CHAPTER 8
MISSISSIPPI STATE UNIVERSITY

Agricultural and Biological Engineering Department
Mississippi State, MS 39762

Principal Investigator:

Gary M. McFadyen, (662) 325-0887

WEARABLE ECG MONITOR

Designers: John Kosko and Brian Flowers
Supervising Professor: Dr. Filip To
Agricultural and Biological Engineering Department
Mississippi State University
Mississippi State, MS 39762

INTRODUCTION

The purpose of this project was to create a device that would reduce the time it takes to respond to a heart attack by detecting conditions that could lead to the onset of cardiac arrest. This project was the hardware development portion of a broader project to develop a complete a low powered wearable device capable of outputting an ECG signal to a handheld computer

SUMMARY OF IMPACT

People who survive heart attacks sometimes have reduced physical and mental functions as a primary or secondary result of the heart attack. The leading cause of cardiac arrest is ventricular fibrillation. The key to preventing death or disability from cardiac arrest is recognizing the problem early and quickly providing proper treatment. This device will monitor the heartbeat of individuals who are at risk. Through the utilization of GPS and cellular communications, it will also notify emergency personnel in the event of a heart attack.

TECHNICAL DESCRIPTION

The hardware developed in this project was designed to detect the electrical impulses from the heart, amplify and filter these signals, convert the signals to digital format, and deliver the signals to a handheld computer for analysis. Pre-gelled silver/silver chloride disposable electrodes were used to measure the electrical impulses from the body. An amplification circuit consisting of three operational amplifiers was designed and fabricated. A prototype circuit was also fabricated using TI082 amplifiers. The electrodes were connected to the circuit using ribbon cable. LabView software was used to generate a simulated ECG signal to test the circuit. The device is shown in Figure 8.1.

This circuit will be integrated into a handheld computer for analysis of the ECG data.
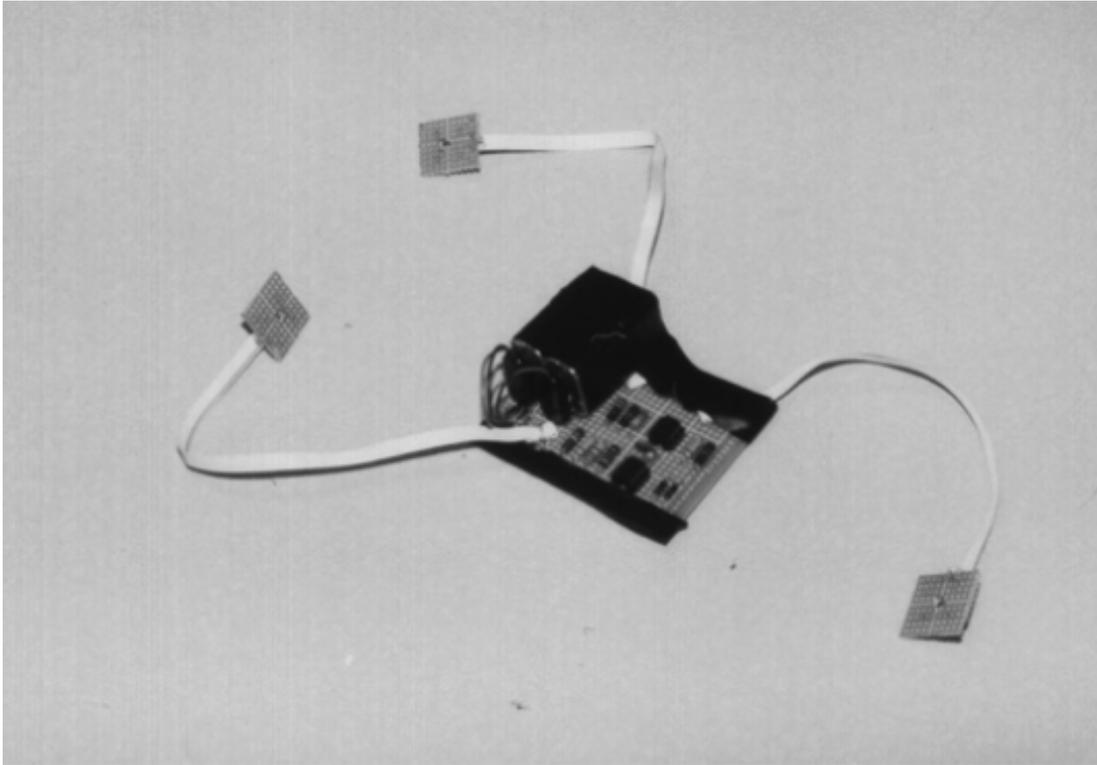
Figure 8.1. Wearable ECG Monitor.

ECG ANALYSIS SOFTWARE

Designers: Patrick Bergin and Brandon Etheridge
Supervising Professor: Dr. Filip To
Agricultural and Biological Engineering Department
Mississippi State University
Mississippi State, MS 39762

INTRODUCTION

Cardiac arrest is the leading cause of death in the United States. Therefore, advancements in current emergency cardiac care are needed. A critical factor affecting the recovery of a person who has a heart attack is the time between the onset of the attack and the beginning of treatment. This project is part of a larger project to design and fabricate a wearable EKG monitor that monitors the heart at all times. In its complete form, the unit will utilize a heart attack prediction algorithm to provide a notice of imminent problems. The device will then contact emergency medical personnel and alert them to the problem. This part of the design will detail the creation of a processing unit that accepts, translates, displays, and transmits an EKG signal.

TECHNICAL DESCRIPTION

The overall goal for this project was to design a portable system that can accept, store, display, and transmit EKG data. However, the project also has other requirements. The system needs to use minimal power, be comfortable to the user, and withstand outside forces in order to practically function.

This design utilizes a Palm Pilot handheld computer or the Visor from Handspring. The system must be able to interface through serial connections with EKG leads to process the heart signal and with a GPS device. Utilizing a microprocessor, the Palm Pilot must also host the algorithm to predict heart attacks. Newer versions of the Palm Pilot include built-in cellular phone and wireless Internet capabilities making it a viable communication option. The Palm Pilot and Visor both have battery lives of approximately two months. Therefore, using the Palm Pilot device would solve almost every design problem. This option would provide the best functionality with sufficient power efficiency and a reasonable development timetable. The Palm Pilot is small, and it is carried by millions of people every day. The Palm Pilot processor has sufficient ability to obtain the EKG signal, analyze this signal, and determine if a heart attack will occur. The Visor also has a module with upgrade capabilities. The module makes it possible to include additional hardware and programs such as EKG leads, the GPS system, and an algorithm for processing the EKG signal.

The first step in the design was to gather digital sample data in a compressed format from MIT's Cardiology Center (Physiobank, 2001). A C program was then written to decompress the data into a list of numbers. These numbers could then be displayed and graphed using Excel, thus providing a visible EKG sequence. This proved the validity of using a string of ASCII characters as a digital representation of the EKG system. The compression algorithm provided a good opportunity to save memory space on the handheld computer if needed.

The program operates on an event loop structure. An event can be any change noticed by the handheld computer. This could include the opening or closing of a program, movements with the stylus, or data entry into a field. The program continually loops while searching for and dispatching any event. The first event captured is the opening of the program. This event triggers AppStart, which opens the serial connection. When the close program event is triggered, the serial connection is closed by AppStop to avoid any errors. If no event is detected, the ScanSerial function is called for each loop. This program accepts data character by character until a full integer representation is recorded. The string is then converted to an integer and stored as EKG data within an array.

After the integer data are stored, the information is plotted on the Visor screen. The DrawLine function takes the previous data point and draws a line to the new data point, incrementing the horizontal location by one pixel. Once the graph has reached the end of the screen, the horizontal locator resets to zero and the function EraseRectangle is called. This clears the

screen so the new data will not overlap.   To check the accuracy of the data transmission, the function EchoData is called after a full screen of data (160 data points) has been processed by the handheld. This function sends the data string from the handheld to the computer display, and this can also be used later to send EKG data out of the serial port to other devices.

A program that can accept EKG data, store it, and display it on the screen was developed. Further development effort is required before a real time system can be realized.   Critical components identified include the following: heart attack prediction program, power management, communication protocol, and a pilot study. This project has formed a basis upon which the complete wearable EKG system can be developed.

The cost of this project is $957.

VOICE ACTIVATED TELEPHONE

Designers: Sunil K. Singh, Andrew DeLongchamp
Supervising Professor: Dr. Gary McFadyen
Agricultural and Biological Engineering Department
Mississippi State University
Mississippi State, MS 39762

INTRODUCTION

A voice activated cordless telephone was designed for people with limited motor ability. This device allows one to dial, answer, and hang up the telephone by verbally stating the command he or she wants the telephone to perform. The required hardware for the project includes a Voice Extreme IC, a cordless telephone, a speaker, microphones, analog switches, and various other electrical components (see Figure 8.2).

SUMMARY OF IMPACT

Many people with disabilities have limited motor ability, making it difficult to operate a traditional telephone. There is a need for a voice-activated telephone.

TECHNICAL DESCRIPTION

This project was divided into software and hardware components. The code for the software portion of the project was written in a program similar to C and downloaded to the IC memory.

Software:

The software can be divided into three parts: 1) activation of IC, 2) choice, and 3) dialing. The first part requires the use of the Voice Extreme IC's capability of word spotting. This capability allows the IC to listen at all times to the user until a trigger word is spoken, making the phone truly hands-free.

The next part of the software is the choices menu. After the IC has spotted the trigger word, it prompts the user to please say a word. It then waits for the user to select one of six choices: 1) long distance, 2) local, 3) campus, 4) off campus, 5) answer, and 6) end. The program then accesses the proper function. The answer and end commands are used to answer and end a telephone call.

The third part of the program deals with the dialing of a telephone number. After one of the choices has been entered, the corresponding function is called.

The function tells the program the number of digits it needs to store in memory to make the corresponding call. For example, to make a local call, seven numbers must be entered into a telephone. To do this, a speech recognition function was placed in a loop so the function would run seven times. Each time the speech recognition function is accessed, it prompts the user to say a digit of the telephone number. The function also stores the digit in an array so it can be used at a later point in time.

After all the digits have been stored into an array, the program prompts the IC to go through the answer protocol. Three hundred milliseconds after the phone is turned on, the program accesses the array in which the phone number was stored. The corresponding DTMF tones for the number are sent through the speaker.

Hardware:

There were two parts to the hardware section of this project. The first part deals with turning the telephone on and off. To perform any function on a standard telephone, the user presses a button. This action completes the circuit between two points on the keypad. Because the goal of this project was to make the phone completely hands-free, a way to simulate this pressing of a button was required. A Fairchild Semiconductor quad analog switch (p/n MM74HC4316) was used to provide this feature. The analog switch has a control input and two output pins. When the control input becomes high, the output pins are connected, thus closing the circuit. The circuit remains closed throughout the entire time the control input pin is high. Once the input becomes low again, the circuit opens.

The second part of the hardware deals with the integration of the telephone, IC's speakers, and microphones. The speaker outputs were connected in parallel to an 8-ohm speaker. An 18-ohm resistor was placed in front of the IC's speaker source. The resistor is used to protect the IC so it will not be

driven by the telephone. The speaker has an impedance of 8 ohms. Therefore, placing an 18-ohm resistor (and adding that to the internal impedance of the IC itself) will direct most of the current coming from the telephone to the speaker.

The end results of this project allow one to answer a call, hang up after the conversation, and to dial a call. The cost of this project was approximately $750.
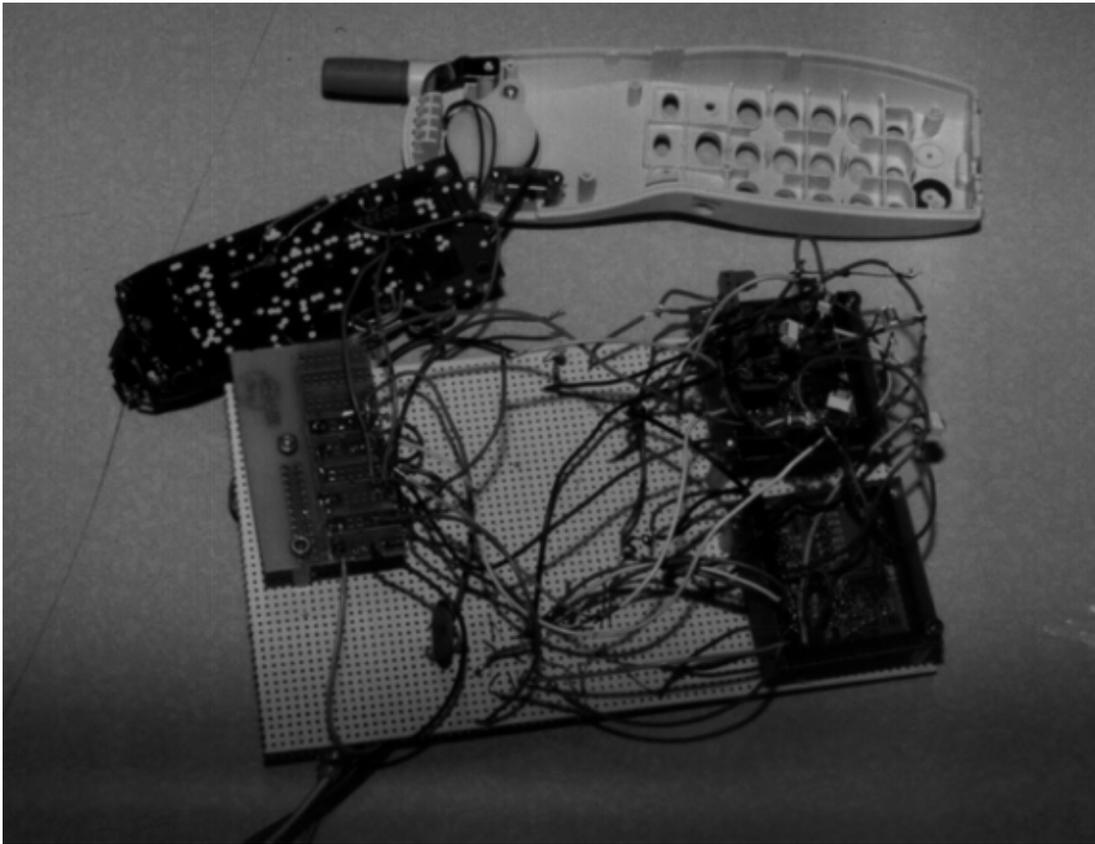
Figure 8.2. Voice Activated Telephone.