CHAPTER 11
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VOICE RECOGNITION CLOCK

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INTRODUCTION

As a part of a class project, a group of fourth grade students attempted to envision what common devices used today would look like twenty years from now. One of these ideas was an alarm clock that tells the time in response to a spoken request. The students realized that such a device could be built today, and further, this device would be useful to a person with visual impairment or blindness. The teacher for this class approached the project engineers and asked if such a device could be built for the fourth grade students.

For such a device to be useful to a person with visual impairment or blindness, specifications provided by the students stated that the alarm clock be portable, have a display that is easy to read (for persons who are not blind but have visual impairment), have a voice output to tell time when activated, and be activated through voice input.

SUMMARY OF IMPACT:

The finished clock was delivered to the students. In a class ceremony, the students presented the talking alarm clock to a student with blindness, who continues to use the device. The collaboration between the elementary students and the project engineers resulted in a device that allows a person with visual impairment or blindness to more easily tell the time, a group of elementary students observing and becoming involved with the design process, and the sharing of a joy for engineering among the young students and the project engineers.

TECHNICAL DESCRIPTION

The design of the Voice Recognition Clock centered around three components: the voice input, the talking alarm clock, and interface circuitry.

Figure 11.1. Students During Construction. (From an Article in the Fargo Forum).

A HM2007 Voice Recognition Processor Demo Board was selected for the voice input. This board is an evaluation board for the Hualon HM2007 Voice Recognition Chip, capable of recording and recognizing up to 16 different words or phrases.

The evaluation board comes fully assembled and ready to use. To program a word or phrase, the operator types the word that he/she is going to say (from 00 to 16) on a keypad, followed by a pound key, and speaks into a microphone. When that word is spoken again and recognized, the number (from 00 to 16) is displayed on a two-digit LED display and sent to an eight-pin BCD output port.

Arbitrarily, word #08 was selected as the word that will trigger the talking alarm clock. The buffer circuitry looks for the spoken word #08. A flash of an LED on the evaluation board signifies that a word was detected, and then the number 08 appears on the LED display. Once detected, a one-shot closes an electronic switch.

A Radio Shack Alarm Clock Radio (Cat. No. 63-912) was used for the talking alarm clock. This alarm clock has a large 1" LED display and a speech chip built in. When the operator presses a "Voice" button, a momentary switch is closed and the alarm clock "speaks" the present time. By shorting this switch with the output of the buffer circuitry, the operator is able to trigger the alarm clock by speaking whatever phrase was previously recorded in position #08 in the voice recognition board.

The final design of the clock is housed in a 14cm x 19cm x 16cm Plexiglas enclosure and weighs about 1kg. The keypad for programming the voice recognition board and the speaker are on the top of the clock. In addition, three buttons for setting the time, the alarm, and resetting the voice recognition board are placed.

The total cost was approximately $250.

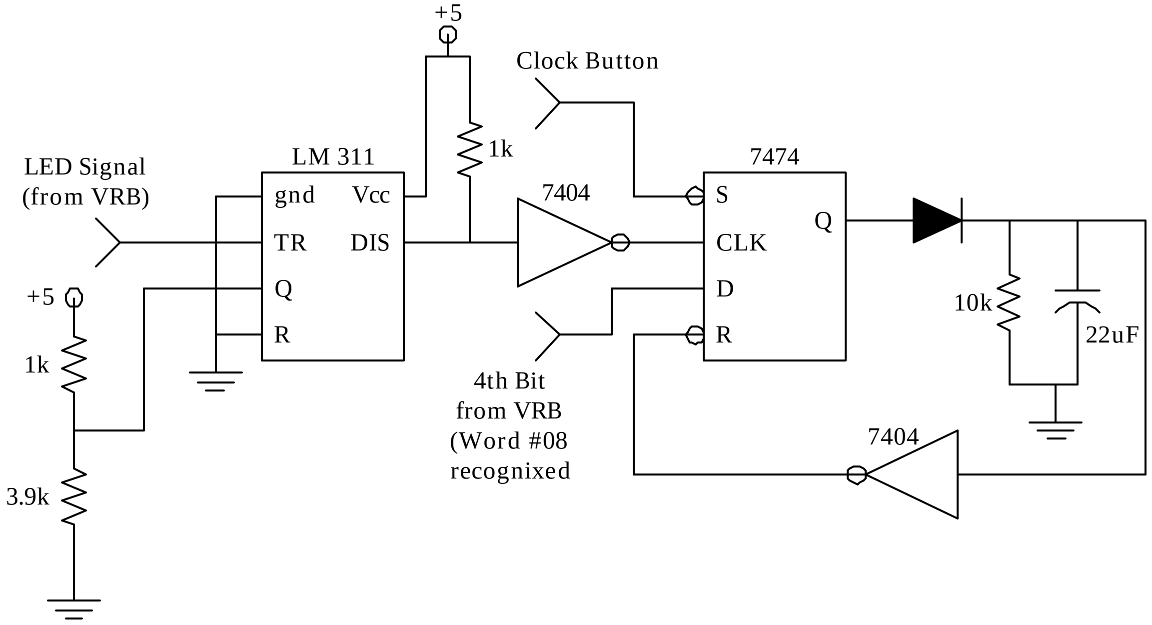

Figure 11.2. Buffer Circuitry Between Voice Recognition Board and Talking Alarm Clock.

ALARM CLOCK FOR INDIVIDUALS WITH HEARING IMPAIRMENT

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INTRODUCTION

Individuals with hearing impairment have a difficult time finding an alarm clock that is capable of reliably awakening them in the morning. An alarm clock that shakes the bed of the owner was designed to provide a reliable and pleasant way for individuals with hearing impairment to awaken.

TECHNICAL DESCRIPTION

The Alarm Clock for the Individuals with Hearing Impairment consists of four main components: an alarm clock, a radio transmitter, a radio receiver, and an “alarm.”

The clock module is contained on a pre-made board containing the clock chip, display LEDs, and the circuitry, requiring only a 9V power supply to operate. A 9V wall transformer provides power to the clock module as well as to the speaker and radio transmitter.

When the alarm goes off, a +5V signal is sent to the radio transmitter and the speaker. The transmitter uses AM modulation on top of a 1 MHz carrier to transmit the alarm to the receiver.

Two oscillators are used in the transmitter. One is used for the carrier signal and the other is used for the modulated "ON" signal. A 20MHz programmable chip oscillator produces the modulated signal. Its frequency can be divided 256 times to 78.125kHz. A 12-stage binary ripple counter then divides this signal to produce a 1.2kHz signal. This signal is used to modulate a 1 MHz carrier using the following circuit.

By using a 1 MHz carrier modulated at 1.2kHz, a portable AM radio was used to test the functionality of the transmitter and to estimate the range. A two-meter range was easily obtained with little or no use of antenna. For a reliable signal, a six-meter range would be preferable. To obtain a greater range and to remove the harmonics from the 1 MHz square wave used for the carrier, an amplifier and LC tank were added to the final stage of the transmitter.

A seven-transistor superheterodyne receiver was used for the receiver of the modified alarm clock. This radio receiver came in a kit and receives radio frequencies from 540kHz to 1600kHz - the standard AM band. For this project, the receiver was tuned to 1 MHz.

The output of the receiver (tuned at 1 MHz) detects whether a 1.2 kHz signal is detected by the receiver or not. If a 1.2 kHz signal is detected on the 1 MHz carrier, a 2n222 transistor switch turns on a pair of motors. These motors have off-balance loads on their shafts, creating the "shaking" of the receiver box.

The final design consists of two units: the radio/transmitter and the receiver/shaker. The radio/transmitter is placed in a 20cm x 12cm x 5xm Plexiglas enclosure. This includes a 2cm LED display for the time, buttons for setting the time and alarm, and a power jack for the 9V wall transformer. The receiver/shaker is placed in a 30cm x 10cm x 5cm Plexiglas enclosure and contains room for the motors, the receiver, and several batteries.

Field tests found that the receiver reliably detected the alarm at ranges of 3 meters without any external an-

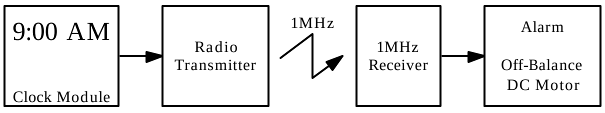

Figure 11.3. Block Diagram for the Device.

tennas on the transmitter.

The total cost of the project was $182.

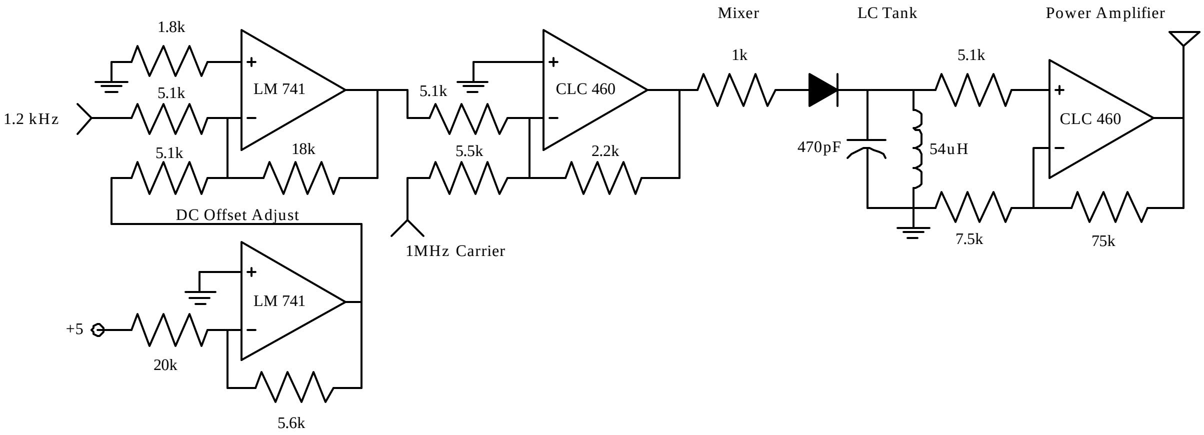

Figure 11.4. Circuit Diagram.

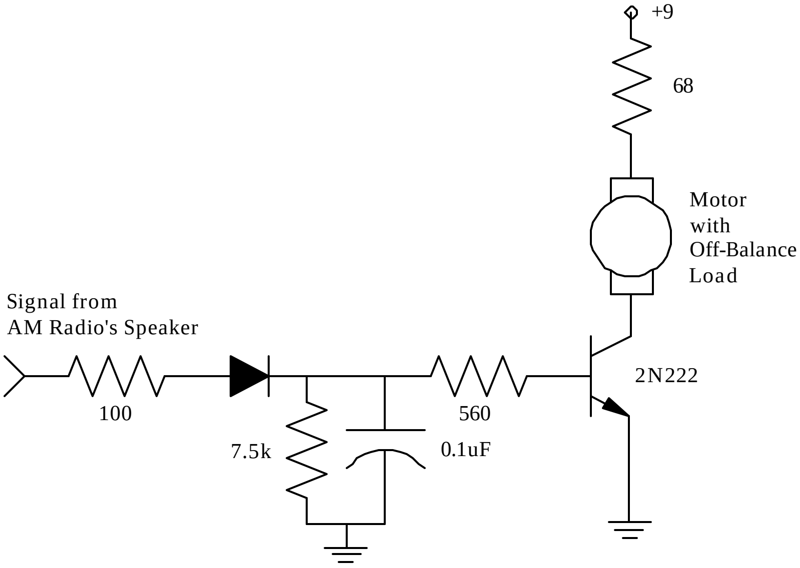

Figure 11.5. Circuit Diagram.

CAMERA FOR INDIVIDUALS WITH VISUAL IMPAIRMENT OR BLINDNESS

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INTRODUCTION:

While a person with visual impairment may not be able to "see" with his/her eyes, he/she can still obtain information through the sense of touch. The goal of this project was to design a device that converts light intensity to a physical output, allowing the user to "feel" the image rather than see it.

SUMMARY OF IMPACT:

The camera allows the light intensity of an object to be sensed by feeling the height of solenoids. Unfortunately, several difficulties were observed with the design. First, the solenoids tend to chatter. This may be due to electromagnetic compatibility problems, ground loops in the design, or an exceedingly high gain in the buffer. Second, the solenoids do not provide a firm surface. Weak springs were required so that the current demand of the solenoids was not excessive. Weak springs, however, result in pixels that are too compliant when touched. Third, even with light springs this design required too much power. Before this design is expanded to a larger grid size, a better actuator must be incorporated.

TECHNICAL DESCRIPTION

The light sensor consisted of a 5mm photovoltaic cell mounted in a handheld unit. Each sensor was placed in tubes 2 cm long to provide a 30-degree field of view for each sensor. Five of these sensors were placed in the handheld unit, as shown in Figure 11.7, allowing the camera to observe a 30-degree x 90-degree region.

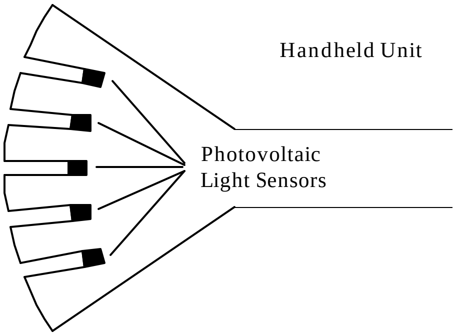

Figure 11.7. Sensors.

To allow the microcontroller to read the light level from the light sensors, a buffer circuit is used to amplify the voltage produced from the sensors to a 0-5V signal. Two AD 626 instrumentation amplifiers provide a gain of 100 for the sensor and remove any common-mode noise. A 0.47uF capacitor provides a low-pass filter with a corner at approximately 1 Hz to prevent aliasing at the A/D converter. A diode is then used to reduce the sensitivity of the sensor at high light levels.

For this device, the 6811 microcontroller acts as a five-channel voltage-to-pulse width modulation converter. The 0-5V signal from the buffer is read into the 6811 from Port E, an 8-bit A/D converter. Using real time interrupts, these inputs are read every 32.77ms. Each

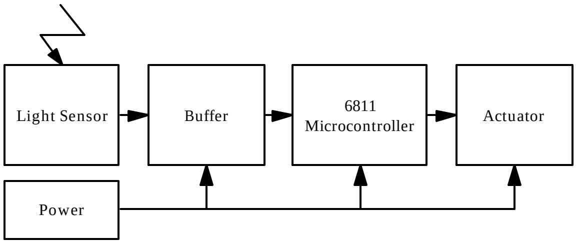

Figure 11.6. Block Diagram of the Device.

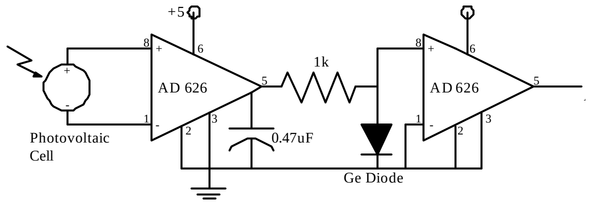

Figure 11.8. Buffer Circuit.

time they are read, the value read from the A/D is copied to a buffer (Figure 11.8).

Five pulse-modulated signals proportional to the voltage read from the A/D converters are generated by the 6811 through the real time clock. Every timer overflow (time=00) causes an interrupt that sets the outputs from Port B high (the start of the PWM signal). When the on-board timer exceeds the value in the buffer for a light sensor, the appropriate bit on Port B is cleared. This creates a 0-5V PWM signal with a duty cycle nearly 0% for a dark room and nearly 100% when the sensor is pointed at a white object in the room.

The actuators chosen for this project are five STA pull type solenoids from Lennex Corporation. These solenoids require 24V to operate and provide a pull strength of approximately 0.3N. The iron shafts of these solenoids are connected by a spring to a rod above the solenoids. When no current is applied, the rod is fully extended. The 6811 can then control the height of these solenoids by adjusting the voltage applied to the solenoid.

A 2n222 transistor serves as a power amplifier for the 6811 to drive the solenoid, as shown in Figure 11.9.

The cost was $502.

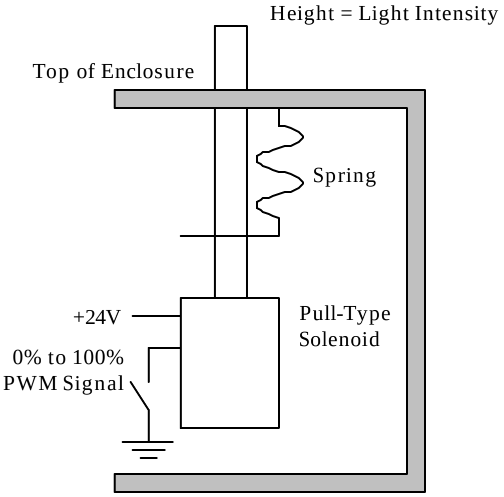

Figure 11.9. Solenoid.

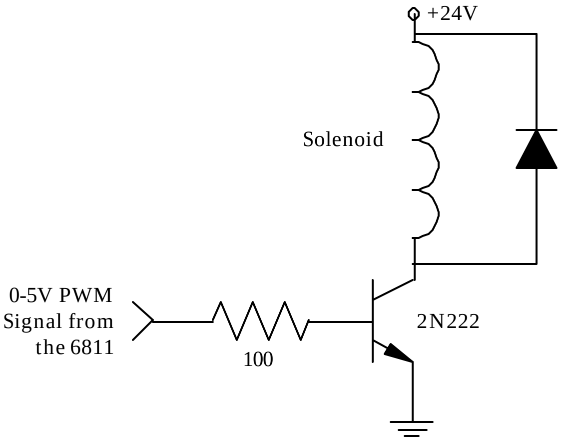

Figure 11.10. Another Circuit for the Device.

EXERCISE ENHANCER

Project Engineers: Jamie Hauser, Kasey Morlock, Jeremy Mattson, Don McAdoo
Client Coordinator: Jon Hinrichs, Hawley High School, Mawley, MN
Supervising Professor: Dr. Jacob Glower
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INTRODUCTION

Exercise and conditioning are important for maintaining one's health. Exercise strengthens muscles, improves coordination, and may even improve one's mental state. Exercise is especially important for someone who is recovering from an accident, or for elementary school students with limited coordination.

Unfortunately, while exercise is important, exercises are often inconvenient, requiring a physical therapist to ”encourage” and supervise, and expensive, as such programs are often not reimbursable by insurance. In addition, exercise programs may require individual attention - something a K-12 instructor is not able to provide when teaching a large class.

A device that is inexpensive, portable, computer controlled, and capable of monitoring one's exercises automatically, is a tool that could eliminate common concerns about exercise programs. Such a device would enable teachers to provide individual exercise plans for students with limited coordination, allow the students to work on their own, and to monitor their activity without taking time away from other students.

One type of exercise commonly used for conditioning and rehabilitation exercise requires the patient to hop back and forth as fast as he/she can for a set amount of time. Numbers are often painted on the floor, as shown in Figure 11.11, to facilitate the activity. A physical therapist or teacher then counts how many times the patient can do several different patterns (such as hopping from square 4 to 5 and back, 4 to 2 to 5 and repeat, etc.).

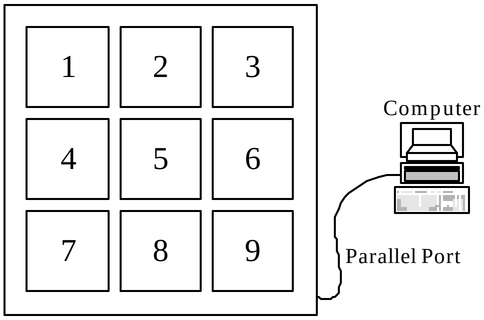

Figure 11.11. Grid.

In this project, an instrumented floor connected to a PC was built. Design criteria were that the floor allow the therapist to prescribe the pattern to follow, allow the therapist to determine the time of the test, have the total number of successful repetitions automatically counted and recorded on the PC, be portable, and be inexpensive.

SUMMARY OF IMPACT

First, the Exercise Enhancer may allow instructors to better monitor the progress of students who are recovering from an injury or have limited coordination.

Second, the ability to better monitor the progress of students allows instructors to accurately assess the efficacy of different exercises.

Third, the Exercise Enhancer is completely automated, so instructors may be able to work with more students at one time. The computer conducts tedious activities such as counting and recording the number of repetitions for each exercise.

This device was delivered to a high school for evaluation. Future improvements will make this device usable by any physical therapist or teacher.

TECHNICAL DESCRIPTION

The foot speed timer is a grid of nine squares that is set up on the floor. For this design, a 3.2m x 3.2m square made of plywood was used for strength and cost effectiveness.

Each of the nine panels is made out of a separate 35cm square piece of plywood. Four doorstops are placed under each panel, raising them when no weight is applied. When a student stands on a panel, the doorstop compresses and a switch underneath the panel closes. In this way, a 3x3 keypad is created, allowing the instructor to monitor which square (if any) the student is standing on.

The nine switches in the floor panel are connected to the parallel port of a PC along with pull-up resistors as shown in Figure 11.12.

With this setup, the parallel port can be read using C++ for DOS. The readings for the student standing on each panel are summarized in Table 11.1. Note that by using the wiring shown in the previous figure, three pins should read high and three should read low at all times. This provides a error correction and allows the software to detect when the parallel port cable has not been connected to the platform.

Software to monitor the parallel port and detect these sequences was written in C++ for DOS. This software allows the operator to monitor the number of times the student completes an exercise as well as the time it takes to go between squares to 1/60th of a second.

The total cost for this device was $178.

Square Student is Standing On	Data on Parallel Port Pins 2/3/4/5/6/7
None	010101
1	100101
2	001101
3	000111
4	110001
5	011001
6	010011
7	110100
8	011100
9	010101

Table 11.1: Parallel Port Readings According to Panel.

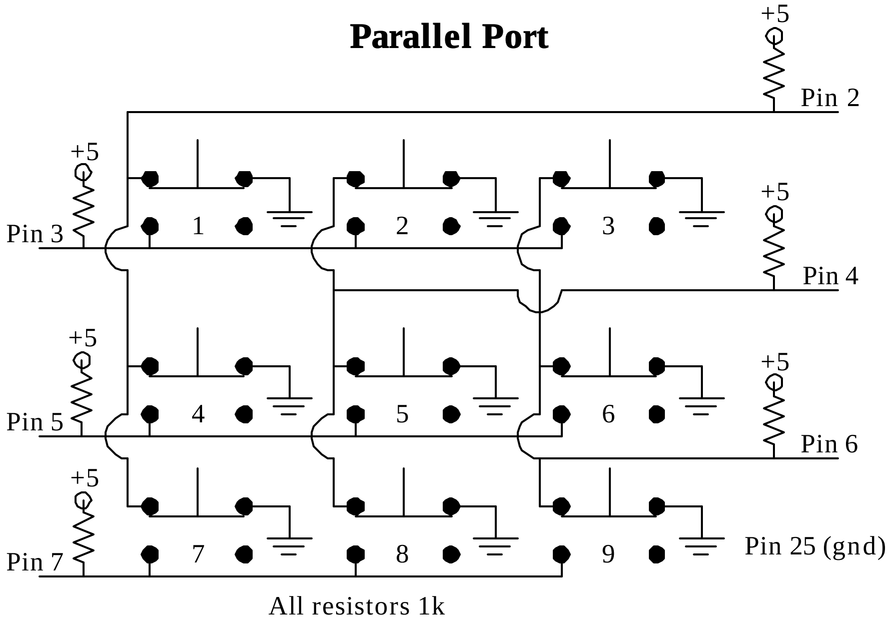

Figure 11.12. Circuit Diagram.

FORCE MEASUREMENT FOR PROSTHETICS

Project Engineers: Scott Wandler, Randy Kahlstorf, Dan Lang, Bryan Smith
Client Coordinator: Lisa Miller, St. Alexius Medical Center, Bismarck, ND
Supervising Professor: Dr. Jacob Glower
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INTRODUCTION:

Physical therapists at a medical center requested a device to provide balance feedback to patients who use prosthetic legs. The device was to measure the weight a patient applies to his/her prosthetic limb, and display this weight to the patient.

It is hoped that, with biofeedback, patients will be able to "feel" how much weight they are applying to a prosthetic limb. This in turn may help accelerate the process of learning to walk with the prosthesis.

SUMMARY OF IMPACT

This device was delivered to physical therapists at a medical center. Based upon their experience using this device, further refinements will be necessary.

TECHNICAL DESCRIPTION

Since prosthetic limbs are relatively expensive and custom designed for each patient, it was not considered feasible to place a force sensor on the limb itself. Instead, a device was sought that can be added to a shoe.

The Force Measurement for Prosthetics Device consists of two main components: a force sensor and a hand-held display. The force sensor selected was a pair of Air Nike running shoes. These shoes have an air pocket along the length of their soles. As the patient places more weight on the shoe, the pressure in the air pocket increases. (Note: both Air Pippen basketball shoes and Air Nike running shoes were used in this project. Air Pippen basketball shoes do not experience a significant change in air pressure when one stands in the shoe - almost as if the air pocket were decorative. The Air Nike running shoes proved to be much softer and more sensitive.)

To measure this air pressure, a hypodermic needle is inserted into the air pocket of the running shoe. This needle is glued to a piece of surgical tubing 1.5m long with a 100psi pressure sensor (Digikey part NPC-410) glued to the other end, creating a disposable needle/pressure sensor unit. A second surgical needle is placed on a basketball pump for reinflating the shoes prior to use.

The output of the pressure sensor is amplified with a gain of 100 by an AMP04 instrumentation amplifier. This signal then drives a 10 segment LED bar display.

The LED bar display is controlled by a TSM-3914 chip. This chip has two reference resistances (Rlow and Rhigh) and Signal In voltage as its inputs. Rlow determines the voltage at which no LEDs are turned on. Rhigh determines the voltage where all ten LEDs are turned on. Intermediate voltages then activate a proportional number of lights.

Two potentiometers allow the operator to set the two control voltages. When the operator is not applying any weight to the show, the low set point is adjusted until no LEDs are on. When the operator places all of his/her weight on the shoe, the high set point is adjusted until all LEDs are lit. From that point on, the LED display will show the approximate weight the patient is applying to that foot - from 0% to 100% of their weight.

The resulting design for this device costs $198 - 70% of which comes from the running shoes. By using off-the-shelf running shoes, this device should be usable for any patient with any shoe size. Further, since the air pocket can be reinflated (it leaks, however the pressure will remain for a day or two - long enough for a walk), the same pair of shoes can be used for a several patients. Finally, since the bar graph display can be calibrated for each user, this device should be usable for both children and adults.

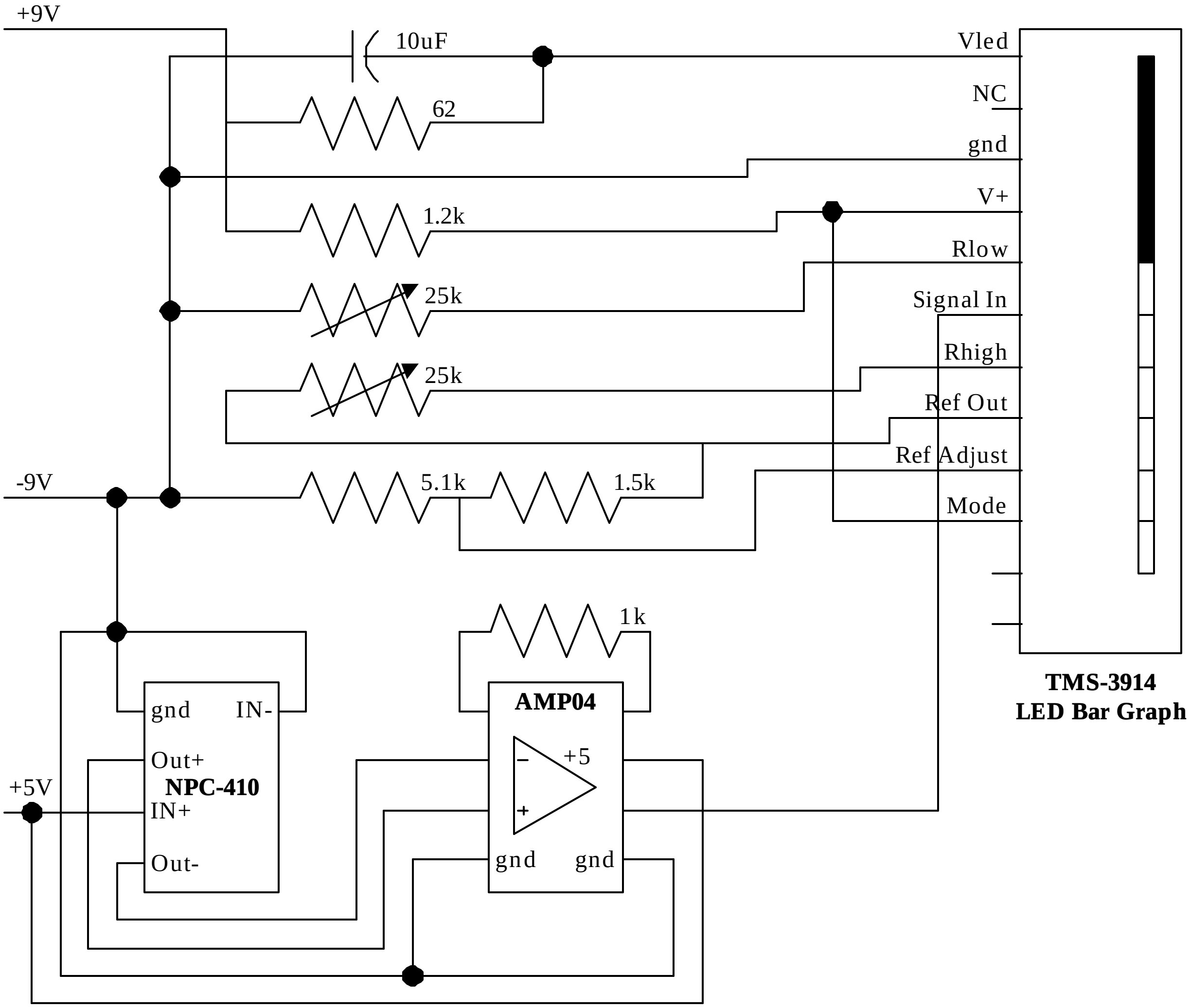

Figure 11.13. Circuit Diagram for the Device.

VOICE SPECTRUM ANALYSIS

Project Engineers: Cheryl Bernstetter, Tanya Hylden, Scott Swanson
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INTRODUCTION

Learning to speak can be a difficult process. Even the smallest of words must be heard repeatedly over time before a plausible resemblance of the word is uttered. This process of auditory recognition is the primary method of learning to speak.

For individuals with hearing impairment, learning to speak may seem impossible. Limited auditory ability makes learning to speak difficult. Sign language and obtaining feedback from a hearing person may be the only means of communication for individuals with hearing impairment. Many of the electronic speech labs on the market can be very costly, cumbersome, and difficult to operate. In addition, learning to use these devices requires person-to-person contact, which can be a drain on a speech-language pathologist's time and resources.

With these obstacles in mind, the project engineers set out to design a method for helping individuals with hearing impairment learn to speak and pronounce words accurately.

SUMMARY OF IMPACT

The portable PC and software will be tested and monitored by a professional from a communications firm starting in the summer of 1998. The feedback obtained through the initial use of the device will eventually lead other design groups to improve the device to make it usable by any speech-language pathologist and/or client.

TECHNICAL DESCRIPTION

Design Approach:

One of the desired outcomes of this project was to use the clients' visual ability to help them learn to speak. Linguistic sounds can be broken up into distinct components called phonemes. Phonemes are combined to form words. Phonemes are audibly distinct due to their formants, which are unique groups of waveforms of varying frequency and intensity. Spectrograms display these groupings, providing a visual representation of speech graph indicating time, frequency and intensity. This display would distinctly show the groupings of the waveforms, their frequencies, and their intensities, thereby giving a display unique to each word.

For example, the word “speaking” is displayed in a spectrogram on the following page. The horizontal axis displays time, starting with the /s/ sound on the left and ending with the /ng/ sound on the right. The vertical axis displays frequencies, starting from DC on the bottom to 10kHz on the top. Intensity is displayed showing the strongest sounds in bright colors and the weakest sounds in dark colors.

The /s/ sound contains a large amount of white noise and is seen by the first 20% of the sound. The /p/ is a sharp spike just after the quiet dark zone, one third of the way from the beginning of the word. The long /e/sound shows a clean signal with a strong overtone. /k/ is a sharp noise 70% of the way through the word. A soft /i/ followed by a /ng/ sound completes the word.

A desired outcome of this project is portability and user friendliness. If the software interface is written to be user-friendly, this teaching aid could be used independently of the speech-language pathologist. If it is designed to be portable, the client could take the device home and out into diverse environments, increasing the amount of practice time available to the client.

Cost is the greatest concern for this project. Most other electronic speech tools are very expensive, costing up to $20,000. A lower-priced tool would enable more speech pathologists to acquire this technology for their labs, increasing the resources for their clients.

In order to meet the desired outcomes, a laptop PC was selected for this project. These computers meet the requirement for portability, cost less than $2,000, have voice inputs built in, and have graphical displays as required for this project. Further, by developing software for a laptop PC, anyone who owns a PC will be able to use the software free of charge.

Functional Description

Software routines were written for the PC using MATLAB.

First, the target signal must be chosen. This target defines the "correct" pronunciation of the word and serves as a target the patient is trying to match. Two options exist here: either a previously recorded .WAV file can be used as the target signal or a new .WAV file can be created. This flexibility allows the patient to use the device on his/her own time independent of the speech-language pathologist by using previously recorded files. The speech-language pathologist can also record new words for his or her clients as progress is made.

Next, once a target signal is selected, the spectrogram of the target signal is displayed on the top half of the screen using several modified MATLAB routines.

Once displayed, the operator is prompted to try to match the word. A .WAV file is created, recording whatever the operator says. This file is then converted to a spectrogram and displayed on the lower half of the screen.

At this point the similarity or difference between the target and the attempt should be apparent.

If the operator wishes to try again, he/she may go back to the sound recorder, create a new .WAV file, and display the new attempt.

The cost for this project was approximately $2,500 - due to the requirement of a portable PC for the project and compilers for the design group. Once the software is finalized and compiled, the cost to the user should be nothing. If the user has a PC with Windows 95 and a microphone, he/she must simply install the software.

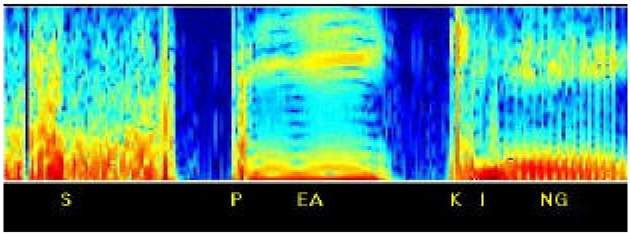

Figure 11.14. Spectrogram of the Word "Speaking."