# CHAPTER 17
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# TELE-TALK: A COMMUNICATION DEVICE FOR PERSONS WITH HEARING IMPAIRMENT

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## INTRODUCTION

Currently, devices available for a person with a hearing impairment to communicate over phone lines have limitations. The most common device used for telephone communication, the Telecommunications Device for the Deaf (TDD), must interact with another similar TDD unit. If a caller does not have a TDD, a call to a special service provider involves an operator typing and transmitting TDD data. Likewise, the operator can receive data and speak the responses to the non-TDD user. Having an intermediary requires extra time to make the translations and is available in only limited regions of the country.

For people with partial hearing loss, a telephone audio amplifier is often used. However, when this device is used in conjunction with a hearing aid, audio feedback may result. Some telephones have a variable volume control feature to limit the amount of feedback in the hearing aid. The feedback coming from the hearing aid within the user's ear is sometimes painful.

Tele-Talk is a device designed to allow a person with a hearing impairment to communicate directly with the person they are calling.

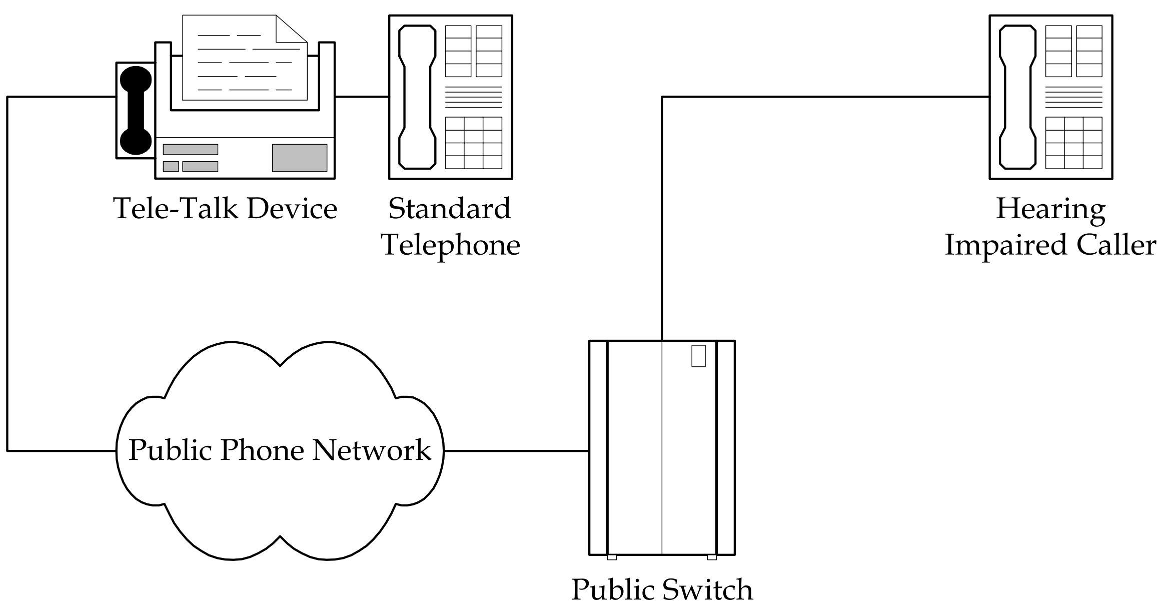


Figure 17.1. Phone Service Connections.

## SUMMARY OF IMPACT

Tele-Talk is a device that allows a person with a hearing impairment to communicate directly with the individuals they are calling. This device uses many off-the-shelf components, including speech recognition software, a telephone interface, and a Head-Mounted Display (HMD). The software requirements include seamless or continuous voice translation, quick access to a dictionary of words, and appropriate input/output device signal processing. The software runs on a compact computer motherboard, which digitizes incoming speech and transmits digital output to the appropriate display device. In addition to the internal display unit, a Head-Mounted Display (HMD) was developed. The HMD unit provides wireless, ergonomic, line-of-sight viewing of the text output. This makes Tele-Talk ideal for conference settings, where eye contact with multiple people is necessary.

## TECHNICAL DESCRIPTION

Tele-Talk is comprised of five central components:

- telephone signal processing
- speech and input/output software
- A central processing unit (with associated hardware)
- A built-in graphical display, and
- An external HMD.

A telephone usually plugs into an RJ11 phone service jack. Tele-Talk uses the same port to act as a handset, or simply provides a pass-through connection to the original telephone, as shown in Figure 17.1. Users still use the telephone to place and receive calls.

The user with a hearing impairment is able to use the telephone to place an outgoing call and enable Tele-Talk when the recipient picks up on the other end. Tele-Talk and the HMD unit must be powered on prior to placing/receiving calls.

The display shows a greeting message when the unit is ready to handle calls. One of the most important features of Tele-Talk is its display formats. The text is translated directly from the telephone line and sent to the display where it can be read for several seconds before scrolling off the screen. The HMD unit display is ergonomically adjustable and allows extended viewing with reduced eye and muscle strain. Tele-Talk may be left in standby mode when not in use, and disassembles into compact, portable components that may be carried within a briefcase.

### *Telephone Signal Processing*

The phone signal received and the analog audio output are input to a sound card. The Xecom XE0068 is used for ring detection, 2 to 4 wire conversion and supplying the analog output signal needed for the sound card, as shown in Figure 17.2.

A transmit function is able to transmit the hearing impaired user's voice over the phone line after it is

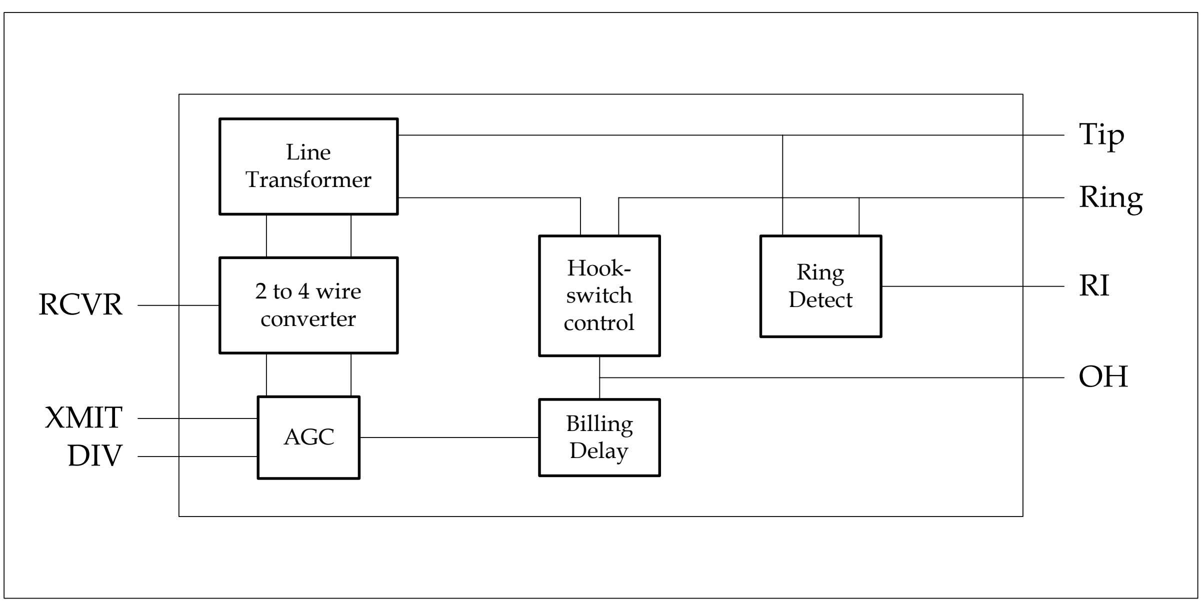


Figure 17.2. Block Diagram of the Communication System.

received from the microphone. A visual indicator shows the status of the phone line and signal incoming calls. This information is provided at the output of the DAA module from the ring indicator, RI, and the Hookswitch Control, OH. When the phone rings, the input is low and the output goes high to turn on the light. A 7404 inverter is used to drive the ring indication LED. The receiver output is wired to a 1/8" jack and plugged into the sound card.

### *Speech Recognition Software*

The Speech Recognition software was chosen for continuous speech, speaker independence and a large vocabulary. The Dragon Naturally Speaking Preferred Edition is the software that best met the requirements.

### *Central Processing Unit*

The AAEON (PCM-5890) embedded computer exceeded the requirements of the speech recognition software. The computer has an Intel Pentium 200 MHz central processing unit and a 72-pin SIMM (Single Inline Memory Module) 64 MB EDO memory module. The motherboard has an onboard 512KB pipeline burst L2 cache. There are serial, parallel, and keyboard connectors on the embedded system that are needed for the initial programming and testing of the system. The serial port (RS-232) is used for one-direction communication with both display units. The keyboard is needed for character input to install the operating system and software. The internal IDE interface is used for data transfer from the hard drive and the CD-ROM. The CD-ROM is only needed for the installation of the operating system and the software and was removed after the initial software installation. The floppy drive interface connects to a 3 ½-inch disk drive to aid in the installation process. The PCM-5890 supports CRT displays and Mono, STN, and TFT color panels at a resolution of 1024 x 768 with 256 colors. The unit also displays both CRT and LCD displays simultaneously, which is done during the testing process. The maximum power requirement with an Intel 200MHZ processor at +5VDC is 6 amps.

### *System Power Configuration*

Figure 17.3 illustrates the power configuration for the Tele-talk device. The system can either operate from the 12VDC supply while plugged in, or from the rechargeable battery when no wall outlet is available. The master control switch keeps the battery from being drained if the device is unplugged and not in use. The master control switch must be in the on position in order for the device to operate. The switch lights up to indicate that it is in the on position. The power supply used to power the computer is the HE104. A 12VDC DPDT relay is used to switch between the 8.4VDC from the rechargeable battery and the 12VDC from the AC/DC adapter. This relay

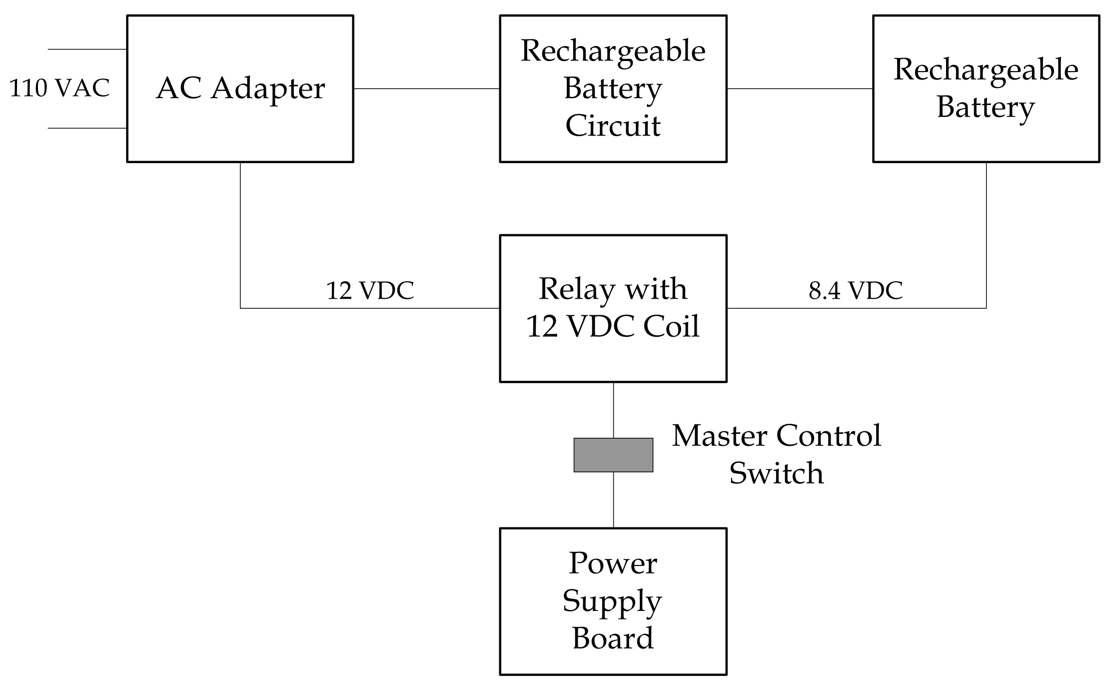


Figure 17.3. Power Configuration.

has contacts that are rated for up to 10 Amps due to the high current draw for this application. One set of contacts, which are normally open, are connected to the 12VDC from the AC adapter, and a separate set of contacts, which are normally closed, are connected to the 8.4VDC, which is supplied from the battery. The 12VDC relay coil is connected to the 12VDC from the AC adapter. When the coil is energized (coil closes), the normally open contacts close, and the normally closed contacts open. Therefore, if the device is plugged in, the relay coil is energized and the 12VDC contact is closed, and the 8.4VDC battery contact is open. If the device is unplugged, the 12VDC contact is open and the 8.4VDC battery contact is closed. The outputs of the two contacts are tied together and the switching time for the relay is less than 25ms. For this application, an 8.4VDC NiMH battery is used. This battery has a current rating of 6AH. The rechargeable battery was recharged using the Maxim 712CPE fast charge circuit.

### *Internal Graphical Display*

The internal display unit is a TFT-LCD (Thin-Film-Transistor Liquid-Crystal Display) graphical display with a 12.1 inches diagonal viewing area, made by Toshiba. The Tele-Talk device is shown in Figure 17.4. The display area is 800 pixels × 600 lines. This display has EL backlighting allowing the unit be used in situations where proper lighting is not always available. This graphical display was chosen because it is compatible with the CPU, size, and low power consumption. The graphical display also allows the use of a mouse to load and run the software. This is an important feature since upgraded versions of speech recognition program and operating systems will be continually produced.

### *External Head-Mounted Display*

The HMD shown in Figure 17.5 is central to Tele-Talk's conferencing applications. It provides the user with complete freedom of movement while relaying the translated conversation directly to one of his or her eyes. By combining the virtual display image on one eye, and the user's normal vision on the other, the


Figure 17.4. Tele-Talk.

translated text is superimposed over the user's line of sight. Allowing the user to maintain eye contact with other subjects is critical to the practical success of a daily-worn virtual display. The virtual display system is enclosed in two parts, a belt pack, and the glasses-mount headgear.

The belt pack serves a multitude of purposes. It contains the control board for the display optics. The wireless link circuitry, signal processing board, and portable power supply also resides in the belt pack.

The text sent to the HMD exits Tele-Talk's serial port, where it is pre-processed for transmission at 1200bps via a Linx Technologies LC series TX/RX chipset. The 1200bps data rate, combined with the carrier-present, carrier-absent transmission format, allows extended range from the base unit and helps combats bit errors. The text is generated through Tele-Talk's voice processing software and is then mirrored to a terminal emulator running a script to send all translated text out the serial port. Though not essential, the link uses a bi-directional RS-232 protocol; the HMD only sends device state codes back to the main unit (to satisfy the terminal emulator).

The display incorporates a patented vibrating mirror assembly by Reflection Technology. Image-modulated columns of 256 LEDs are used with a horizontally vibrating mirror to produce a crisp, monochromatic image of 864 by 256 pixels. The optics are light and power efficient. The focal distance and bi-level brightness can be adjusted. The control for the optics is based on a Motorola 68000 processor. Custom printed circuit boards were made to house the Linx TX/RX chipset and the signal processing electronics, augmenting the P5's native controller board. A Maxim Electronics RS-232 driver connects to an encoder, to communicate with the controller board.

Tele-Talk allows a person with a hearing impairment with vocalization skills to communicate freely on a telephone via cutting-edge voice recognition software implemented within a self-contained portable computer-based system. The incoming telephone signal is intercepted, processed, and shown textually on an easy-to-read display. A HUD allows further freedom and improved ergonomics while using the device. Until now, telephone communication required special external services, intermediaries, or caller-dependent hardware, such as TDDs for a person with a hearing impairment. Tele-Talk effectively addresses these issues by providing an independent, versatile, voice translator for the hearing impaired.

The total cost of this project is $4,447.

Figure 17.5. Head Mounted Display.

# REMOTE DOOR LOCK CONTROLLER

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## INTRODUCTION

The Remote Door Lock Controller unlocks a door mechanism using a wireless remote controller. Such a device is helpful for people with limited motor abilities who may find this task difficult.

## SUMMARY OF IMPACT

The Remote Door Lock Controller is designed for a client with some paralysis due to Cerebral Palsy. The client had expressed a desire to have a remote door lock controller because it is difficult for him insert and rotate a key. The client also desired the added security that this device would provide to his apartment door, which he otherwise would not be able to manually lock. The device is designed such that it will not interfere with other household devices. Also it is secure enough so that only the client and the apartment complex administrators can access the door lock and enter the apartment.

## TECHNICAL DESCRIPTION

The Remote Door Lock Controller, essentially a wireless remote, is made up of two major parts:

- A wireless remote controller and
- A receiver that also controls the electric deadbolt (the door lock mechanism).

In operation, the user unlocks a door by pressing a button on the remote controller. A signal scrambler on the remote transmitter and its receiver/electric deadbolt controller is employed, making unauthorized access virtually impossible. Figure 17.6 illustrates the Remote Door Lock Controller.

Velleman distributes a kit that comes complete with instructions, boards, and components that are useful in constructing a simple function remote RF transmitter and its receiver. It also employs a signal scrambler, which prevents unauthorized access of the receiver/door lock controller. The wireless remote uses a RF spectrum frequency of 433.92 MHz to transmit the addressable unlock command. This wireless remote employs an IC, which scrambles the information to be transmitted so it can prevent unauthorized use.

The user presses the UNLOCK button on the remote transmitter. An addressable command encoder assigns a particular bit string to that command. The transmitter sends the bit stream at 433.92 MHz to the receiver. The receiver reconstructs the command to its original DC form. The descrambler IC decodes the digital pulse, enabling the addressable command controller to create a 9V signal that activates a relay that in turn controls the electric deadbolt mechanism. The electric deadbolt mechanism unlocks the door if the 12VDC signal is present. Simply pushing it closed locks the door.

The approximate cost of the Remote Door Lock Controller is $600.

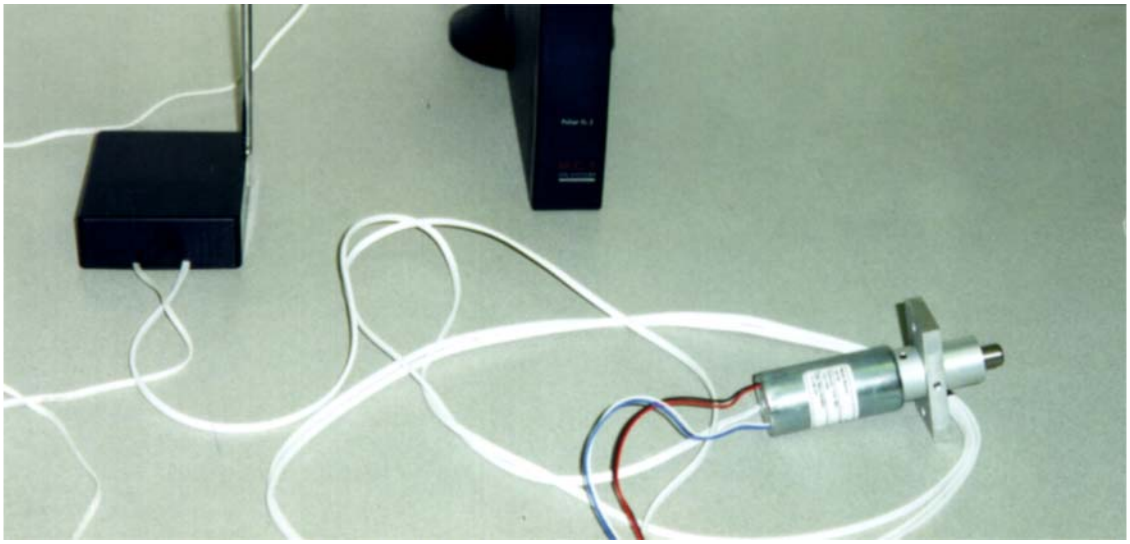

Figure 17.6. Remote Door Lock Controller. The device with the antenna (left) is the receiver with two small transmitters shown next to the deadbolt. A large uninterruptible power supply is in the rear.

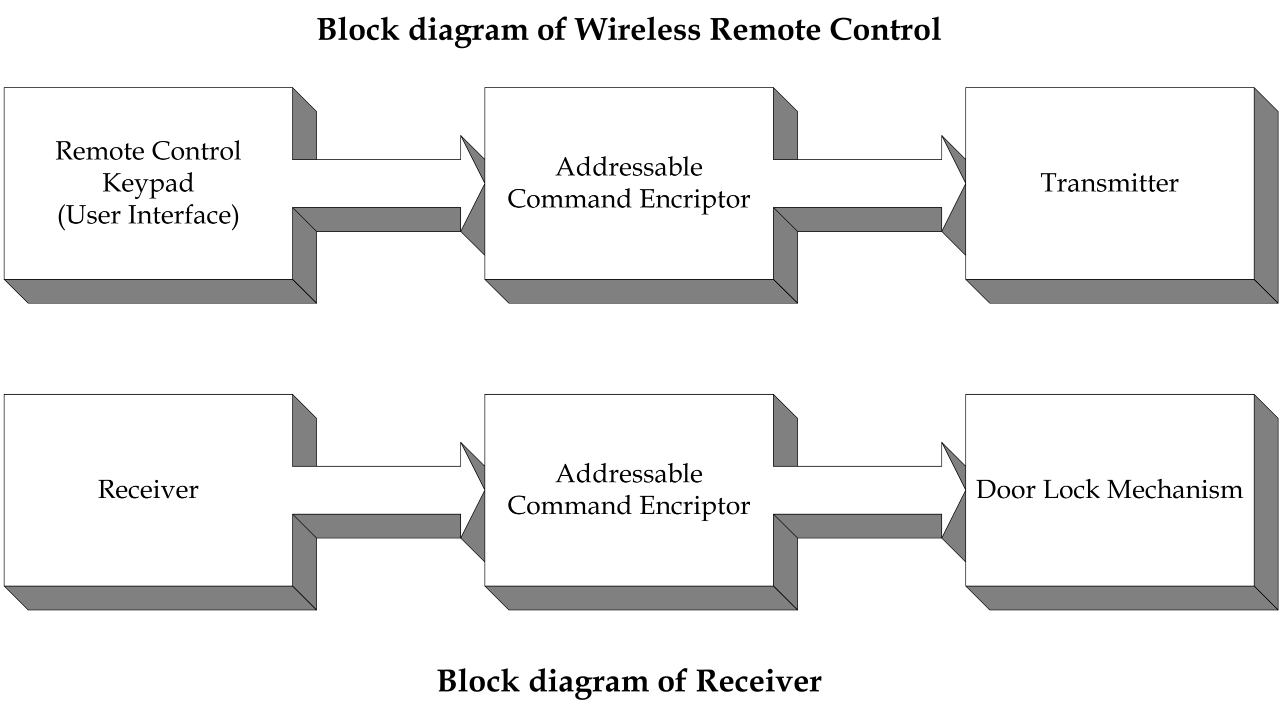


Figure 17.7. Block Diagram for the Remote Door Lock Controller.

# REMOTE ENVIRONMENTAL CONTROLLER

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## INTRODUCTION

The Remote Environmental Controller (REC) is a wireless remote control device that controls household lighting using simple on/off commands. The REC is helpful for people with limited or no motor abilities by enabling them to control the environment without moving throughout the house.

## SUMMARY OF IMPACT

The client has spina bifida and is in a wheelchair. He requested a device that allows him to control household lighting. The Remote Environmental Controller (REC) is a wireless remote control system that is portable and easy to operate.

## TECHNICAL DESCRIPTION

The REC consists of:

- A wireless remote controller,
- A receiver that controls the individual appliance switches,
- An individual addressable light, and
- Wall power switches

The device is shown in Figure 17.8. The addressable switches employ a Sears X10 operation control protocol. This protocol is a 5V pulse generated by a controller and modulated onto the house AC line at the zero crossing point with the purpose of controlling compliant equipment. In operation the user activates a light or an appliance in the house by pressing the appropriate button on the remote controller. X 10 protocol devices are used instead of RF communication devices since they are commercially available and are less difficult to mechanically implement.

To operate, the user depresses the ON button for a particular appliance or light on the remote keypad. In turn, the addressable command encoder assigns a particular bit string to that command and it will only activate a particular light or appliance. The transmitter sends out the bit string at a frequency of 310MHz. The receiver reconstructs the 310MHz command back to its original DC form. Then the addressable command modulator creates a specific 5V, series of 120kHzpulses for that command. They are then mixed in at the zero crossing of the 60HZ cycle of the AC power line by the modulated command mixer. Finally these 5V, 120kHz command pulses are interpreted by the appropriate addressable switch that is X10 protocol compliant.

The approximate cost of the Remote Environmental Controller is $500.

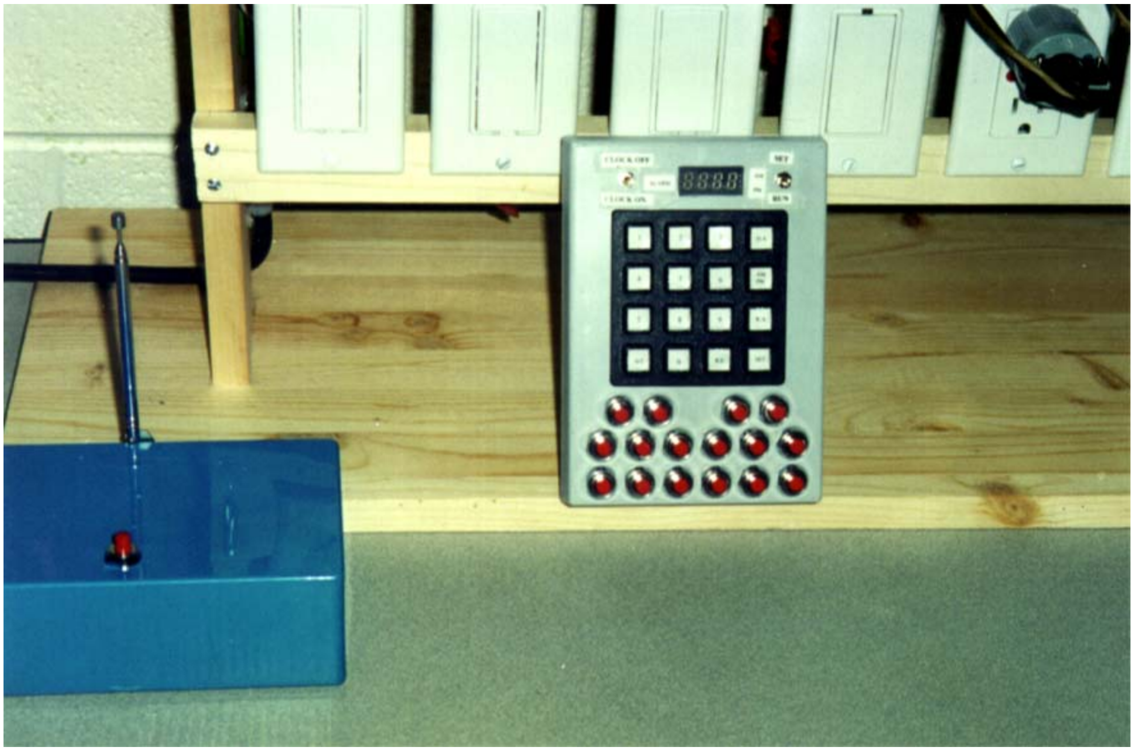

Figure 17.8. Remote Environmental Controller. The Receiver is on the left. The Remote Controller is the device with the keypad in the center. Addressable wall switches are shown in the rear, still attached to their test bed.

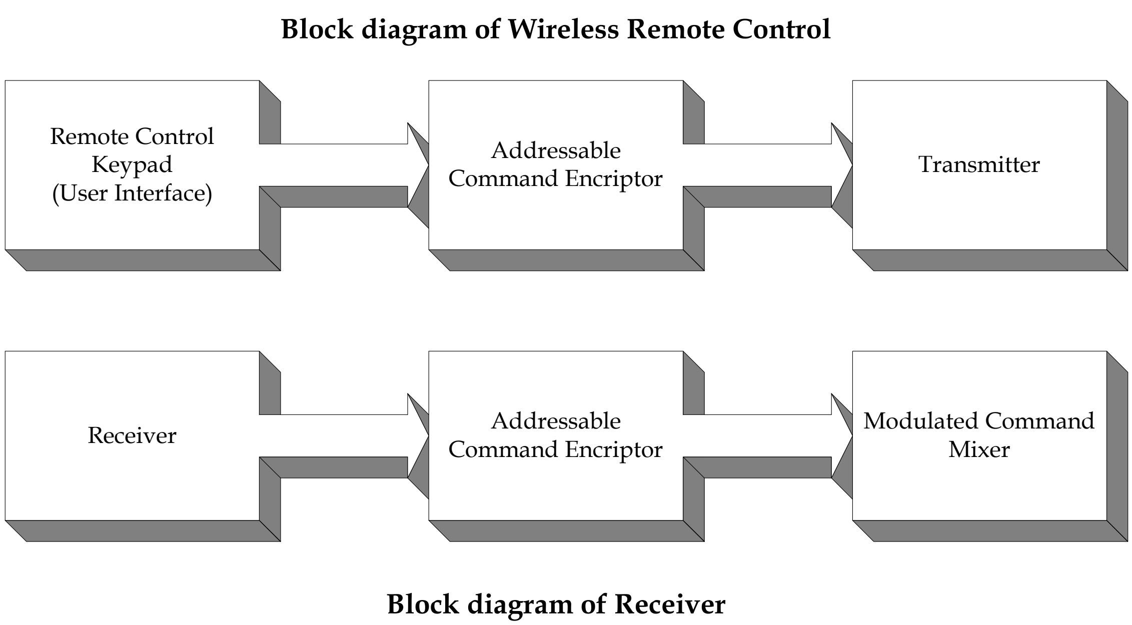


Figure 17.9. Block Diagram for the Remote Environmental Controller.

# VOICE THERMOSTAT REMOTE CONTROL

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## INTRODUCTION

The client, a 46 year-old gentleman with multiple sclerosis (MS) and paraplegia, desires a device that allows him to control the temperature at his residence. The device is voice actuated, circumventing his impairments. A voice-activated chip is utilized in the design and fitted to a thermostat. The device is speaker dependent. Safety features are incorporated into the device allowing it to be deactivated should a malfunction occur. The user speaks the desired temperature into a built-in voice sensor (microphone), the signal is processed, recognized, and sent to the thermostat, which in turn regulates itself according to the given instruction. A photograph of the device is shown in Figure 17.10.

## SUMMARY OF IMPACT

The demand for products using voice recognition technology is increasing, partly because of innovative and significant improvements made in this area. Many people would benefit from this technology.

## TECHNICAL DESCRIPTION

The device consists of four main blocks, called stages. A block diagram of the device is shown below in Figure 17.11. The first stage contains a microphone and an analog wave filter. In this stage, the user's speech is conditioned so that it can be interpreted by the recognition system. The next stage incorporates the recognizer. Here, the conditioned signal is processed and an output digital word is generated in its output. The third stage comprises a decoder. Here, the output word is converted to a suitable digital word that regulates the thermostat accordingly. It also helps with the display of the room and desired temperature. The fourth stage includes the output displays, a prompt speaker, and a deactivation switch.

### *Input Stage*

The spoken word (command) is amplified and filtered to a level suitable for the recognition chip. The filter provides approximately 53dB of low-noise mid band gain, 2-bit controllability, and 1st-order band-pass response with 3dB points at roughly 700Hz and 3.3KHz. The built-in voice sensor is made up of an omni-directional microphone with an amplification of 58dB.

### *Recognizing stage*

The recognizer contains a speech recognition chip called the VoiceDirect IC. In addition to performing speech recognition, the chip plays speech prompts, performs control functions, provides status outputs, and interfaces to external ROM and serial EEPROM. The chip's neural network recognizes words or phrases with greater than 99% accuracy.

### *C. Decoding Stage*

The decoder is a logic circuit that converts the digital output word coming from the recognizer to suitable levels of voltage that control the thermostat. There is one distinct level of voltage and digital word that corresponds to each desired temperature setting and voltage level.

### *D. Output*

The output stage simply takes the values given by the decoder, and drives the thermostat and the LED displays. Here, a thermostat utilizing comparators and a ±1°F accuracy temperature sensor is implemented.

The approximate cost of the Voice Thermostat Remote Control is $530.

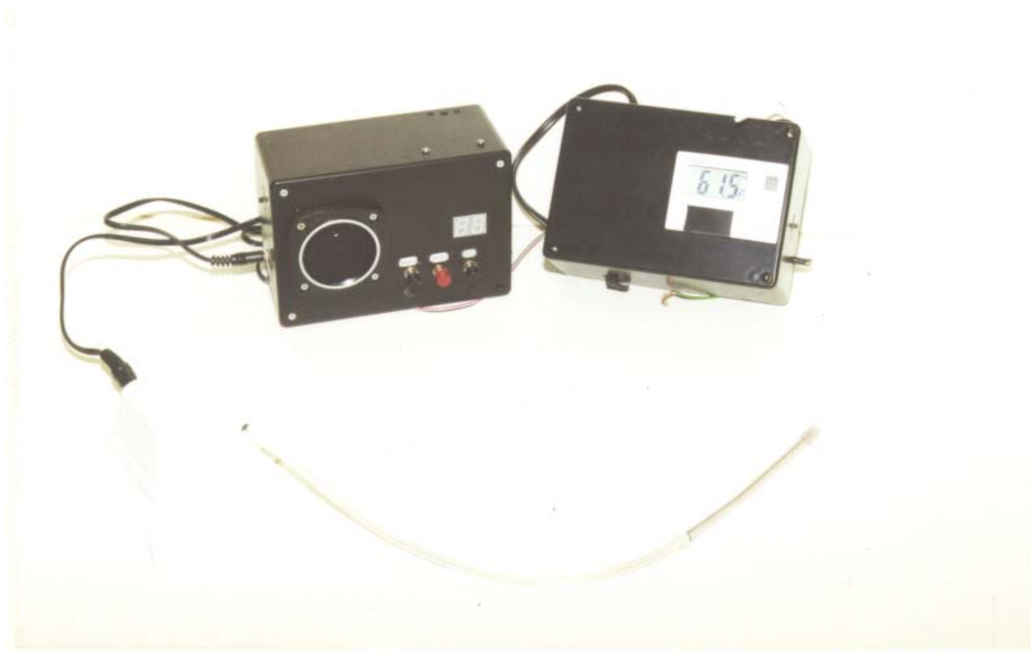

Figure 17.10. Voice Thermostat Remote Control.

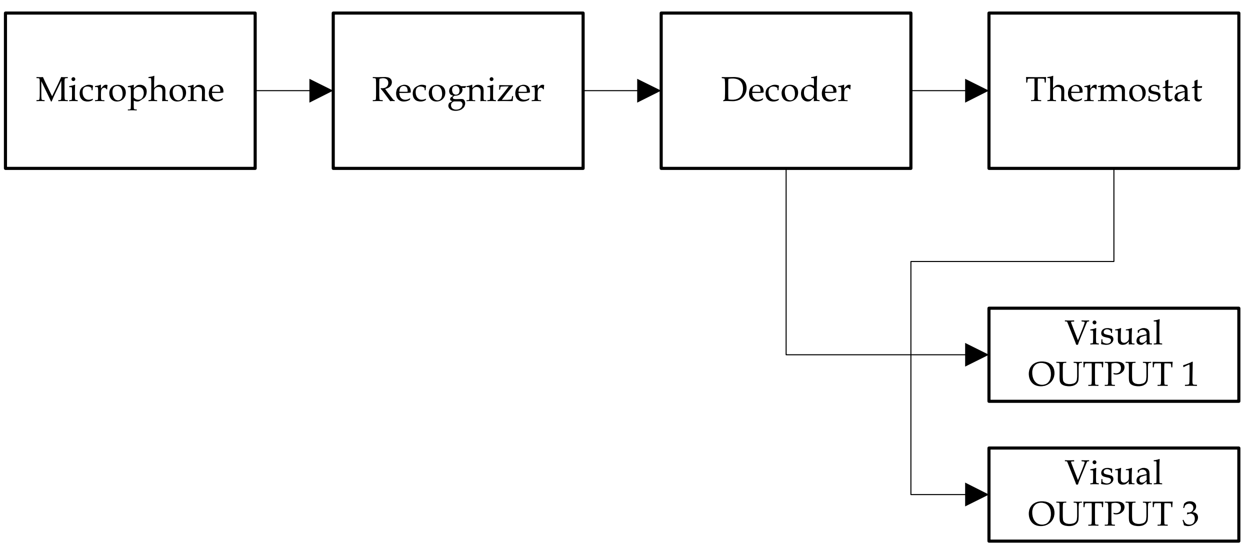


Figure 17.11. Block Diagram of the Voice Controlled Thermostat.

# HAND AND FOOT DRIVEN TRICYCLE WITH UNIQUE ROWING DESIGN

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## INTRODUCTION

A hand and foot driven tricycle (T-Rider) is designed for a fifteen-year-old girl with an inner ear disorder that affects her balance. This project addresses her desire to have a recreational device, such as a bicycle, which incorporates specialized safety devices that allow her to ride without concern with regard to her balancing difficulties.

Since the intended user is weak in both her arms and legs, an ordinary dual hand and foot pedaled tricycle is difficult for her to use. The T-Rider will be propelled by a combination of hand (arm) and foot power where the hand power is more from the upper body and supplied by a rowing motion. A standard caliper lever is mounted on the handlebars to provide the braking power to the front tire. A coaster brake stops the rear tire when the pedals are reversed. A freewheel hub is provided so that in between rowing motions, the bicycle will simply coast.

## SUMMARY OF IMPACT

The design criteria for the T-Rider are defined by the capabilities of the client. The intended user desires a device that provides therapy, exercise, and above all enjoyment. This device is suitable to meet the needs of the intended user’s physical strengths.

## TECHNICAL DESCRIPTION

T-Rider utilizes an existing adult size tricycle frame. A local cycle shop donated the frame for the T-Rider. This frame is extensively modified to meet the needs of the client. The frame has two bars on each side of the rider instead of the standard tricycle frame that has one center bar (shown in Figure 17.12). The rider is seated much lower in the tricycle and the bars distribute the rider's weight more evenly. The bars also act as brush guards to protect the rider's legs from obstacles, such as branches. The seat is designed to provide support and comfort for the rider. The seat is set at a 50-degree angle and utilizes a Velcro chest strap to keep the rider securely fastened to the seat. The seat is welded low in the frame to place the rider in a comfortable stable position. Flip up armrests are included to allow easy transfer from a wheelchair into the T- Rider.

A chain connected to the handlebars drives the front drive system. This chain can by placed in various mounting positions to increase or decrease effort required to provide propulsion. The other end of the chain is connected to a spring that returns the handlebars back to original position after the rider has completed a rowing motion.

The rear drive is constructed using a 1/2-inch steel rod. The rod ends are cut at forty-five degree angles and welded in a crank fashion. This crank is mounted to the frame with enclosed bearings that allow for the rotation of the crank. Special medical foot restraints are used for the pedals. These are sized to a specific shoe size and have two Velcro straps to keep the riders feet securely fastened into the pedals. The chain that drives the rear tire rides on a sprocket that is welded to the crank pedal system. The T-Rider is constructed using standard BMX bicycle parts allowing the owner to easily replace or modify any of the parts.

The cost of parts/material was about $650.

Figure 17.12. T-Rider.

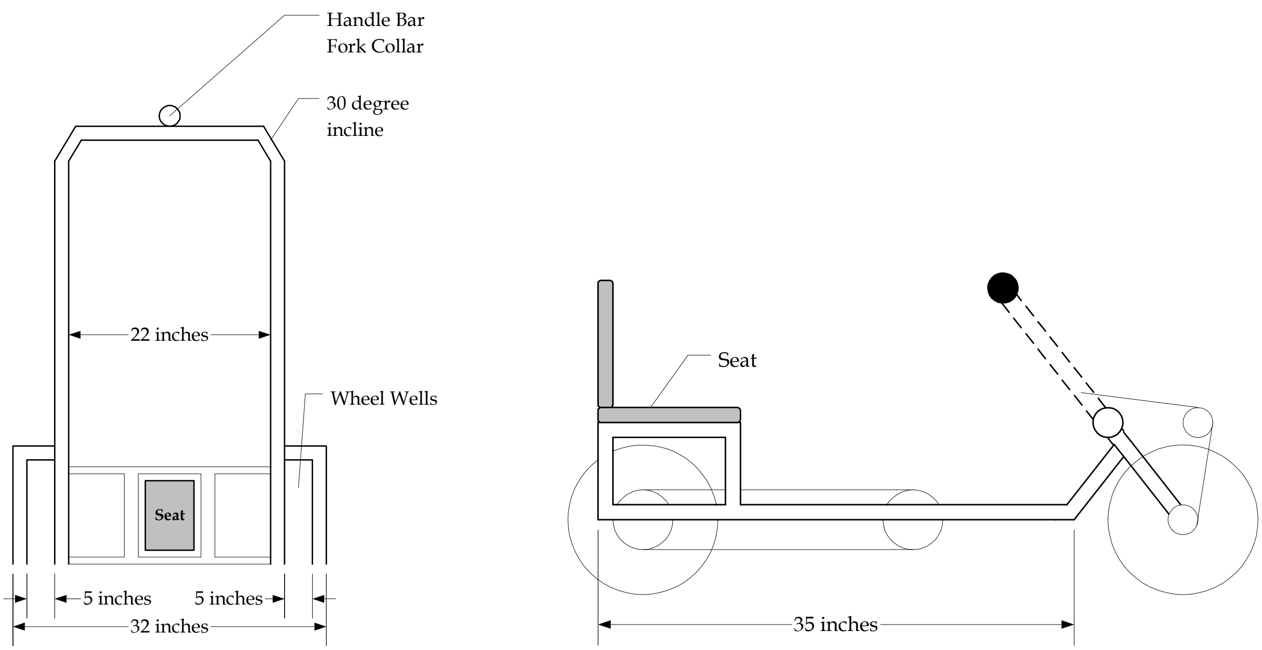


Figure 17.13. A. Front view of the T-Rider. B. Side view of the T-Rider

# A COMMUNICATION DEVICE WITH SEQUENTIAL LIGHTING

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## INTRODUCTION

A communication device (Light-Com) enables the user to depress a button corresponding with a picture item in order to identify personal needs or items for educational purposes. Light-Com utilizes large lighted areas and controllable reaction times to accommodate different abilities.

The light-Com is designed specifically for a child with cerebral palsy, who is non-verbal and hearing impaired. The client is capable of depressing a switch, given a sufficient amount of time to achieve this movement. When the child sits in her chair, her head is tilted back at approximately a 30-degree angle. A device that lays flat on a table or desk directly in front of her is difficult for her to see. The client's teachers have been mounting an existing device on books and boxes in order to raise the device into a comfortable position; requirements are such that it is at eye level during usage. The Light-Com is shown in Figure 17.14.

## SUMMARY OF IMPACT

It is difficult to evaluate the cognitive abilities of children who are non-verbal and have hearing impairments. By placing an item into one of the cubbyholes and a corresponding picture onto the card rail, the teacher can ask the student to stop the light progression when the illuminated light reaches the correct item. Once it has been established that the student can make a conscious decision of which item he or she desires, the devise may then be used for communication. A teacher or parent can put different items, such as a toy, a food item, a cup of juice, or a toy block, in each of the cubbyholes. The student may then be asked to stop the light progression at the desired item. The large lighted areas of different colors make the exterior of the device appealing to a child. It also helps the child distinguish between the different items.

Figure 17.14. Light Com.

## TECHCNICAL DESCRIPTION

The device consists of four large cubbyholes. The rear walls of the cubbyholes are colored plastic lenses, making each compartment easily distinguishable. The enclosure and lenses are constructed using 1/4 inch Plexiglas. On the top surface of the device there is a card rail to insert photos or flashcards. A wheelchair-mounted switch is also provided.

A digital circuit controls the sequential illumination of the device. The components included in the digital circuit are:

- A LM556 timer chip,
- A LM163 2 bit counter,
- A LM139 2 to 4 decoder (demultiplexor),
- An lM7404 inverter chip,
- A ULN2803 Darlington array to supply sufficient current to the lamps, and
- A JK flip flop.

Since the switch is a one-position momentary switch, a debounce circuit containing a resistor and capacitor with a JK flip flop is implemented to obtain two distinct states. When the switch is depressed once, the output is a digital "high" output. When the switch is depressed again, the output is a digital "low" output. This circuitry controls the enable pins on both the counter and Demux.

During normal operation, the timer provides an adjustable clock pulse to the 2-bit counter. Connecting the first timer in the LM556 chip to a 3 Meg Ohm potentiometer provides the adjustable clock pulse. This potentiometer is mounted on the side of the enclosure for the teacher or user to set the speed interval of the flashing lights to a comfortable rate. The clock time can range from microseconds to 26 seconds, which is a sufficient amount of time for the child to react to the light. The counter sends the 2 bits into the 2-4 decoder, counting in progression at each clock pulse. Since a low signal is shifted through the 4 bits, an inverter was used to obtain the high signal. This high signal then goes into the Darlington array that sinks up to 500mA that is sufficient to drive the lamps. A block diagram is shown in Figure 17.15.

The circuit is powered by a 120-6 volt AC transformer, or by 4 D cell batteries mounted in a battery pack that is accessible from the rear compartment of the enclosure. The lights used are standard one-watt flashlight bulbs. The elliptical reflectors from flashlights are also used to project the light onto the lenses.

The cost of parts and materials was about $200.

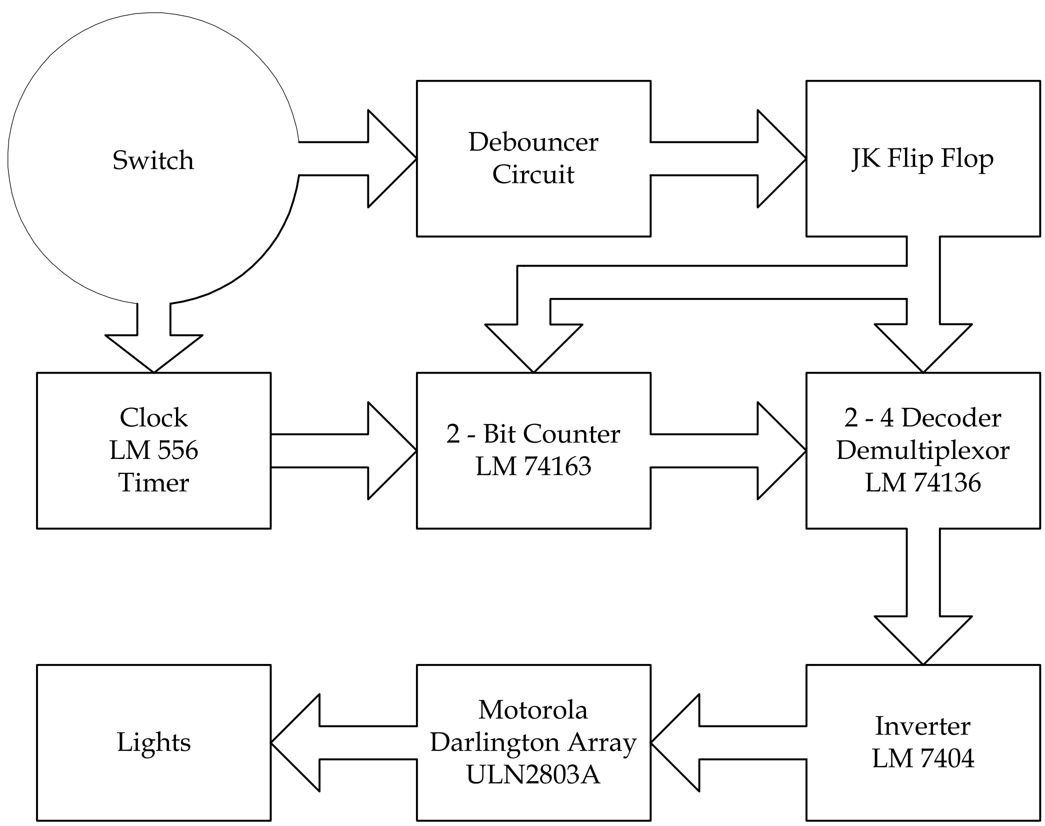


Figure 17.16. Block Diagram of Light Com.

# ASSISTED MUSICAL/LEARNING DEVICE (AMLD)

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## INTRODUCTION

The Assisted Musical/Learning Device (AMLD) is an electronic device that combines musical creativity and educational applications into one. A front and side view of the device is shown in Figures 17.16 and 17.17. The AMLD enables a person with cerebral palsy to play a musical instrument, and makes learning basic hand and eye coordination skills through a unique control panel an enjoyable experience.

There are many effective educational and musical devices that can be operated with ease. However, the same devices pose problems for individuals with physical impairments, preventing them from performing the minute operations required to operate such devices.

The client is a seven-year-old boy with cerebral palsy. The client is cortically blind and has weak vocal cords and limited motor coordination. He uses a wheelchair. He expressed the desire to play a musical instrument. However, he cannot play a hand-held musical instrument. The AMLD has large, easily manipulated control buttons and is designed to be played without the user holding the device. It can be attached to a wheelchair.

## SUMMARY OF IMPACT

The AMLD may improve the quality of life for some individuals by helping them practice hand and eye coordination while helping them learn letters, shapes, and numbers. But most of all, the device is fun to use.

## TECHNICAL DESCRIPTION

The AMLD produces five piano sounds and five drum sounds. The sounds are initiated by pressing one of the five buttons attached to the device console. Each of the five drum buttons represents a different drumbeat, and each piano button a different pitch of a piano. The unique design of the AMLD console allows an instructor to interchange buttons with different designs embossed on them. These designs can be shapes, numbers or letters. Once the desired buttons are installed, the instructor asks the user to identify a particular shape or digit and then press the proper button.


Figure 17.16. Assisted Musical/Learning Device (AMLD).

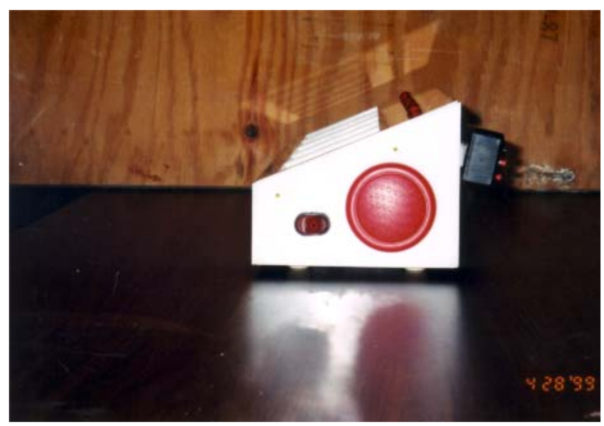


Figure 17.17. Side View of AMLD.

Shown in Fig. 17.18 is a block diagram of the device. Eleven different lines electrically connect five console buttons to one another. These buttons, which are mechanically differentiated by unique pin designs on their reverse, pass a signal on to an ISD voice record/playback chip. The ISD chip is an analog-sampled data system with:

- An on-chip microphone pre-amp,
- Anti-aliasing and smoothing filters,
- A storage array,
- A speaker driver,
- A control interface, and
- An internal precision reference clock.

The chip has the ability to store 60 seconds of sound using an internal clock sampling frequency rate of 6400 Hz, utilizing a 10-bit address. There are 52, 3.5 " Plexiglas buttons that correspond to letters of the alphabet and varying shapes and musical sounds, resulting in 52 different pin combinations. Upon pressing one of the buttons, that particular signal is transmitted into the ISD chip, which initializes a certain address within the chip. This particular address stores a pre-recorded musical note or verbal sound of the educational aspect to be learned. The signal is then amplified by an LM386 voice amplifier and then reproduced by two eight-ohm speakers. There are two outputs each time one of the buttons is depressed. These outputs correspond to the control button indicating lights and the audible output sounds associated with the button being pressed

The remote control is used for the instructor to communicate with the client. It allows the instructor to illuminate one of the five indicating lights above the actual control buttons, thus indicating which buttons are to be pressed.

The total cost is approximately $500.

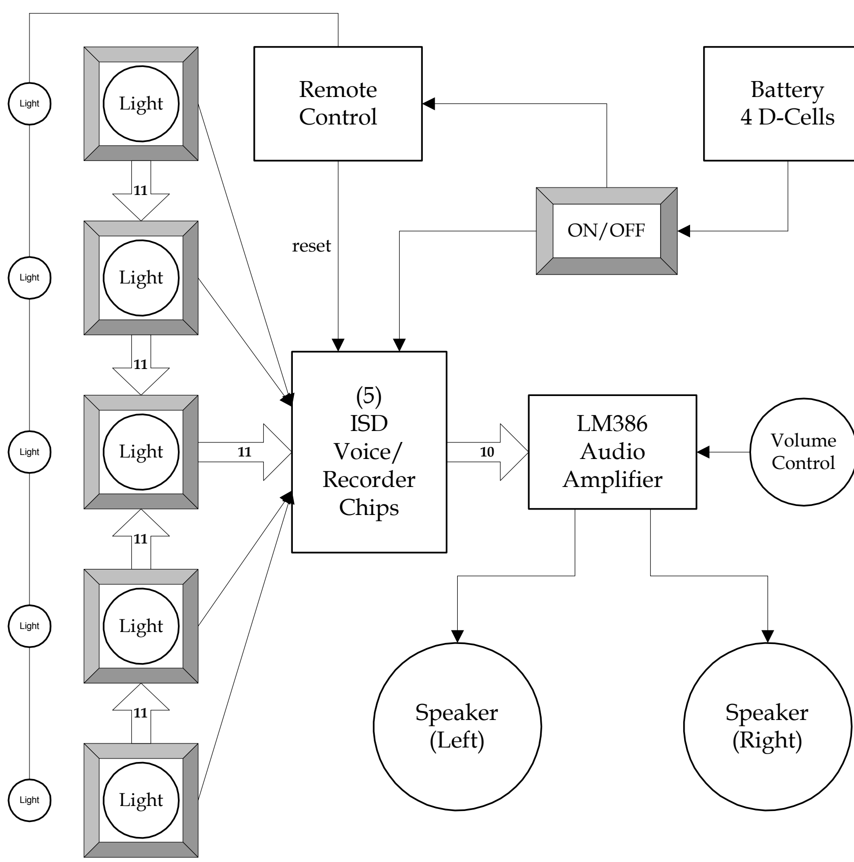


Figure 17.18. Block diagram of AMLD.

# ELECTROLOCK: A VANDAL-PROOF, 12-BUTTON PROGRAMMABLE KEYPAD TO CONTROL AN APARTMENT DOOR

*Designer: Tu Anh Le*
*Client Coordinators: Dr. Lee Mclean, Ms. Carol Magliocco from the UCONN A.J. Pappanikou Center*
*Supervising Professor: John D. Enderle*
*Department of Electrical and Computer Engineering*
*University of Connecticut*
*260 Glenbrook Road*
*Storrs, CT, 06269-2157*

## INTRODUCTION

An electronic keyless security system is needed to give the mother of a 12-year-old girl with autism full access control with confidential coding, while preventing her daughter from wandering off. The device can withstand hundreds of pounds of force, more than enough to handle the child's potential destructive forces.

## SUMMARY OF IMPACT

The Electrolock provides a fail-safe electronic security system in a practical, affordable and easy-to-use package. It uses 6-digit access codes to lock and unlock the door. The Electrolock is vandal proof and can withstand any destructive force that the client may cause. Therefore, this device gives the client's mother a sense of security. A photograph of the final device appears below in Figure 17.19.

Figure 17.19. Electrolock. Shown is the keypad controller with the electronic deadbolt to the right.

## TECHNICAL DESCRIPTION

The Electrolock system controls one door. The system consists of five main components:

- A 12-button alphanumeric keypad,
- A BL1600 micro-controller,
- An OP6000 keypad-LED-beeper interface,
- An electronic deadbolt, and
- An external 12VDC supply.

### *Keypad system*

Three to six digit codes in any combination (even repeated digits) can be entered into the Electrolock to lock or unlock the door. Six-digit codes allow up to one million possible combinations. There are two types of codes, access and authorization. Access is for lock/unlock operation while authorization is for changing both codes. The keypad system has two LEDs that indicate lock and unlock status. Codes are stored in non-volatile EEPROM memory. There is an audible key beep when codes are entered from the keypad. One of the most outstanding features of this product is the immunity to all types of electromagnetic interference (EMI) and radio frequency (RF). All electronics are housed in a steel case. A block diagram showing codes operation is shown below in Figure 17.20.

### *Output*

This system yields one high current output. The rating of this output is 12 VDC and 1 Amp, enough to drive a 12 VDC, 0.94 Amp electronic deadbolt.

### *Electronic Deadbolt*

The heavy-duty electronic deadbolt is a 12VDC fail-safe version that locks when the power is applied, and unlocks when the power is removed. This deadbolt can withstand hundreds of pounds of force, and it is also recommended by the fire department for its high safety and security standards.

The cost of parts and material was about $434.

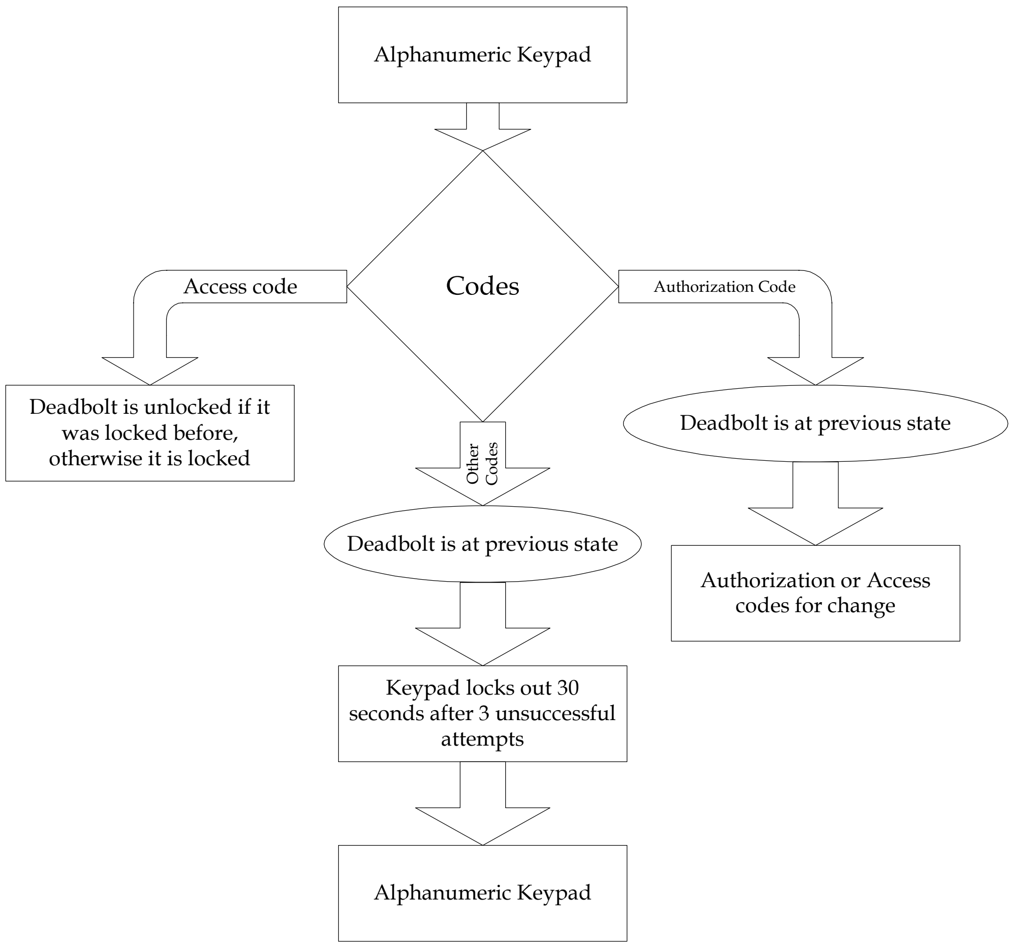


Figure 17.20. Block Diagram Showing Codes Operation.

# HAND-HELD ELECTRONIC MAGNIFYING CAMERA FOR PATIENTS WITH VISION PROBLEMS

*Designer: Tu Anh Le*
*Client Coordinators: Dr. Lee Mclean, Ms. Carol Magliocco from the UCONN A.J. Pappanikou Center*
*Supervising Professor: Dr. John D. Enderle, Ph.D.*
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*260 Glenbrook Road*
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## INTRODUCTION

A hand-held electronic magnifying camera was designed for a client who is legally blind due to the effects of multiple sclerosis on her optic nerves. Magcam is an inexpensive and portable magnifying camera that transmits magnified images to a display screen. It is less expensive and more portable than a closed circuit television (CCTV), a device that many with low vision find helpful.

## SUMMARY OF IMPACT

The small, lightweight (less than 2lbs.), portable and compact (palm held) Magcam provides CCTV quality at a low price, providing visually impaired people the ability to see and read. The device is shown in Figure 17.21.

## TECHNICAL DESCRIPTION

Magcam has four basic elements:

- A magnifying camera,
- A video processor controller,
- An AC adapter, and
- A displaying screen.

The display can be any TV, computer monitor or LCD (with video input port).

### *Camera Assembly*

Maximum magnification provided by the Magcam ranges from one-third to double the size of the display. Magnification is variable to the display size. No focusing or lens adjustments are needed. The Magcam remains in focus when the camera is moving. The camera operates using 9 VDC. It does not have any memory to store data; it acts simply as a video transmitter that sends the scanned information to the video processor. The camera has a DCX (Double Convex Lens) to focus and magnify at the same time. The camera uses a push on/off switch.

### *Video Processor Controller*

A video processor controller is separated from the camera assembly in order to reduce camera weight. This also allows the camera to be hand-held. The video processor contains a microchip that modulates and transmits information from the camera to the display screen. This device is used to convert the base-band signal from the camera into a TV channel.

The cost of parts/material was about $ 234.

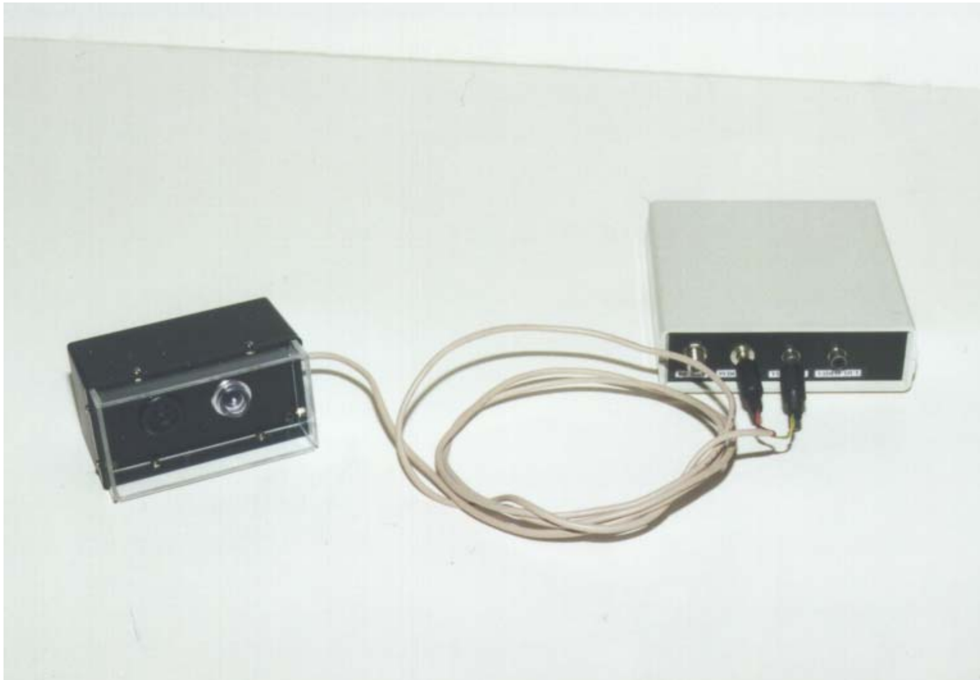

Figure 17.21. Magcam Camera Assembly (Left) and Video Processor Controller.

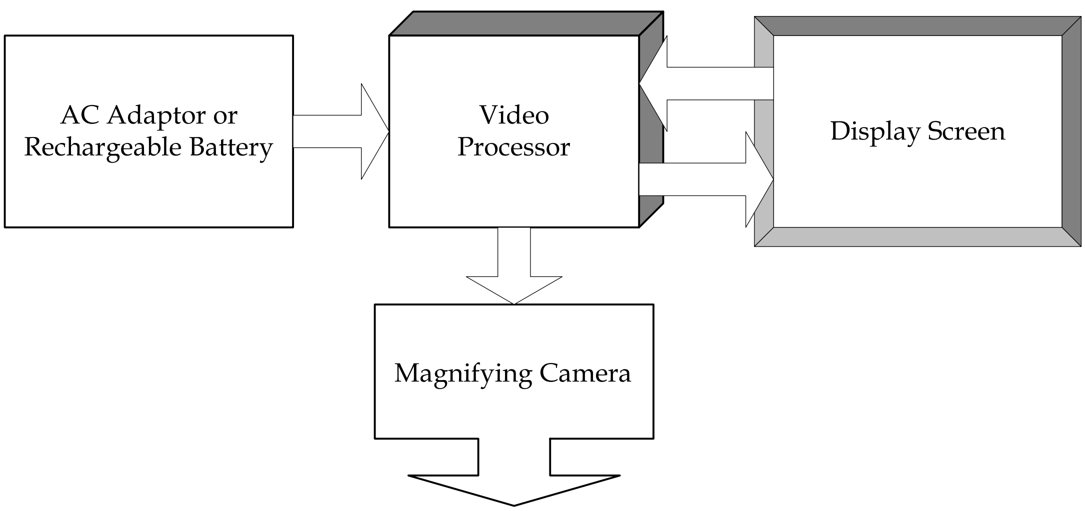


Figure 17.22. Magcam Block Diagram.

# VOXEBOOK AUGMENTATIVE COMMUNICATION SYSTEM

*Designer: Alexander B. Krasij*
*Supervising Professor: John D. Enderle*
*Electrical and Computer Engineering Department*
*University of Connecticut*
*Storrs, CT 06269-2157*

## INTRODUCTION

The Voxebook is an augmentative communication system integrating existing notebook computer technology with specially designed software with an external switch, providing the user with a quality communication method. The device is designed for a user with cerebral palsy who experiences severe speech and writing challenges, to allow him or her to have an effective way of communicating.

## SUMMARY OF IMPACT

The client for whom this project is designed is a nine-year-old boy with spastic quadriplegia due to cerebral palsy. With motor impairments in all four limbs, it is very difficult for him to control his environment. The augmentative communication software was designed to allow flexibility to adapt to the client's needs over time. The Voxebook addresses both communication and learning issues and makes the interface accessible to the user.

## TECHNICAL DESCRIPTION

The Voxebook Augmentative Communication System utilizes existing speech synthesis technology to provide the user with a voice. The software utilizes the industry standard Picture Communication Symbols (PCS) icon library by Mayer-Johnson in its graphical user interface, for easy recognition, especially since the client is familiar with these symbols. The accessibility modifications to the notebook computer include an external switch connected to the PC that allows for a user with mobility impairments to interact with the software. In combining these features in a unified system, an effective communication method is provided. A picture of the Voxebook is shown in Figure 17.23.

Hardware components include:

Figure. 17.23. The Voxebook System.

- A standard unmodified Pentium class notebook computer (which is inexpensive and sufficient for the software the system runs),
- An external augmentative communication switch, and
- An adapter used to interface the two.

The most important characteristic of the software is its usability, allowing the user to make the necessary selections to navigate through its various screens. The Voxebook system has its own proprietary software, called Voxeware, a speech output communication software package. The target education level for the software is from first through fifth grade. The Voxeware software package is a stand-alone product, so it is possible to cleanly exit from it to the operating system and to use other software on the same machine. It is also possible to run the Voxeware software on any other computer running Linux that is configured with the appropriate hardware, including desktop systems.

The user mode of the software displays a screen showing the six icons of the current board layout.

The selection process begins immediately, consisting of a selection field moving clockwise through each of the icons in succession and then it repeats. When the appropriate icon has been highlighted, the user depresses the external switch to select the image. As each image is highlighted, the device outputs the corresponding speech sequence. Once an image is selected, it is highlighted in a more pronounced way, the speech sequence is repeated, and a new board is displayed on the screen. The process is then repeated until the user selects an icon that represents a final choice, in which case the selection process has ended and no new boards are displayed. Once this is accomplished the program returns to the main menu or repeats the process, depending on the configuration of the user mode. The software includes a configuration mode that allows board layouts to be created, linked, loaded, and saved.

The cost of this project is $3249.

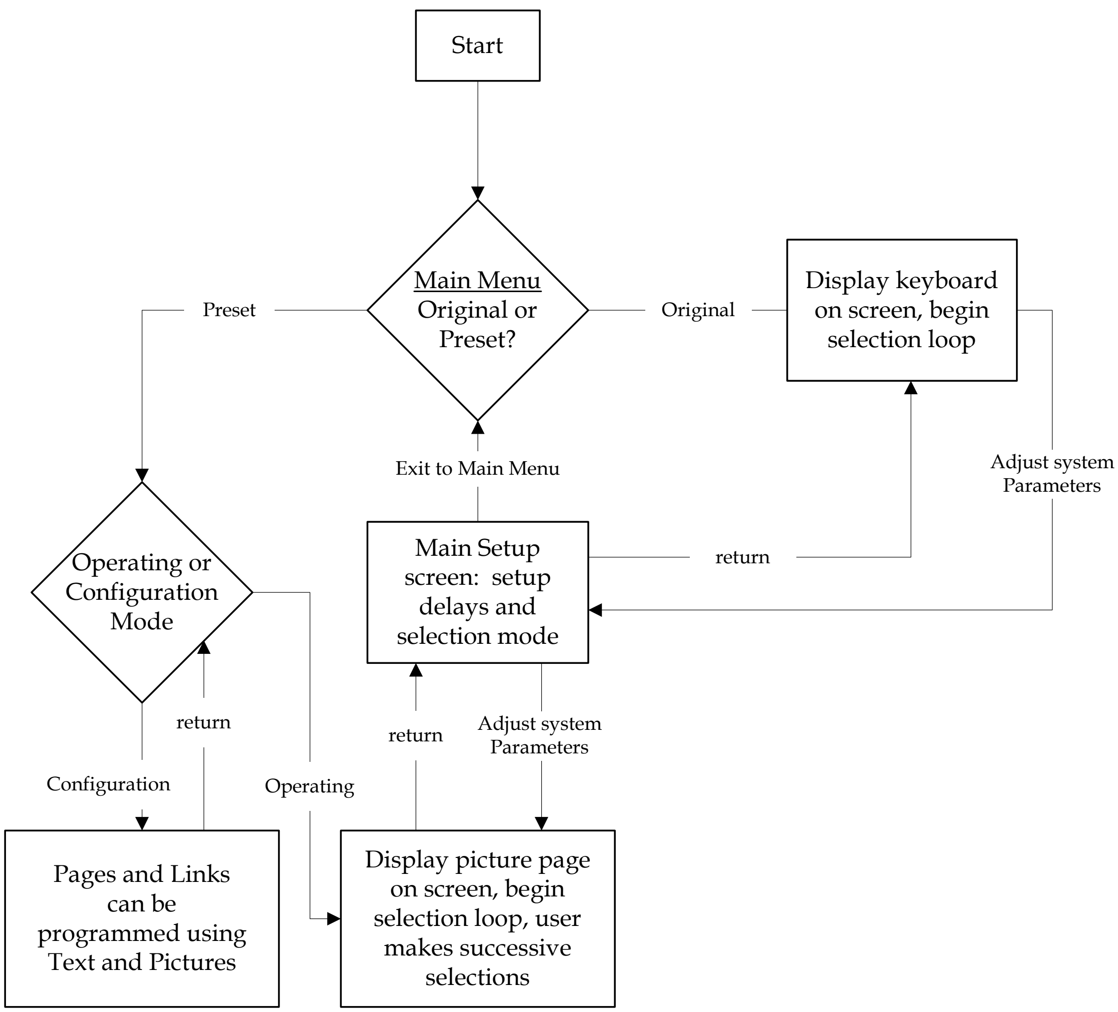


Figure. 17.24. The Voxebook Block Diagram.

# DIGITAL HEARING AID

*Designer: Jason Mitchell*
*Supervising Professor: John D. Enderle*
*Technical Assistant: William Pruehsner*
*Electrical and Computer Engineering Department*
*University of Connecticut*
*Storrs, CT 06269-2157*

## INTRODUCTION

The Digital Hearing Aid (DHA) was designed to be a low-cost, digital replacement for a standard analog hearing aid. There are many advantages to using a digital hearing aid, the main one being its programmability, which allows for a more precise auditory fitting to match the client's needs. A digital hearing aid processes sound waves by encoding them as a series of numbers that measure pitch and volume at any instant in time. This method of processing the sound wave, bit by bit, is more precise and allows for filtering of background noise without affecting overall sound quality. Feedback reduction algorithms are used to minimize any hearing aid whistling that is caused by acoustic feedback. Since hearing loss also includes sensitivity changes to certain sound frequencies, this customization improves the user's hearing capabilities. To implement this design, the client must acquire an audiometric profile from an audiologist. The audiometric profile is typically mapped and downloaded to the memory of the digital hearing aid where it is stored for use when the aid is fitted to the individual.

## SUMMARY OF IMPACT

The client has lost almost all of her hearing in her right ear and wears an analog hearing aid in her left. The current hearing aid that she wears does not reduce or eliminate noise and acoustic feedback for a comfortable listening experience. Also, sudden loud noises are uncomfortable and are at dangerous decibel levels for the client. Since the cost of digital hearing aids on the market are very high, and she was advised by her doctor to use one, the DHA project provides a low-cost solution to meet her requirements. A photograph of the Digital Hearing Aid is shown in Figure 17.25.

## TECHNICAL DESCRIPTION

The signal conditioning process begins with the input stage, where a microphone converts the sound signal into an analog voltage signal. The microphone transducer contains a high voltage internal electronic membrane, a metal electrode and a field effect transistor. The microphone acts as an anti-aliasing filter that blocks undesirable high frequency components. A pre-amplifier is also used in this stage to amplify the microphone signal. In the second stage, an analog-to-digital (A/D) converter changes the analog signal into a digital signal. This serial data stream adds some high frequency noise to the signal; therefore a low-pass filtering algorithm is used to remove the noise, creating a cleaner 16-bit waveform. The signal is then re-sampled to optimize the signal for more manipulation.

The digitized signal is mathematically manipulated in accordance with the client's hearing profile. The digital signal is split into seven frequency bands; each is adjusted as determined by the pre-set hearing profile. The four higher frequency bands and the lower three frequency bands are compressed using algorithms that improve speech comprehension and listening comfort. The high frequency compression algorithm incorporates adaptive gain to preserve the contrast between sharp consonant sounds, while the low frequency algorithm incorporates syllabic pressure to keep the volume at a comfortable level. A Texas Instrument TMS320C25 Digital Signal Processor (DSP) accomplishes the digital processing. The code for the DSP was written using MATLAB and C software programs. After conditioning, the signal is converted back to an analog signal using a digital-to-analog (D/A) converter. The output stage represents the speaker, with acoustical characteristics that block undesirable high frequency sound to give quality sound reproduction.

The cost of parts and materials is approximately $500.

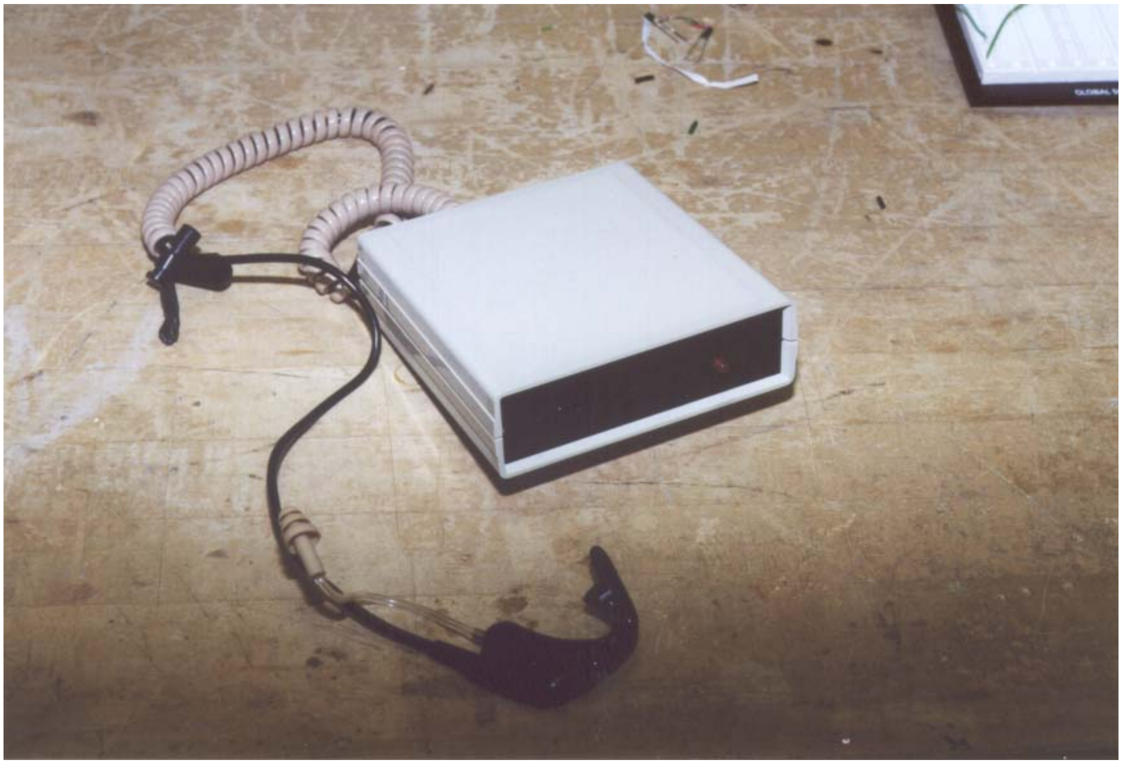

Figure 17.25. The Digital Hearing Aid.

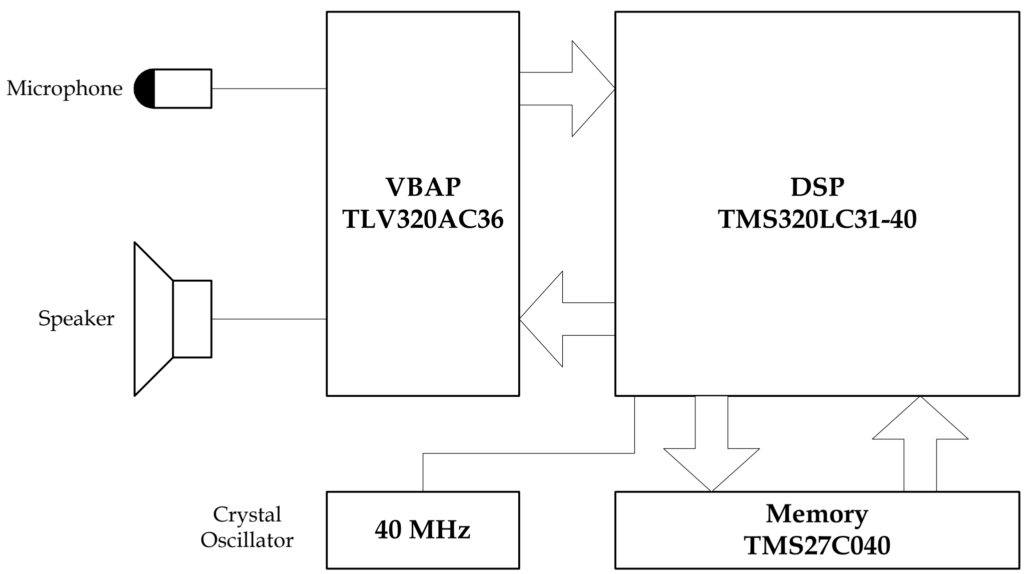


Figure 17.26. Block Diagram of the Digital Hearing Aid.

# TALK AID

*Designer: Juan Antonio Rodriguez*
*Client Coordinator: Josette Caro*
*Supervising Professor: John Enderle*
*Electrical and Computer Engineering*
*University of Connecticut,*
*Storrs, CT 06269*

## INTRODUCTION

Talk Aid is a communication assistance device for a child with autism who has trouble communicating. He is often frustrated because he has difficulty consistently coordinating his vocal cords to communicate. Talk Aid provides a method of communication that relieves his frustration, thus allowing him to concentrate on communication. A photograph of the Talk Aid is in Figure 17.27.

## SUMMARY OF IMPACT

The device produces a vocal output and a digital display output. Having these two features in one device, the client communicates more effectively. The vocal output of the device is the primary method of communication. The digital display, corresponding to the vocal output, provides visual feedback. The scalability of the device allows the device to grow along with its user.

## TECHNICAL DESCRIPTION

The BL1600's (Z-World) combination of logic-level I/O and high-current drivers makes it a versatile controller in a compact "form factor." The PLCBus expansion port allows adding I/O lines, serial ports, relays, and D/A and A/D conversion channels as needed. Programs for the BL1600 are developed using the Dynamic C software development system. One can install SRAM and EPROM chips from 32-kbyte to 512-kbyte, and flash EPROM from 64-kbyte to 256-kbyte. The microprocessor of the BL1600 is the Z-180, which runs at 9.216 MHz. Using a programmable controller is the most flexible way to develop a control system. C is the preferred language for embedded systems programming. Variables a0 - a9 are the 10 bits that drive the voice synthesis chips. This program is continuously looking for an input. This insures that the device will always be working from a code perspective.

ISD's patented technology brings analog data into the semiconductor memory world. Few external components are needed:

- A microphone,
- A loudspeaker,
- Switches,
- A few resistors and capacitors, and
- A power supply or battery - to build a complete voice record and playback system.

All other devices - preamplifiers, filters, AGC, power amplifier, control logic and analog storage - are built into the chip. Pins 1 - 10 correspond to a0 - a9. These pins define the starting address for messages or set the device to an operation mode.

The OP6100 (Z-World) operator interface is ideal for applications requiring users to enter commands or data, read messages, or monitor systems functions. Each operator interface connects directly to a Z-World controller that offers LCD or PLCBus ports. Once connected to a Z-World controller, the interfaces are configured using Z-World's Dynamic C software development system. Dynamic C (Z-World) also provides all software drivers necessary to scan keypads, display messages, and create graphics. A keypad overlay allows easy creation of custom keypad elements and legends. The OP6100 offers a 4 x 20 character LCD and a 4 x 6 keypad. If a custom user interface is needed, individual interface components are available for purchase. Individual components include LCDs, keypads, and controller boards.

The cost of parts and materials is about $425.


Figure 17.27. Talk Aid.

# TOY TRAIN SPOTTING SYSTEM

*Designer: Jaret Stickney*
*Client Coordinator: Rachel Wheeler-Rossow*
*Supervising Professor: Dr. John D. Enderle*
*Electrical and Computer Engineering Department*
*University of Connecticut*
*Storrs, CT 06269*

## INTRODUCTION

The Train Spotting System was designed for a child with limited body strength due to severe neurological deterioration. He has little if any ability to control a device such as a toy vehicle. A large plastic train, currently owned by the client, has no directional capabilities. Additionally, the train has no braking system to stop forward motion. The motor on his vehicle provides little power and operates for only short periods of time. The current design addresses these limitations. A photograph of the Train Spotting System is shown in Figure 17.28.

## SUMMARY OF IMPACT

The client has limited body strength due to severe neurological deterioration. The design of a remotely operated toy vehicle used by a caregiver provides the child entertainment. The client simply rides on the vehicle while another individual controls the remote joystick.

## TECHNICAL DESCRIPTION

The system uses:

- Five ultrasonic sensors,
- 2 DC motors,
- A 12 Volt DC Battery,
- A BL1600 micro- controller (Z-World),
- 5 PIC16C74A micro- controllers, and
- A number of toggle safety switches.

Using the sensors and toggle switches, the system is able to operate with little supervision.

A 12 Volt lead acid battery, chosen for its long-term effectiveness and durability, supplies power. It is located under the seat and has easy accessibility for recharging.


Figure 17.28. Train Spotting System.

The motors are located in the rear of the vehicle and control both the direction and the steering of the vehicle. These 12 Volt DC permanent magnet, brushless motors are paired with gearing in order to drive the vehicle at approximately 1.5 mph. A simple motor control circuit allows for a change in direction and the ability to adjust the speed of the motor.

The motors have a capability of driving a 75-pound child and accelerating to maximum speed in 1.5 seconds. A gearing ratio of 50:1 allows for enough torque and acceleration to operate in virtually any indoor or smooth outdoor surface. The two motors receive input from the processor. The power and direction of the motors is then communicated to the logic chips on the motor control board to determine the action to take place via the FET chips.

The processor used in the design is the BL1600 and is the central processing unit for the Toy Train Spotting System. The processor receives input from the remote control and the sensor control units and determines the proper action to take place for output to the motor control circuits. The microprocessor compares these inputs to determine if a direction is safe for travel and outputs to the motor control if the action is capable. If the remote control is idle, the motor control circuits receive no power and simply stall the motors. If an action is not permitted due to the condition, the motors again stall and the processor waits for a different input. The process by which the motor control receives output by the comparison of sensor and remote input is referred to as the “object collision prevention”. The processor goes through a continuous loop of comparison at the initiation of power. The continuous loop guarantees that an action will be looked at regardless of the input.

The five sensors in the system utilize ultrasonic object detection. These sensors allow for mobility of the vehicle in essentially any direction. They are located in the four corners of the vehicle and there is an additional one on the front underside for detection of a stairway or a drop in the floor. These sensors have a beam angle of 15 degrees and detect objects from 6” to 35′. Polaroid and Texas Instruments sonar Ranging Module provided the sensors.

The circuitry used in conjunction with the modules involves a PIC16C74A micro-controller. When power is given to the sensor control unit, the micro-controllers then initialize the modules. At this point a 9-millisecond delay is given to the “inhibit” pin on the module by the PIC controller, and allows the modules to stabilize. When the delay is complete, the controller then waits for the module to send an “echo” signal to an input pin allowing for the code of the controller to work. The code does a simple comparison between a predetermined distance of 13” and the distance it took the sensor to receive the ultrasonic reception. A high signal is sent to the output of the controller if an object is within this “object collision prevention” zone. The processor as described above then receives this input.

Seat safety switches, along with a master switch and a front panel power switch, are also utilized to

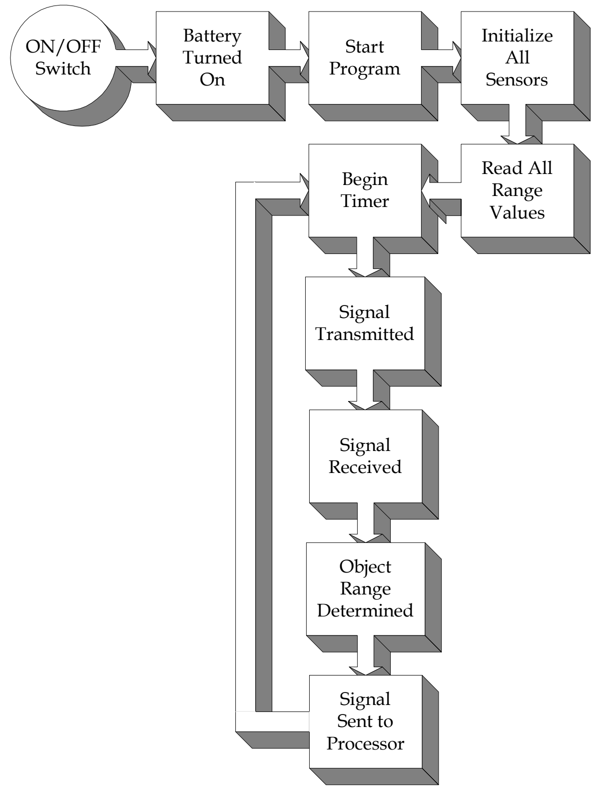


Figure 17.29. Block Diagram of Train Spotting.

ensure child safety. These three toggle switches immediately power down the vehicle at any point. The seat safety switch toggles if pressure is relieved from the seat.

The front panel switch is conveniently located on the handle of the child’s bracing bar. This switch is necessary if the child is ready to stop riding the vehicle. The last switch is for the master power. This switch is behind the vehicle and can only be reached by the caregiver when the child is in the seat.

The approximate cost of the Toy Train Spotting System is about $850.

# TEACHING PIANO

*Designer: Jeremy Shattuck*
*Supervising Professor: John Enderle*
*Department of Electrical and Computer Engineering*
*260 Glenbrook Rd*
*Storrs CT 06269-2157*

## INTRODUCTION

The Teaching Piano is a multiple subject teaching device and electronic piano for children with cognitive and physical impairments in a classroom setting. The Teaching Piano can help teach numbers, the alphabet, the days of the week, and word-picture association by combining a large, easy to use, colorful key piano interface with a teacher's interface. It can also work with flash cards and vocal outputs. The Teaching Piano is conceptualized as an educational device that addresses motor coordination skills and allows for their improvement while preventing frustration on the part of its user. The educational aspects of the device can be increased in difficulty as the user's skill improves. Lessons are controlled by the teacher and the flash card based teaching allows a broad range of lesson planning. The Teaching Piano is also a toy.

## SUMMARY OF IMPACT

The Teaching Piano allows the teacher to control the educational lesson of one child while allowing time to provide attention to other children in the classroom. The design is compact (20"x10"x10"), portable, and durable. The large piano keys enable use by children with varying degrees of muscle coordination. The bright colors and stimulating output help to maintain attention. The Teaching Piano is shown in Figure 17.30.

## TECHNICAL DESCRIPTION

The Teaching Piano runs in two separate modes, piano and teaching. In piano mode, the Teaching Piano simply acts as an electronic piano. The depression of any of the piano keys sends an input signal to the micro-controller, which outputs the appropriate address signal to a voice/record playback chip, which outputs the appropriate piano note, as shown in Figure 17.31.

In teaching mode, the teacher can place five flash cards in any order across the sheet music ledge of the piano. Each piano key correlates with the flash card above it. The teacher can then program the order in which he or she would like the child to play the piano in relation to the order of the flash cards. When the child presses a correct key, a small toy head rises from beneath the piano top, says "That's correct", and lowers back down. When the child presses an incorrect key, a short buzzing sound is heard. After the child has gone correctly through the entire sequence, a short melody is played with the accompaniment of the toy head rising. This process is shown in Figure 17.32.

Figure 17.30. Teaching Piano

A Z-World BL1600 'Little G' micro-controller controls the Teaching Piano. Inputs arise from the teacher's interface located on the side of the piano and the child's piano keys. Outputs consist of two status LEDs, used during programming of the teaching mode, (these located on the teacher's interface), a voice chip that plays piano notes in piano mode and short messages in teaching mode, and a mechanical head that rises up from beneath the piano top.

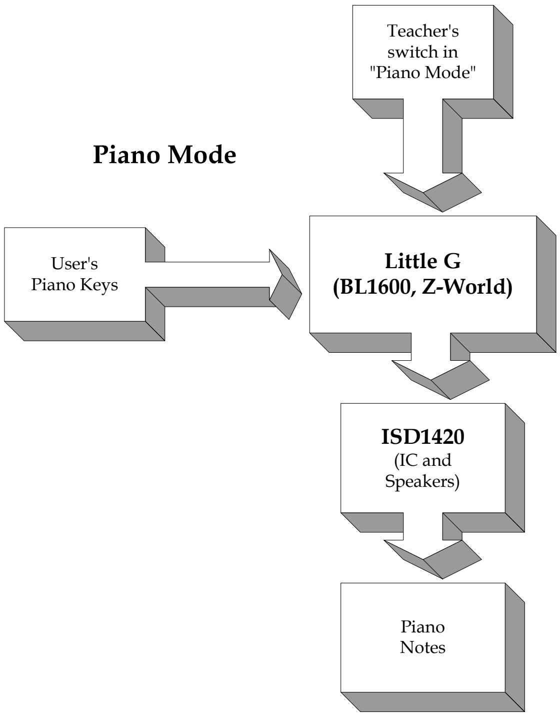


Figure 17.31. Piano Mode Flowchart.

## *Casing*

The piano casing is built from durable 3/4" thick wood, sanded and painted in warm, eye-catching green (piano), orange (piano keys), and almond (piano keys).

## *Microcontroller*

The central processing unit of the Teaching Piano is a Z-World BL1600 Little G micro-controller programmed by Dynamic C® software. The BL1600 has 12 digital inputs, 14 digital outputs, 32K SRAM, 32K EPROM, and 512 bytes of EEPROM. The BL1600 is powered by a wall outlet step-down transformer and provides 5VDC to the other components of the device.

## *Mechanical Head*

The figure of a tiger head rises from beneath the piano top, pushing the hinged top open, using a 5VDC motor using a geared axle and a teethed pole, which react with one another for upwards and downwards motion. To provide enough power between the micro-controller and the motor, a PWM motor control circuit is placed to control the motor with digital input signals.

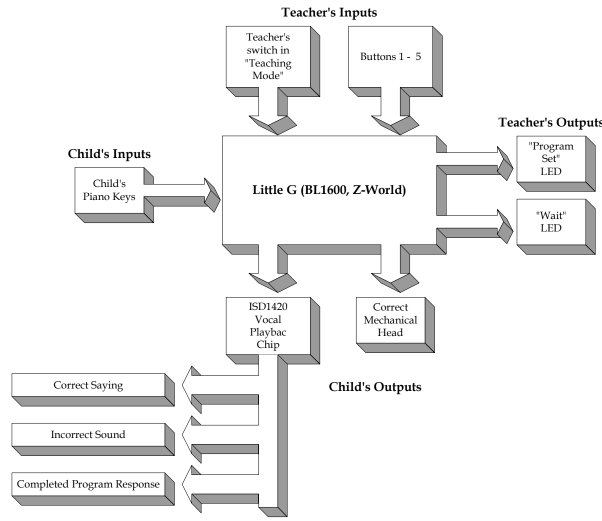


Figure 17.32. Teaching Mode flowchart.

## *Vocal output*

An ISD1420 voice record/playback chip generates vocal outputs. On the chip are recorded five piano notes (2 sec.), two short messages (2 sec. each), and one short melody (6 sec.). These are accessed using an 8-bit digital input address from the BL1600. The message is then outputted through an amplifier of gain 30 and speaker located on the back of the Teaching Piano.

## *Teacher's interface*

The teacher controls the Teaching Piano by an interface located on the side. On the interface are:

- A power switch,
- A mode switch,
- Two status LEDs, and
- Five buttons for programming the order for the teaching mode.

## *Child's interface*

The child uses the five large piano keys on the front of the piano. Beneath each key is a button that is depressed when the child depresses a piano key.

The cost is $380.

# EDUCATION STATION WITH REMOTE COMMUNICATION DEVICE

*Designer: Mike Stanczyk*
*Supervising Professor: John Enderle*
*Department of Electrical and Computer Engineering*
*University of Connecticut*
*260 Glenbrook Road*
*Storrs, CT. 06269*

## INTRODUCTION

The Education Station and Remote Communication Device is designed for a 13-year-old female who has difficulties maintaining her attention span at school. Her main source of locomotion is a wheelchair, which she relies on frequently due to fatigue and mild seizures. She is non-verbal and communicates through facial expressions and pointing at pictures. Testing methods that measure her level of independence may be compromised due to her lack of focus. When she is distracted, her grades decrease and her ability to learn is limited. The Education Station was designed to help address these problems. The Education Station is attached to her wheelchair tray and placed in the student's line of sight, allowing her to better focus on the task at hand. The Education Station tests involve matching a picture to an item, manipulating an item, matching a color, identifying a peer, or completing a four-step process.

The Remote Communication Device operates as a sub-unit of the Education Station. This device helps enhance the client's test scores and also acts as an alternative communication device.

## SUMMARY OF IMPACT

The Education Station and Remote Communication Device interact to improve a student's test scores. They both feature a voice recorder to give an audible description of a picture or flash card. The Education Station is designed to attract the attention of the student by being directly in her line of sight and by being decorated in various bright colors. Since the student is asked to press a button that corresponds to a given picture, four large 2" buttons are provided, each with an appealing smiley face design. The Remote Communication Device is compact and uses re-chargeable batteries so that the student has an alternative way to communicate with others.

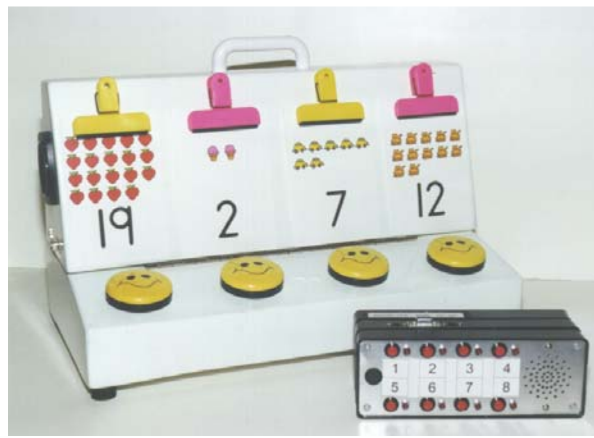

Figure 17.33. Education Station with Remote Communication Device.

## TECHNICAL DESCRIPTION

The front panel of the Education Station has four large 2" buttons and four clips to hold pictures. The side panel has a female jack for the external power source, an output port for the Remote Communication Device, and two stereo speakers. The rear panel has a 12-button keypad with an alphanumeric display and a microphone. A removable top allows for storage of the Remote Communication Device, flash cards, the power supply, and the remote cable.

The Remote Communication Device has a top panel with 8 buttons, 8 LEDs, a speaker, and a microphone. The side panel has an on/off switch, a play/record switch, and an input port.

The Education Station and Remote Communication Device is shown in Figure 17.33. The student chooses one of the smiley face buttons when the instructor asks a question. The Education Station uses a BL1600 series (Little G, Z-World) micro-controller and an OP6000 (Z-World) keypad with an alphanumeric display. The keypad is used for programming the voice recorder as well as to choose what message is heard when a correct button is depressed.

The alphanumeric display indicates what message is heard. The keypad and alphanumeric display are both used to program letters into the display corresponding to the recorded message. Each message has a number assigned to it so that the teacher can input it into the keypad, and the number is found on the back of each picture.

The Remote Communication Device includes eight buttons that input into the micro-controller. The record button is hidden to prevent unwanted message changes. Each message can be played at any time. If a signal is sent from the Education Station, the appropriate light will flash for ten seconds, allowing the student to press the button next to it. After the button is pressed, the message is played and resets when finished.

When the Education Station is activated, the micro-controller program is initiated and loops infinitely until the play or record button is pressed. If the play button is pressed, a code is sent from the keypad to the input port of the micro-controller. This code is searched for in a database that initializes the code that corresponds to the keypad. When the code is found, the address that corresponds to it is sent through an output port to initialize an ISD2575 voice recorder. The alphanumeric display shows the message that is played when the correct choice button is pressed. Next, the program continually checks the choice buttons against the control buttons until there is a match. When they are equal, the program outputs a signal to enable the voice recorder. If they do not match, a buzzer sounds and then the program checks the buttons again. On occasion, a signal is sent to the Remote Communication Device. These signals are for special cases when a picture on the Education Station matches a picture on the Remote Communication Device.

If the record button is pressed, a code is sent from the keypad to the input port of the micro-controller. This code is searched for in a database that initializes the code that corresponds to the keypad. When the code is found, the address that relates to it is sent through an output port to initialize an ISD2575 voice recorder. The program automatically allows the message to be recorded for duration of three seconds and is verified by an LED when finished. Once the recording is verified, the program returns to the beginning, awaiting a new command.

One of eight on the Remote Communication Device can be pressed at any time to hear a pre-recorded message. As soon as the device is activated, it starts in the play mode until the record button is pressed. It also loops through the program until a signal is received from the Education Station. If a signal is received, the program loops through a cycle of 10 seconds. A delay loop set-up for 1 second is initiated in order to make the LED stay on for one second and then stay off for one second. If the button is pressed within the 10 seconds it will output the message. If the button is not pressed, the program simply returns to the beginning.

When the record button is pressed, it waits for an input button to be pressed for 3 seconds, by incrementing a counter 3 times for a period of 1 second. Once it has been pressed for 3 seconds, the LED turns on, allowing the recording process to begin. When the light turns off, the recording is stopped and the program returns to the beginning.

The total cost of the Education Station and Remote Communication Device, including the power supply, communication link and flash cards, is approximately $450.

# WATER TEMPERATURE CONTROL SYSTEM

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## INTRODUCTION

The Water Temperature Control System is designed to control water temperature based on a pre-set temperature that is programmed into the unit by the client or an aide. The Water Temperature Control System can be installed in any type of shower or bath, and fits in standard 2 x 4 walls. Anyone wishing to take a shower with this device is able to input his or her name with a preferred temperature and store them in the memory bank. A back-up battery is incorporated to protect memory during power failure.

## SUMMARY OF IMPACT

The client attempts to adjust water temperature but, due to reduced sensory and motor capabilities, he turns the hot water to a scalding temperature. The Water Temperature Control System enhances the client's independence and minimizes the risk of injury by scalding water. This product is simple to use.

## TECHNICAL DESCRIPTION

The Water Temperature Control System consists of two major modules:

- An operator interface, including a graphic LCD display with large font for easy reading and an oversized keypad for entering the name and preferred temperature of the shower water, and
- A water temperature adjustment unit, which consists of an electronically controlled hot and cold water-mixing valve.

The device controls water temperature within ±0.2°F (0.1°C). The control panel is enclosed in a durable plastic enclosure. The water temperature adjustment unit is built from solid brass, stainless steel, and aluminum. Circuitry and parts are water resistant. Figure 17.35 shows the installed control panel.

Figure 17.35. Installed Front Panel of the Water Temperature Control System, Mounted in a Closet that Backs up to the Shower Plumbing.

Figure 17.36. Installed Water Temperature Adjustment Control System.

The Water Temperature Adjustment Unit uses a high-speed microcomputer that automatically adjusts the hot and cold water valves 10 times a second, preventing temperature change in the shower when the water supply is reduced due to use of other water systems throughout the house. If either the hot or cold water supply fails, the Water Temperature Adjustment Unit shuts down the other supply, preventing scalding or freezing. Typical shower controls such as the hot and cold-water knobs remain installed to allow traditional control of water temperature if desired. See Figure 17.36 for a view of the Water Temperature Unit

## *Control Panel*

The Control Panel is installed on a wall near the shower. The Control Panel stores the name and preferred water temperature in °F, displays the name and the water temperature, and controls the Water Temperature Adjustment Unit. A micro-controller (BL1600, Z-World) stores names and temperature settings corresponding to a particular name. Water temperature is read by a temperature sensor (via an A/D converter) and compared to the pre-set value. Adjustments then sent as an 8 bit binary code to a stepper motor control circuit for the water-mixing valve. An on-board Flash-EPROM contains the adjustment program.

A Graphic LCD display used for viewing the name and corresponding temperature of the client or anyone that will use this product is included in the Control Panel. The Graphic LCD display has 240 x 64 pixels, and a 5.2″ x 1.54″ viewing area. The LCD display has an 8 bit direct interface and an LED back light as an option that is used for easier viewing in dimmer surroundings.

A Keypad is used to perform the following functions:

- Entering the name of user and desired water temperature,
- Recalling the name and desired temperature from memory, and
- Manually adjusting water temperature.

A 12 VDC, 400 mA, linear power supply, is used as the main power source for the control panel.

## *Water Temperature Adjustment Unit*

The water temperature adjustment unit is installed within the shower wall on the hot and cold water

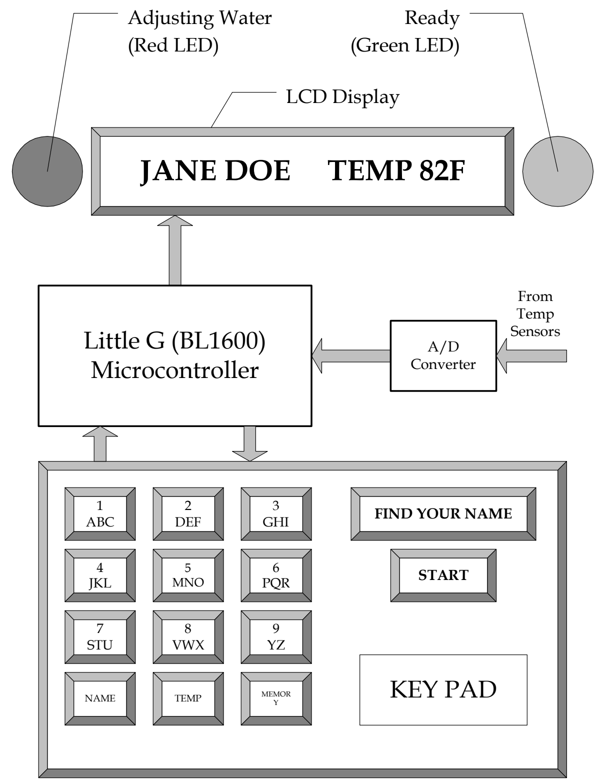


Figure 17.37. Diagram of the Front Panel.

supply pipes. It consists of the following components:

- Two stepper motor controlled valves for adjusting water flow, one each on the hot and cold water supply,
- A Thermocouple Probe for reading the mixed water temperature,
- A faucet assembly added to the current assembly, and
- A 12-16 VDC (AC power adapter) that provides the necessary power.

The adapter is plugged into any available 115 VAC outlet in a utility room. The adapter cord is plugged into a socket on the back of the water temperature adjustment unit. Low voltage extension cables are supplied.

The cost of this project is $593.

# REMOTE CONTROL INTERFACE TO A DIGITAL THERMOSTAT

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## INTRODUCTION

A client with spinal muscular atrophy desires an easier way to control the room temperature in her living environment. The Remote Control Digital Thermostat (RCDT) is designed for mounting on the client's wheelchair to control a redesigned microprocessor-controlled thermostat with a graphical display output. A photograph of the RCDT is shown below in Figure 17.37.


Figure 17.37. Remote Control Digital Thermostat.

## SUMMARY OF IMPACT

The client has a genetic progressive motor neuron disease impeding the transmission of nerve impulses to the muscles. The client uses a wheelchair. She has limited access to most objects in her apartment due to her limited range of motion. She has difficulty adjusting the thermostat on her wall. The RCDT was designed to enable the client to independently control the thermostat. Since the device uses RF communication, the client can control the temperature in her apartment from anywhere in the room without having to worry about objects interfering with the thermostat. This is required since the client cannot point the remote control directly at the thermostat.

## TECHNICAL DESCRIPTION

There are six major components of the RCDT:

- The digital temperature sensor,
- An RF transmitter,
- An RF receiver,
- A microprocessor control,
- A relay system, and
- A graphical display.

Two main units, a push button remote control unit, and a Linx Technologies 418 MHz LC transmitter circuit are mounted on the client's wheel chair arm via Velcro, and the receiver unit is mounted on the apartment wall. The receiver unit contains a Linx Technologies 418 MHz receiver circuit, a Z-World BL1600 Microprocessor, an Analog Devices TMP04 digital temperature sensor, a 5 VDC relay, and the Z-World OP6300 graphical display that displays the desired set temperature and room temperature.

A functional block diagram is shown in Figure 17.38. When one of the pushbuttons of the remote control is depressed, the RF transmitter modulates the 418 MHz carrier frequencies that are detected by the RF receiver. Since the LC-TX is a modulated Carrier-Absent/Carrier-Present transmitter, when the buttons are not depressed, the carrier is absent, which indicates to the receiver that a binary 0 is being transmitted. Depressing a button generates the carrier, which the receiver interprets as a binary 1. This is then passed to the data output of the receiver. Data rates up to 4800 BPS can be sent. Sending data through the LC series modules requires that the data stream is encoded and decoded as 1s and 0s using Holtek encoder and decoder chips. The receiver then outputs CMOS compatible data, which acts as input to the microprocessor. The receiver output is internally qualified, meaning it will only transition when valid data are present. In instances where no carrier is present the output remains low.

The range, performance, and legality of an RF link are critically dependent upon the type of antenna employed. It is usually best to utilize a basic ¼ -wave whip antenna for initial concept evaluation. Once the prototype product is operating satisfactorily, a production antenna is selected to meet the cost, size, distance, and cosmetic requirements of the product. For the RCDT purposes, a loop or helical antenna for the transmitter is suitable. The receiver also utilizes a helical antenna; however, this antenna is placed outside the actual receiver unit due to cosmetic requirements of the graphical display.

The most suitable temperature sensor for the RCDT is an Analog Devices TMP04 digital temperature sensor. The TMP04 is a monolithic temperature detector that generates a pulse-width modulated serial digital output that varies in direct proportion to the temperature component it is measuring. An onboard sensor generates a proportional voltage as compared to an internal reference voltage that is input into a precision first-order sigma-delta digital modulator. The TMP04 is a powerful, complete temperature measurement system with digital output on a single chip. The TMP04 provides TTL-CMOS compatible outputs for direct interface with a microprocessor.

The BL1600 microprocessor has 12 digital inputs and 14 digital outputs. It also features input for a keypad and output for a graphical display. For RCDT purposes, the Z-World OP6300 graphical display is selected. This display uses 240x64 pixels and a 4x10 keypad, and connects directly into the PLC bus of the BL1600. The BL1600 receives the current room temperature from the TMP04, along with a digital output command from the receiver to increase or decrease the set temperature. Once the set temperature becomes greater than the room temperature, an output of the BL1600 is activated to a logic high that drives the relay to switch the household heating system on. Two keypads are also pre-programmed to increase or decrease the set temperature as a safety feature in case the remote control unit happens to fail.

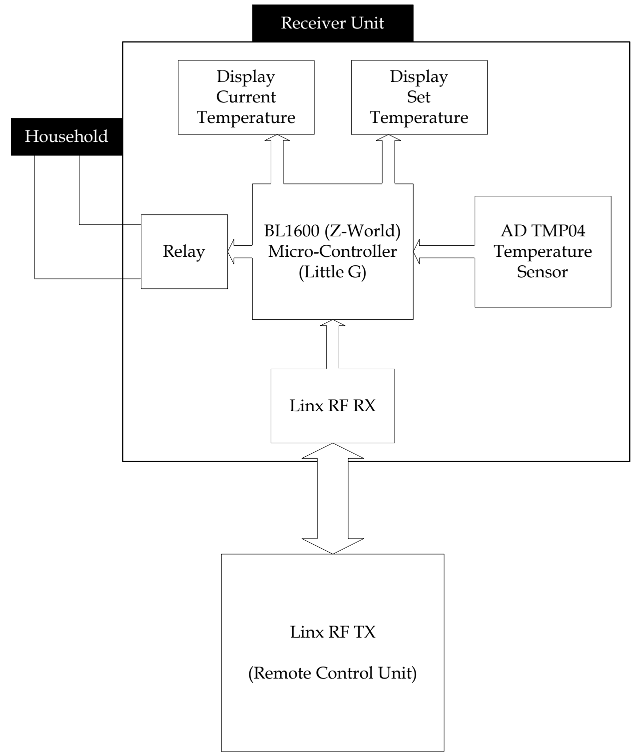


Figure 17.38. Functional Block Diagram of the RCDT.

The cost of parts/material was about $500.

# MOTORIZED MOBILITY DEVICE

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## INTRODUCTION

Scoot Along is designed for a child with cerebral palsy, with no use of her legs and limited use of her hands. She does have the ability to grasp and direct a joystick. The client can control a standard electric wheelchair, but its size proves impractical for use in confined areas. Scoot Along functions as a mobility aid and has in-dash controls that make the device an enjoyable toy. Unlike many other devices on the market, Scoot Along is lightweight and durable, allowing for easy portability. Primary use for the scooter will be in the classroom play area. See Figure 17.40 for a view of Scoot Along.

## SUMMARY OF IMPACT

Scoot Along is a transportation device that can be maneuvered in small, confined areas. Its reduced size makes it a good fit for a small child. Ultrasonic object sensors and speed adjustment controls prevent accidents and ensure safety. In addition to its safety features, fun car sounds are added to the controls to make Scoot Along enjoyable for children to use.

## TECHNICAL DESCRIPTION

The chassis for Scoot Along is a modified toy car. This car exhibits good maneuverability, is motorized, and is small. Modifications to the chassis include the addition of a joystick controller, a central processing unit, two DC motors, a rechargeable battery, 5 ultrasonic sensors, and sound buttons. See Figure 17.41 for a block diagram of the system.

### *Microprocessor*

The central processing unit for the entire Scoot Along system is centered on a microprocessor. A PIC16C74A processor by Microchip acts as this main controlling unit. Programming for the PIC16C74A is done in assembly language using the MPLAB software package, also by Microchip. Inputs are read into the processor from both the joystick controller and the ultrasonic sensors. Basic logic comparisons are made between these two sets of inputs. If no obstacles block the movement of the scooter, a logic "1" is outputted. The vehicle can then be operated in that direction. However, if an object is sensed, then a logic "0" output means the scooter either shuts down or should be moved in the opposite direction.

Figure 17.40. The Scoot Along Mobility Car.

### *Joystick Interface*

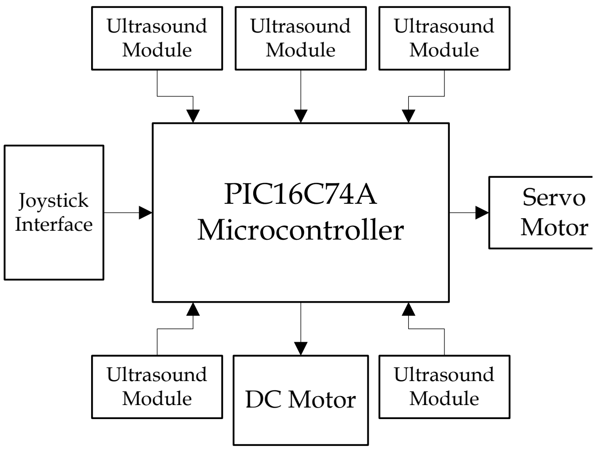


Figure 17.41. Block Diagram of Scooter System.

A common joystick controller is used for directional control. The joystick used for the prototype is a standard joystick used for a home video game system. The scooter remains stationary when the joystick is at center position. Forward on the joystick results in forward motion and likewise for backward, left, and right directions. The joystick interface functions by a potentiometer giving a voltage output between zero and a reference voltage based on the position of the joystick. This signal is sent to the microprocessor for evaluation of forward or reverse and/or left or right movement.

### *Motor Control*

Two DC permanent magnet motors are installed, one for drive of the scooter, and one for steering. The drive motor is placed in conjunction with the rear wheels while the motor used for steering is placed at the front. Several factors were considered when choosing the appropriate motors for Scoot Along.

The first consideration was the load capacity of the vehicle. This includes the weight of the child as well as the weight of the vehicle itself. The maximum load capacity is set to 100 lbs. In order for the motor to make the scooter move, the mechanical energy must also be converted into kinetic energy. With these constraints in mind, two 12VDC permanent magnet motors with appropriate gearing are implemented.

### *Ultrasonic Sensing System*

The intended area of use for the scooter has many obstacles. It is necessary to prevent collisions with these obstacles. A simple circuit in conjunction with an ultrasonic ranging module with transducer is used to detect objects. A signal is sent out from the transducer that sends a return signal if an object is sensed. A simple assembly language program performs this signal process and calculates the distance of the object. The set distance at which the object is sensed is approximately 13 inches. A combination of 5 ultrasonic sensors acts as one set of inputs to the microprocessor.

The total cost for parts and materials for this project was $700.