowed him to gain technical experience, but has also helped him to learn project management, communication, and people skills. He is proficient in several programming languages such as: C/C++, C#, Python, Matlab, Visual Basic and Assembly. With his extensive background in programming, he will ensure smooth integeration between the hardware and software aspects of the project as well as providing solutions to make the most efiicient and practical product.

Parna Niksirat– Vice President of Operations (VP Operations)

Parna is a fourth year Systems Engineering student at Simon Fraser University with a background in Mechanical Engineering Design. She has programming experience using different platforms. Her previous co-operative education work term was focused on programming in different languages: object oriented Delphi, Pascal, C /C++, PL/SQL, VMS. She has used other programming languages such Java, Matlab, Pspice and Assembly in school projects. She is pursuing a minor in Electronics, and has therefore taken courses in signals, digital and analog systems, robotics, actuators/sensors and controls. Her outgoing personality and strong communication skills will be an asset to the team. She believes a team with dedicated members can generate more creative ideas which will lead them to smarter, faster solutions.

Shaghayegh Hosseinpour- Vice President of Research & Development

Shaghayegh has an undergraduate degree in Biomedical Engineering and is a first year Master's student at Simon Fraser University. During the four and a half years of her undergraduate studies, she has gained a deep understanding of various fields in Biomedical Engineering with a focus in Electrical Engineering. As part of her graduate coursework, she has been given the opportunity to work closely with electronics technology through various design, implementation and research projects. Her strengths are her research skills and a strong sense of teamwork.

Sam Seyfollahi – Vice President of Marketing (VP Marketing)

Sam Seyfollahi is a fourth year Electronics Engineering student at Simon Fraser University. Sam has extensive experience in both hardware and software design from his past course work, projects and his internship work. Aside from engineering skills, he also developed strong management and marketing skills which will help him to accomplish his job as VP of marketing.

Farzad Abasi – Chief Technical Officer (CTO)

Farzad Abasi is completing a Bachelors degree in Computer Engineering from the Faculty of Applied Science at Simon Fraser University. He has vast hardware design experience in both Applications-Specific Integrated Circuits (ASIC) design and Field-Programmable Gate Array (FPGA) design. This experience along with his diverse knowledge of embedded systems programming adds the competitive edge Rogue Avionics needs to the produce the most technologically advanced and highest quality UAV on the market.

10. Conclusion

BEST will strive to minimize the cost of portable heart monitoring systems for the consumer while maximizing the functionality and practicality of the product. The final product will benefit not only health care providers, but also professional athletes. Our product will make it easier for athletes to constantly monitor their performance and to help detect early signs of heart failure.

This system will be perfectly integrated, simple to use and to install. We are certain that with the special features included in this system, our monitoring and measuring system will stand out among all other competitors. The Gantt and milestone charts in the schedule section demonstrate that this project will be completed in the time frame allocated. We have highlighted our sources of information and research material. Our potential financial sources have also been presented, and we have clearly defined our solution and proposed a strategy to achieve this objective.

11. Sources & References:

[1] World Health Organization. "Cardiovascular diseases (CVDs)" Internet: http://www.who.int/mediacentre/factsheets/fs317/en/index.html

[2] January 14, 2010," Vital Positioning System"

http://medgadget.com/archives/2004/12/vital_positioni.html

[3] January 14, 2010, "Medical Electronics / Biomedical Circuits" http://www.hobbyprojects.com/B/biomedical_circuits.html

[4] January 14, 2010, "http://www.digikey.com" © 2009, Digi-Key Corporation

[5] RP Electronics (Burnaby)