CHAPTER 10
NORTH DAKOTA STATE UNIVERSITY

Department of Electrical Engineering
Fargo, North Dakota 58105

Principal Investigators:

Daniel L. Ewert (701) 231-8049
ewert@plains.nodak.edu
Jacob S. Glower (701) 231-8068
glower@badlands.nodak.edu
Val Tareski (701)-231-7615
tareski@plains.nodak.edu

VOICE SPECTRA DISPLAY

Client: REM Rehabilitation Associates, Fargo, ND
Designers: Brendt Way and James Sprecher
Faculty Supervisor: Jake Glower
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 58105

INTRODUCTION

For those that are deaf or hard of hearing, learning to speak can seem virtually impossible. It is one of the few cases where, until recent advances in technology, the person trying to talk had limited feedback on sound production or correctness. Similarly, it is very difficult for speech-language pathologists (SLPs) to teach people with hearing impairments how to pronounce words. While people with hearing impairment have difficulty hearing themselves and others, most can see. The student designers' intent was to build a device that displays the spectra of a user's voice along with that of the SLP. If the two spectra look alike, they sound alike.

SUMMARY OF IMPACT

Several devices on the market are able to display the spectra of the operator. Most of these devices are expensive, (on the order of $10,000 or more) and are difficult to operate. In this project, public domain software that is easy to use, free (running on any PC with a VGA monitor and a sound card, and able to be upgraded by anyone who has the ambition to improve the public domain Microsoft C++ code) was developed. Once perfected, this program should enable any SLP with access to the internet to use a PC as a tool for helping people with speech and/or hearing difficulties.

TECHNICAL DESCRIPTION

Program operates as follows. The main program checks if the thread is hung (i.e. the program has crashed). If so, it terminates the program. If not, it waits for the operator to push one of the record buttons. There are two buttons that enable the SLP to record a target sound. A client can then use the lower window over and over again in an attempt to mimic the target spectra.

Once the record button has been pressed, the sound from the microphone/sound card is copied into an array. A fast Fourier transform converts the sound array into a spectrum. This spectrum is then filtered to optimize the display. A threshold function was found to be the best filter for keeping the display simple and meaningful. Once filtered, the data are plotted in the appropriate window of the PC.

Initial experiments with this program showed that it was very good at displaying vowel sounds. Each harmonic is clearly observable. Consonants, however, appear as a very brief blip on the display. Consequently, all consonants with the same manner of production are displayed almost identically.

Upon receiving this device, a second use was suggested by the SLP. People who talk a great deal tend to become hoarse if they speak with a fundamental frequency that is too low. By seeing the spectra of their voice, this display can be used to display their current and their ideal pitches.

The total cost of this project was $1,260, which includes the C compiler and a portable PC for the SLP. The program size is 117k of compiled code that runs on any PC with Windows 3.1/95, has a sound card, and a VGA monitor. This program can be found at

http://www.ece.ndsu.nodak.edu/~glower/design/index.html, listed under Project 102: Voice Spectra.

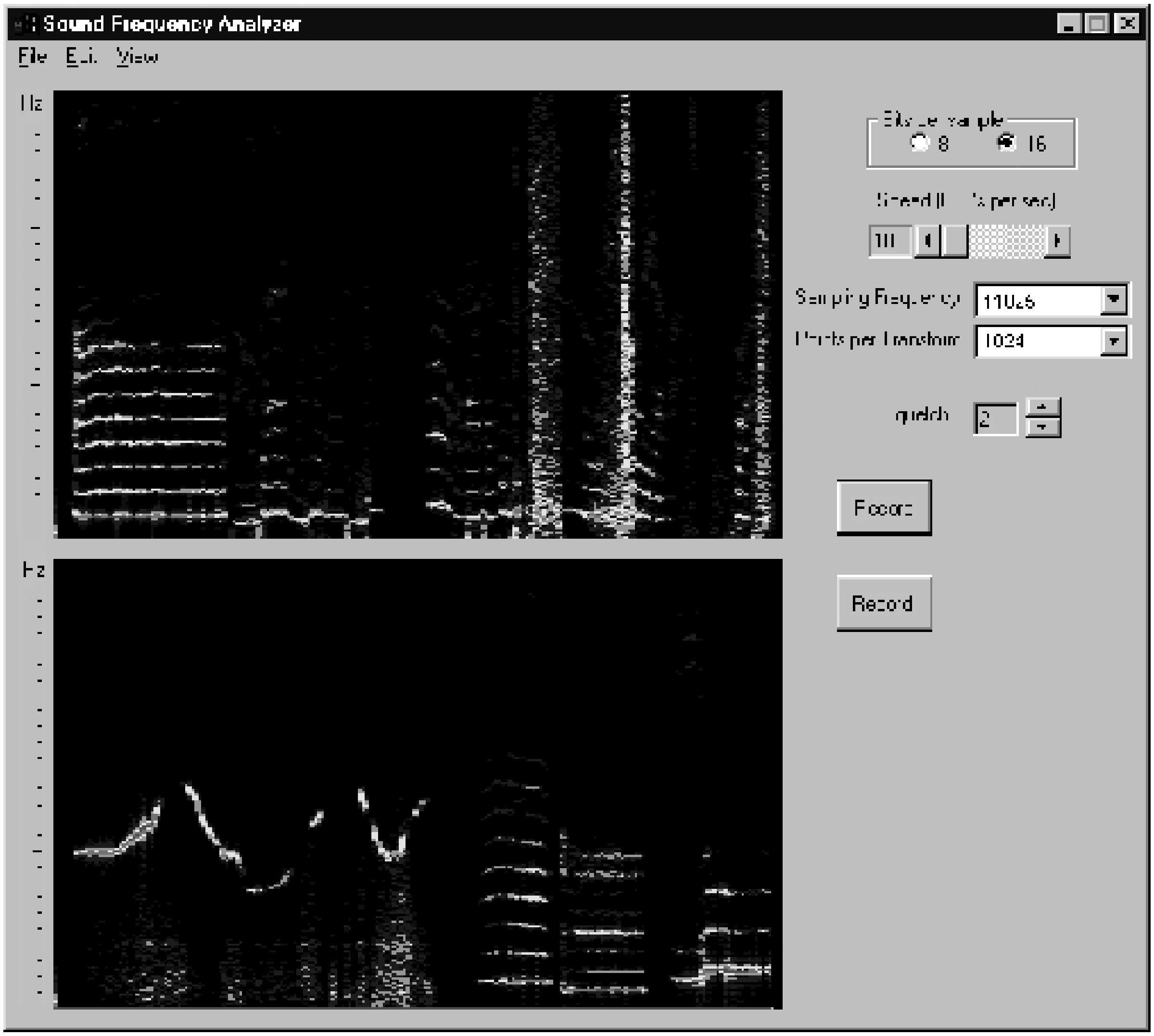

Figure 10.1. The Voice Spectra Program Display, with a Target Spectrum Shown on Top and the Operator's Spectrum Shown in The Lower Window.

SPEAKER VOLUME DISPLAY

Client: REM Rehabilitation Associates, Fargo, ND
Designers: Tim Gilmore, Mike Ross
Faculty Supervisor: Floyd Patterson
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 58105

INTRODUCTION

One of the challenges facing individuals with hearing impairment is adjusting the volume of their speech to an appropriate level in a wide variety of situations. The obvious problem is lack of feedback: a person with normal hearing can tell that a library is quiet while a football game is not, and adjust the volume of his or her voice accordingly. A person with hearing disabilities, on the other hand, may have difficulty discerning the level of the background noise, and likewise, the appropriate level of their voice.

SUMMARY OF IMPACT

To help a person with a hearing impairment know the appropriate level of his or her own voice, a device was built to display both the level of the background noise and the intensity of a speaker's voice. With this device, it should be easier for the operator to know when to shout as well as when to speak quietly.

TECHNICAL DESCRIPTION

The speaker volume display includes six phases. Vocal (and ambient) sound enters the microphone, where the resistance value varies with intensity. An R to V circuit converts the resistance to a voltage. This circuit is very insensitive, the output voltage being only on the order of a few millivolts even when shouting. In addition, there is a 1.4V DC offset to this signal.

The amplifying circuit removes the DC offset with a blocking capacitor and amplifies the signal with a gain of 60,000 to 400,000. The user input allows this gain to be adjusted for use in locations with different ambient noise levels.

The averaging circuit helps provide a steady output the user can see. The intensity of a person's voice varies with time, oscillating up and down very quickly. For this application, the average sound level is a better measure of how loud the person is talking. Therefore, a low-pass filter with a time constant of 0.5 seconds is used to smooth out the signal to the A/D converter. Once amplified and filtered, a bar-graph generator chip is used to drive 10 LEDs from all off (quiet) to all on (loud speech).

Two such circuits are used: one for the ambient noise level and one for the speaker's volume. The difference is distinguished by using two separate microphones: one worn by the speaker and one on the box.

The finished product displays the intensity of the background noise or speaker’s voice fairly well. A plastic case makes the device fairly rugged. Battery drain is on the order of 56mW, allowing the device to operate for about 90 hours on a 9V battery.

Two problems with this device were observed with experimental use. First, it does not work well outdoors. Wind saturates the device. It is also very sensitive to whistles. Adding a band-pass filter may alleviate these problems in future designs

The overall cost of this device is about $60.

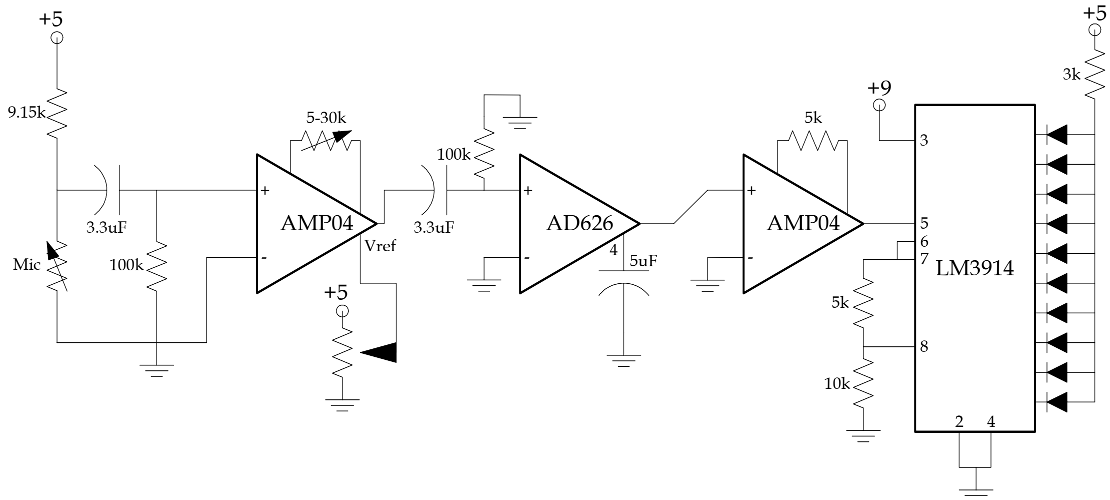

Figure 10.2: Circuit Used to Convert Sound to a Bar Graph Display.

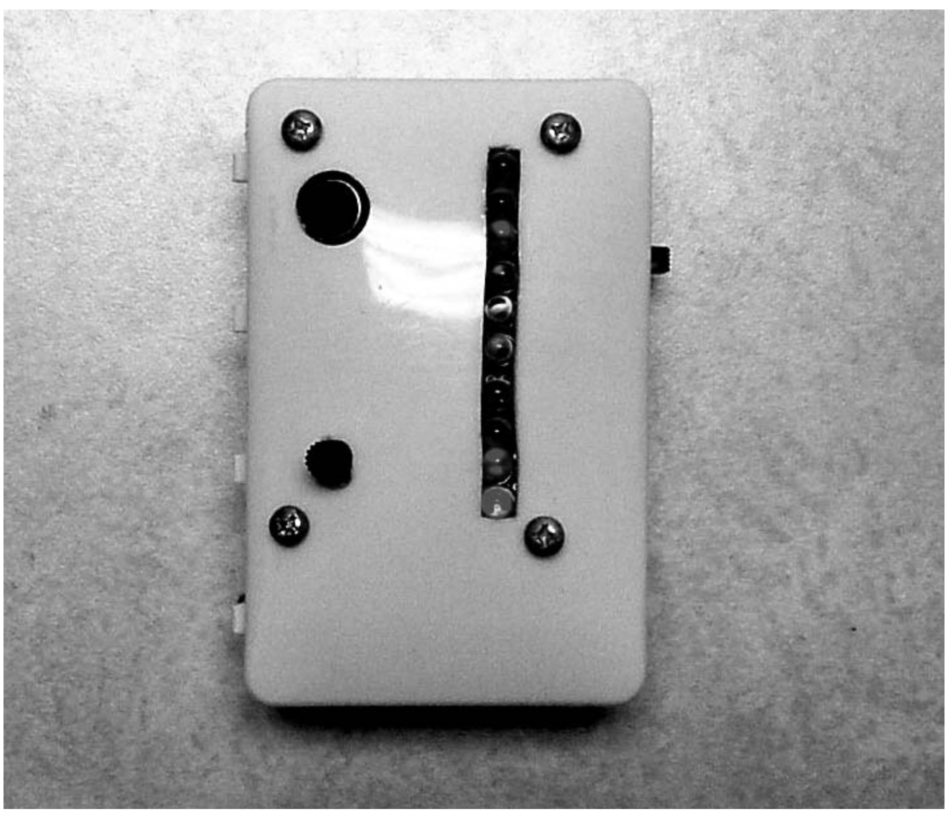

Figure 10.3: Device Used to Display the Volume of the Speaker's Voice.

PERSONAL LOCATOR

Client: Human Communications Associates, Fargo, ND
Designers: Travis Benz, Dana Jenson, Brian Smith
Faculty Supervisor: Floyd Patterson
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 58105

INTRODUCTION

One problem workers at group and nursing homes have is trying to give patients enough freedom to move independently, but not so much that they wander off. To help prevent patients from wandering outside, a device a devices was required to:

- Notify personnel when one of their patients is near a door,
- Set off an alarm if that patient goes out a door, and
- Help locate patients if they wander outside.

SUMMARY OF IMPACT

Personnel at group homes keep track of their patients by constantly monitoring the exits with cameras, placing alarms on doors, and checking who is coming and going. These strategies are labor intensive. An electronic device built to monitor if and when a patient approaches a door is labor-saving. Moreover, if a patient does manage to wander outside, the personnel will be better able to find the patient before he or she is harmed.

TECHNICAL DESCRIPTION

The design of the personal locator is broken into four sections, as shown in Figure 10.4. A transmitter is placed on each door leading outside, operating continuously at 418MHz. Each patient wears a receiver attuned to this signal. When the patient approaches a doorway, the received signal exceeds a threshold, which sets a flip-flop, triggering a second transmitter on the patient to transmit at 433MHz. A receiver at the nurse's station detects this 433MHz signal as an indication that a patient is near a door.

The 433MHz signal is modulated at 375 Hz with a 555 timer using on-off keying. This allows a person with a portable tracking unit to hear a 375 Hz squeal when listening to a receiver with an envelope detector. A directional antenna is used with this unit, allowing the operator to track the signal, greatly helping to locate the individual.

Experimental results show that this unit is able to detect patients who are within about three meters of a doorway. The tracking unit is able to detect the transmitter in a 60-meter open range. Arbitrarily, the transmitter on the patient is modulated at 375 Hz. By using different frequencies (easily set by adjusting a resistor on a 555 timer), the identification of the patient can also be determined by this signal, also helping the personnel locate the patient should the need arise.

The main shortfall of this design is power consumption. Two batteries are used in the unit worn by the patient: one for the transmitter and one for the receiver unit. The life of the batteries is not long - estimated at less than 10 hours when transmitting. As a result, it is recommended that a follow-up unit be designed to use a single power source and have lower power consumption.

The total cost of this project was $420.

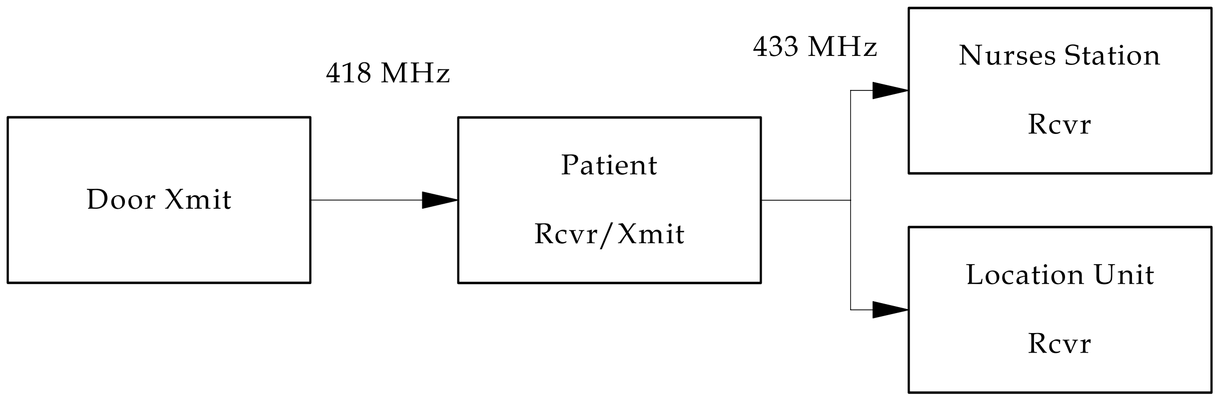

Figure 10.4: Overall Block Diagram.

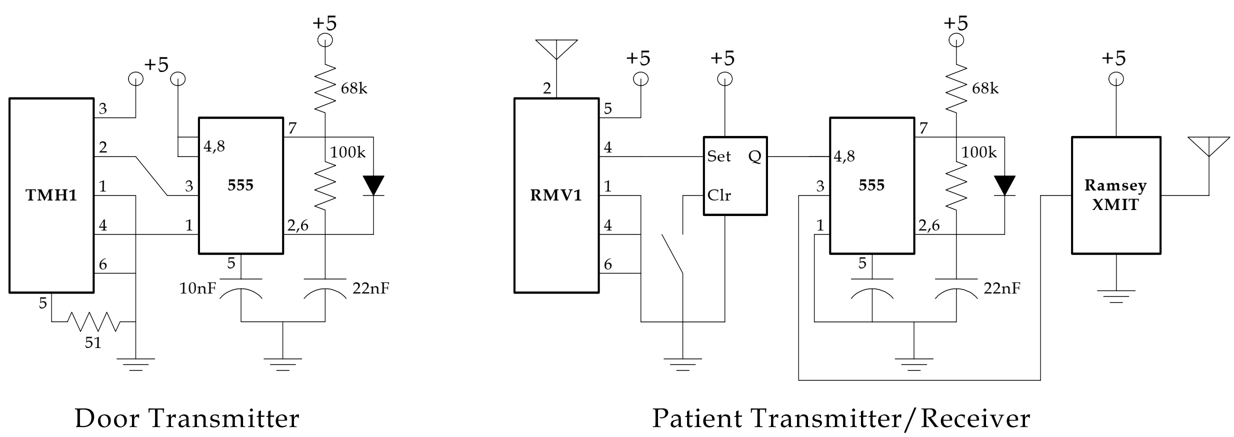

Figure 10.5: Circuitry for the Door Transmitter and Patient Receiver.

VOICE DELAY

Client: REM Rehabilitation Associates, Fargo, ND
Designers: Josh Christenson, Jody Forland
Faculty Supervisor: Floyd Patterson
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 5810

INTRODUCTION

One form of a speech disorder involves speaking too quickly. When this happens, the speaker is not always pronouncing his or her words clearly or in a way listeners can easily understand. One form of therapy to correct this is to have the speaker listen to him- or herself with a 0 to 5-second delay. Presumably, if one cannot understand oneself, others are probably having problems as well. A device was built to record and playback a speaker's voice with a 0 to 5-second adjustable delay.

SUMMARY OF IMPACT

There are several commercially available delayed feedback devices. Many of these devices are expensive or difficult to use because they frequently malfunction. By building a simple to operate device that is relatively inexpensive, speech-language pathologists and clients may be more inclined to use this device in therapy.

TECHNICAL DESCRIPTION

The voice delay unit consists of four sections, as shown in Figure 10.6. The Input Conditioning circuit amplifies and filters the signal from a condenser microphone so that it is 0 to 5V in amplitude and its band is limited to 3 kHz. A SSM2165 compression chip is used to provide automatic gain control. When the microphone input is below 40mV, 5:1 gain compression is provided. Above 40mV, the gain compression is approximately 10:1. The output of this chip is amplified with a 2nd-order Butterworth filter with a bandwidth of 3kHz, made with a pair of 741 op-amps. In addition, the output is shifted so that it is between 0 and 5V.

The Digital Delay Device samples this signal at 8kHz and places the data in a circular stack with a size of 5 seconds. A 6811 evaluation board is used for this function since it has enough memory and is easy to program. While recording, the data in this circular stack is also output to a D/A converter, the location of the pointer determining the delay provided by this unit. The Delay Select input is a knob that the operator can turn to select the desired delay.

The Output Amplifier converts the 0 to 5V signal from the D/A converter to a 300mW signal for a pair of 32-Ohm headphones. An identical second-order Butterworth filter was implemented using a pair of 741 op-amps, identical to the input conditioning circuit. A variable resistor is connected in the feedback path allowing the operator to adjust the volume of the output. The last block, the display, simply tells the operator if the unit is turned on or not.

The resulting design consumes 7 Watts of power and runs on 120VAC. The device weighs slightly over 1kg and is about 20cm x 20cm x 10cm in size. With two knobs (volume and delay) and one switch (on/off), this device is simple to operate and meets the needs of the client.

The final cost for this project was $227.81 - most of which is accounted for by the evaluation board.

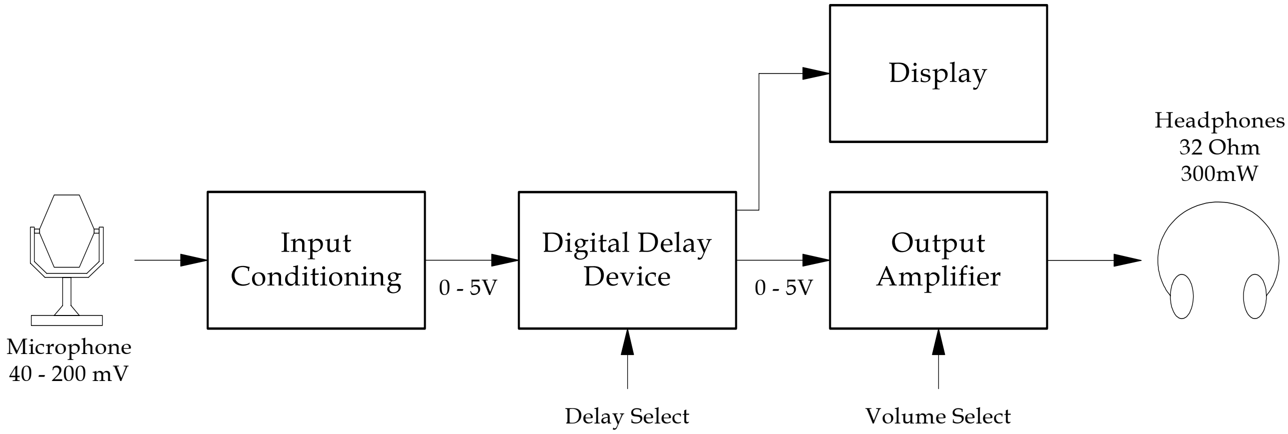

Figure 10.6. Voice Delay Device Diagram.

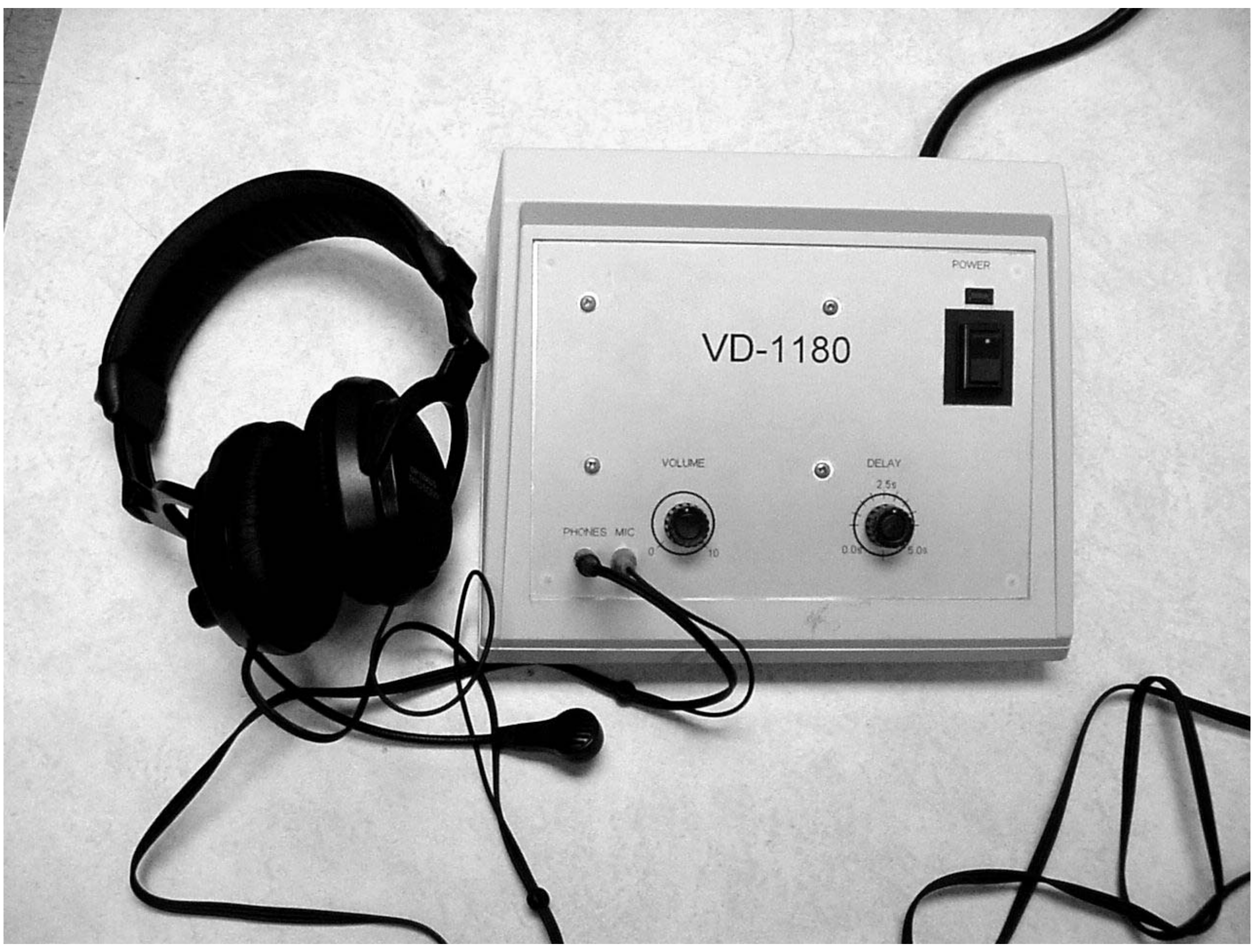

Figure 10.7: Final Voice Delay Device.

CALCULATOR FOR PEOPLE WITH VISUAL IMPAIRMENTS

Client: Julie Anderson, Fargo Public Schools
Marty Berlinger, Chris Scholl, Todd Tosseth
Faculty Supervisor: Floyd Patterson
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 5810

INTRODUCTION

A calculator was designed so that it can be seen easily by a person with 20/200 corrected vision. In addition, the intended recipient of this device has a learning disability, requiring that the calculator be easy to operate by someone with a 7-year-old mental age. Along with addition, subtraction, multiplication, and division, the calculator should also include pi, square root, square, percent, y to the x, fraction to decimal conversion, decimal to fraction conversion, and an a/bc key for fraction entry. Furthermore, the display and keys are to be large and color coded to help the operator find the correct key.

SUMMARY OF IMPACT

Calculators can be valuable tools that help students solve more difficult problems than could be solved by hand. Unfortunately, the recipient of this device had problems finding a commercially available calculator that she could see and operate efficiently. By providing her with a calculator with large keys, a large display, and only those functions that she will use, the recipient will hopefully have a tool that allows her to function well in her studies.

TECHNICAL DESCRIPTION

The design of the Calculator for the People with Visual Impairments can be broken down into three sections: the keypads, processor and display. The keypads are made with individual button arrays (typically 4x1) with clear covers that can be labeled with a piece of paper underneath. This allowed the designers to make laser-printouts of the requested functions (+, x, etc.) on colored paper. The keypad configuration is shown in Figure 10.8.

The processor selected was taken from a TI30Xa calculator. This processor was selected since it is very simple to connect pins to, has all the desired functions, and already has an LCD display driver built in.

The display selected is a 1" tall LCD display along with a cylindrical lens to enlarge the display. An LCD display is used to reduce power consumption. It also worked well with the TI30Xa processor that is designed for such a display. Its dimensions are 30cm x 20cm x 10cm, making it rather large by calculator standards, but hopefully easy to see and operate for the intended user. One 9V battery and two AA batteries draw 11mA for an expected life of 10 hours before the batteries needing replaced.

The resulting device costs $505. Eighty percent of this cost comes from the buttons. While expensive, they are very high quality buttons that should survive several years of use.

Figure 10.8: Calculator for the People with Visual Impairments.

VOICE ACTIVATED TV MONITOR

Designers: Jason Weires, Don Newton, Andrew Woidolovich
Faculty Supervisors: Floyd Patterson, Mike Palmer
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 5810

INTRODUCTION

The intended recipient of this project is a veteran who has quadriplegia because of multiple sclerosis. The recipient lives in a single-family dwelling with his wife. To allow the recipient to keep track of his world and maintain some degree of autonomy, a PC-based system had been previously developed. This setup allows the recipient to use voice commands for environmental control, for example, to turn on and off lights or a stereo.

In addition to these features, it was desired that the recipient's PC be connected to a camera and intercom at the front, back, and side doors of the house. When coupled with motion detectors, this would allow the recipient to know when someone is approaching his house, allow him to look at and talk to the visitor, and furthermore, allow him to talk to his wife when she is working in the back or side yards.

SUMMARY OF IMPACT

Lack of autonomy is a problem associated with quadriplegia. By developing a system that tells the operator when someone is approaching his house and allowing him to selectively turn on cameras and intercoms, the operator is able to converse with and address visitors and his wife without assistance.

TECHNICAL DESCRIPTION

There are six essential components to this system:

- The motion sensor,
- The camera,
- A transmitter,
- A receiver,
- A PCMCIA card, and
- A separate intercom system.

The motion sensor runs on batteries and sends an RF signal to the video transmitter. The motion sensor can be set to turn on any one of 256 X-10 devices. The video transmitter also plugs into the wall through a special device, which senses the signal being sent from the motion sensor. On the motion sensor end, there is a transmitter that sends a signal through the house wiring and then, on the video transmitter end, a receiver senses this signal from the house wiring and then turn the video transmitter on. When installed, the motion sensor will sense either a change in the light intensity or the motion of a visitor and send a signal to power the transmitter.

The transmitter is then coupled directly with the camera such that the transmitter delivers power to the camera through a 12-foot telephone cord. The camera then monitors the front door. A setting on the motion sensor regulates the amount of time that the camera stays on after the motion sensor no longer senses movement or a change of light intensity.

Near the laptop end of this system, the video receiver is also plugged into a wall outlet directly so that it is on all the time. The receiver will only work when the transmitter is sending something; therefore, the receiver acts as a device that is "standing guard" until the video transmitter powers up and sends a signal.

The video receiver then couples directly with a PCMCIA card to send the audio and video to the customer's laptop. The PCMCIA card is powered directly from the laptop computer, so no external power supply is needed here.

The intercom system used from the client's front door is controlled by the PROXi, like any other module that he controls with it. The client instructs the PROXi to provide power to the intercom system when desired and then turn it off when he is done. The client controls many appliances from his PROXi, so we assume that it will not be much different to control an intercom system.

In the lab, the student designers learned that some of the products used did not meet their advertised specifications such as the X-cam Anywhere ability to produce stereo sound. This was frustrating since the student designers were relying on these products. The X-10 modules did not have as much range as advertised so arrangements would have to be made for them to be within working range when the system is fully operational. In the end, all components were functional at an acceptable level.

The biggest concern for the designers was making sure that all components were compatible. Four days were spent installing this device in the home of the client, updating the software on his laptop computer, and checking to make sure the system worked. Ultimately, the client was left with a way to talk to people at any of four doors. The main problem encountered was finding that not all laptop computers are compatible with all software. For some reason, the video card used worked well several of the laptops tested prior to installation, but the video capture locked up the client's computer. A quick fix to this problem was to install a separate video monitor rather than place it on his computer. Follow- up work will address using the new software on his laptop computer.

The overall cost of this project was approximately $5,000.

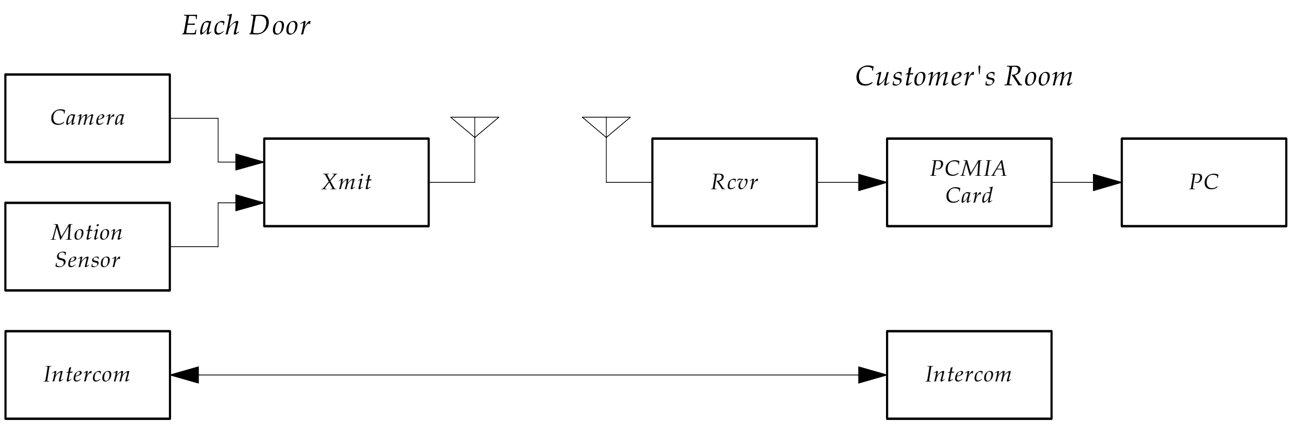

Figure 10.9: Components of the Voice-Activated TV Monitor.