CHAPTER 18
UNIVERSITY OF MASSACHUSETTS LOWELL

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INFRARED DEVICE CONTROL

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Client: The client Page
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INTRODUCTION

A home automation system was designed to enable a person with quadriplegia to gain independence and control over his environment. The system utilizes a standard remote control, specialized computer software, and various infrared receivers and transmitters.

SUMMARY OF IMPACT

The individual for whom this assistive technology project was designed is a person with quadriplegia. Until 1973, he had been a highly recruited baseball and football player. However, after an auto accident, he was paralyzed from the neck down. The client has since regained limited upper body movement and has learned how to utilize this limited movement. He can type on a keyboard using a wrist attachment. He can also use a special mouse, shaped like a joystick, that is sensitive to lateral as well as vertical pressure. By rotating his shoulder, thus moving his arm, he can apply enough pressure so that he can control cursor movement. He applies light pressure to the button on the top of the joystick to select an object. These abilities made the second phase of the project possible: the automation of two household lights, his television and his electric door.

TECHNICAL DESCRIPTION

This system was an extension of a previous project in which the client was first introduced to computer technology and the World Wide Web. A software program, Infrared Direct Control (IRDC), was purchased, installed and tested on a computer system. The software was installed on a standard Pentium class PC with 64 MB of RAM and a 2GB hard drive. It was initially hoped that a voice recognition software application already installed would interact with the IRDC software, thereby allowing the client to have home automation as a hands-free application. However, the IRDC software prohibits TSR memory resident drivers from being loaded while in operation. Unfortunately, the voice recognition software utilized a TSR. Additionally, the voice application modified the AUTOEXEC.BAT file so that it is also incompatible with IRDC.

A special serial cable was attached to COM port 1/IRQ4. The other end of the cable was attached to a data port found inside of the battery compartment of the all-in-one remote control. Velcro was used to secure the cable to the remote since it dislodged easily.

The next step was to configure the X-10 Powerhouse I/R to RF receiver/transmitter. This was simply a matter of choosing which appliance would be assigned to which selector switch. Once the assignments were made, the appliance control modules were configured similarly and plugged into the wall sockets. The appliances were then plugged into them.

Finally, the remote control was brought online by tapping any button on the remote and then clicking on any button on the IRDC Graphical User Interface (GUI).. The IRDC GUI has numerous buttons on it, each of which is color coded so that the user can quickly access the appropriate device and then issue a command. For example, if the client wishes to turn his living room light off, he can select the appropriate button on the X-10 unit (in this case, unit # 1) and then select the AUX button on the GUI and then the power button on the GUI.

Except for software incompatibilities, this project was successfully implemented.

For clients who have limited motor abilities from the neck down, voice recognition software would be necessary. However, this client has acquired some movement over time, making the software incompatibilities insignificant.

Figure 18.1. Infrared Device Control.

SPEECH RECOGNITION FOR COMPUTER ACCESSIBILITY

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INTRODUCTION

A multimedia computer system is a tool used for the distribution, retrieval and retention of information. However, certain features on these systems make them inaccessible to those with physical impairments. Operation of a keyboard and mouse requires dexterity, making these input devices unusable for persons with quadriplegia. Dragon Systems, Inc. has developed speech recognition software that allows anyone to operate a computer with verbal control.

SUMMARY OF IMPACT

Dragon Dictate 3.0 software was purchased, installed and tested on a multimedia computer system. This system can be controlled with a standard keyboard and mouse, or with a headset microphone connected to the internal audio board. All commands (including mouse cursor movement) and data entry (for word processing) can be communicated through the microphone.

The individual for whom this assistive technology project was designed is a person with quadriplegia. He has always wanted to become computer literate but was afraid of both physical challenges and educational requirements. Therefore, the requirements of this project were not merely to install the software and eliminate system conflicts, but also help the client become computer literate.

This project has opened up a new world of information and communication to the client and hopefully will act as a model for readers wishing to expand their horizons and overcome their limitations.

TECHNICAL DESCRIPTION

First, the system had to be purchased and assembled. It was most economical to purchase individual components from vendors and assemble the system in a piecemeal fashion. The components purchased were:

- A Pentium 200 MHz MMX Processor with motherboard,
- A 32 MB EDO RAM,
- A 4 GB EIDE hard drive,
- A 16 x CD-ROM,
- A 1.4 MB floppy drive,
- A mid-size tower with 5 open expansion drive bays,
- A 3d video board,
- An audio board,
- A 56k fax / modem,
- A 17" high resolution monitor,
- Speakers,
- A Microphone, keyboard and mouse,
- Windows 95 and Office 97,
- Dragon Dictate 3.0, and
- (15) Bitnet Internet Service Provider software.

The system was assembled and all IRQ conflicts and driver conflicts were resolved. Then the ISP account was established.

With all software installed and functioning correctly, it was time to establish the client as a user in Dragon Dictate. The software has an intuitive training program that allows the computer to establish a speech memory of the client's voice. He simply read a long list of words and phrases, displayed on the monitor. His intonations were then memorized and from that point forward, when the computer booted up, it waited for commands from the client.

Training the client involved starting with simple tasks and steadily progressing to more complex projects. For example, powering the system up and

shutting the system down was his first lesson. This turned out to be more complicated than first anticipated because some hand movement is necessary; Dragon Dictate is not activated until Windows has completed its power up process. The next few lessons involved basic mouse movement, desktop operations and definitions of terms. Fortunately, Dragon Dictate is forgiving and flexible. For example, to double click on an OK button, the user can tell the mouse cursor to move to that button location and say, "double click", or simply say "OK". The software looks for default buttons in open windows and allows the user to say what is in the button as a command.

Once the client was comfortable with desktop operations, the lessons moved to Internet access and Office 97 operations. He now uses the World Wide Web for information searches on various subjects ranging from disabilities to German newspapers. Also, he client is a high school coach in basketball, football and baseball so he now uses Excel to track data with a spreadsheet on his players. Currently, his training revolves around troubleshooting: occasionally he 'clicks' on the wrong location and causes error messages or loss of data. He is learning how to recover from those mistakes.

Figure 18.2. Computer Accessibility.

BLENDER CONTROLLER

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Supervising Professor: Alan Rux
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INTRODUCTION

The Blender Controller Box was designed to support cooking classes for people with physical impairments. It has one command switch and two modes: manual mode and timer mode.

In manual mode, when the user presses the command switch, the blender operates. It stops operating when the user releases the command switch.

In timer mode, when the user presses the command switch, the blender operates about 15 seconds and then stops automatically. Once operating in timer mode, the command switch will not affect the blender; the blender continues to operate and will stop after 15 seconds. The blender only operates again when the user presses the command switch after the blender stops.

SUMMARY OF IMPACT

It is hoped that the Blender Controller Box will be a helpful piece of adaptive equipment for individuals who participate in cooking classes or prepare their meals.

TECHNICAL DESCRIPTION

The Blender Controller Box has two operation modes: manual mode and timer mode.

Manual Mode

To operate the system in manual mode, the user has to set the mode switch to the manual position. The manual mode switch S1B will contact with +12.0 volt line and light up the LED D3 to indicate the manual mode is in use. Also, the manual mode switch S1A contacts the command switch. If the command switch is not pressed, the input of U2_pin2 is high, the output of U2_pin7 is low and there is no driver to relay K2. The relay switch is in the inactive position (pin_9 and pin_8). As a result, the RF transmitter switch is in the off position and

Figure 18.3. Blender Controller.

sends the OFF command signal to the RF receiver. Therefore the blender will not run.

When the command switch is pressed, the input of U2_pin2 is low, the output U2_pin7 is high and feeds the +12.0 volts to relay K2. When the relay switch is in active position (pin_9 and pin_10), the RF transmitter switch is in the on position and sends the ON command signal to the RF receiver. Therefore the blender will run. Switches 6 and 7 of K2 are shorted and contact ground. The blinking LED D5 will light up to indicate that the blender is running.

Timer Mode

When the mode switch is in timer position, the timer mode of switch S1B will feed +12.0 volts to LED D4 and the timer LED will light up. It also feeds s voltage supply to the 555_timer U3. The 555_timer is set in the monostable mode (one short) with 15 seconds of output. When in timer mode, the command switch will contact the timer mode of

switch S1A. If the command switch is not pressed, the input of U3_pin2 becomes high; the output U3_pin3 becomes inactive. Therefore, there is no drive to relay K2 and the blender is not operational.

If the command switch is pressed, the input of U3_pin2 is low; the output of U3_pin3 will be active and feed the driver voltage to relay K2 in 15 seconds. Therefore the blender will operate for 15 seconds.

Because the 555_timer is set in the monostable mode, the output of the 555_timer will not be able to be reset while in timer mode (15 seconds). If the user presses or releases the command switch while the blender is operating in timer mode, the blender cycle will not be interrupted will continue to run for the length of 15 seconds.

The relay K1 relay prevents the user from activating the blender command switch for longer than 15 seconds. When the command switch is pressed, the input to the U1_pin2 is low, and the output U1_pin7 is high and drives the relay K1. When the relay K1 is active, switches 6 and 7 of K1 will open. Therefore the command switch does not control the system. The system only resets when the user releases the command switch and presses it again after the blender stops (15 seconds).

The package for the Blender Controller Box contains:

- The Blender,
- The Blender Controller Box,
- The RF receiver,
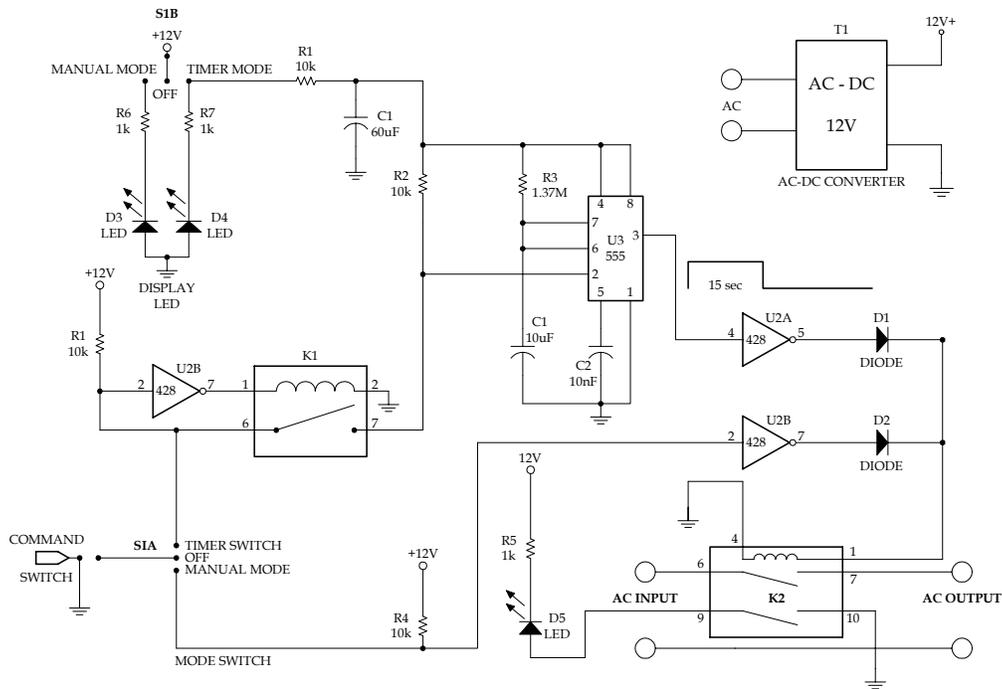- The command switch, and
- An AC power cord.

Figure 18.4. Circuit Diagram.

THE DIGITAL VOICE BOX

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INTRODUCTION

This product will digitally record and play back 16 messages. It was designed to help a person with cerebral palsy, a disease that affects motor coordination skills, including speech. This device will help the client communicate.

SUMMARY OF IMPACT

The design uses a hexi-decimal keypad to equally divide the recording time into 16 segments. The keypad had to be big enough for the client to operate. The heart of the design is an IC called an ISD2590. This device handles all of the playback, record and storage operations. It is manufactured by Information Storage Devises, retails for about $25.00. It has 90 seconds of recording time, allowing approximately five seconds per button.

Performing a playback operation is simply done by pressing the desired button. It is not necessary to hold the button down. Recording is almost as simple: A switch on the side must be set to 'record'. The user presses a button and begins speaking to record, and releases when the message is finished. Finally, the switch on the side is reset to play.

TECHNICAL DESCRIPTION

Rechargeable batteries are used to power the unit. Five hours of charging yields approximately four days of continuous usage.

The ISD2590 was set to operate in "addressed mode", where record and playback operations start at a latches address location. Converting the hex inputs into binary created 16 equal memory locations. The binary equivalent is used as the most significant sign of address space. All other less significant address bits were tied low. The hexi-decimal to binary conversion was done using a 74C922 IC. This chip comes with convenient built-in keypad de-bounce circuitry. When a key is pressed, it outputs the binary equivalent and sets its Data Available (DA) bit high. This tells the circuitry when to turn on.

Playback or record mode is determined by one simple switch (PR). When the ISD2590 finishes recording, it automatically saves a "stop sign" called "End of Message" (EOM). This signal is used to tell the circuit when the playback is finished.

Using these signals, the control logic was created to enable the ISD2590 at the appropriate times.
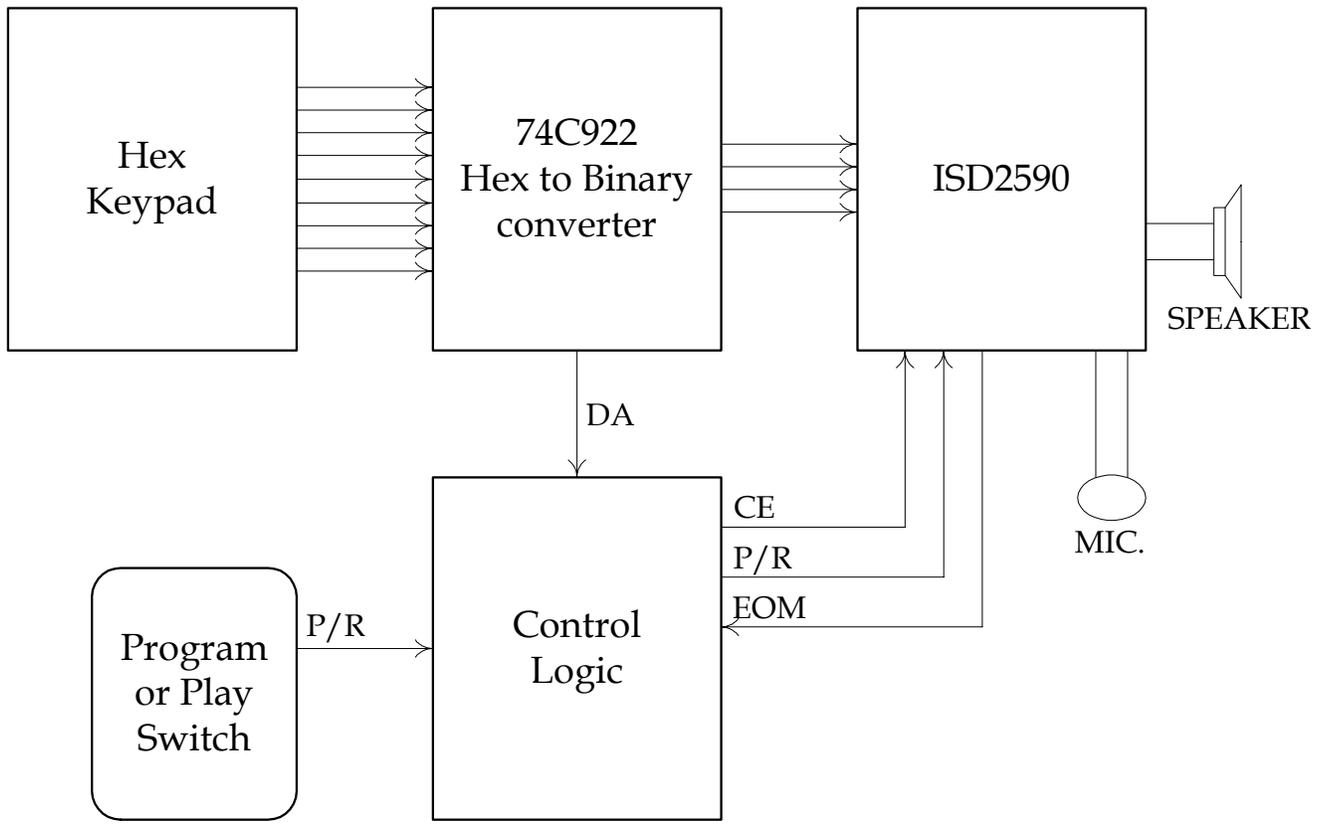

Figure 18.5 –The digital voice box.

Figure 18.5. Block Diagram of the Digital Voice Box.

ENVIRONMENTAL CONTROL SYSTEM

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INTRODUCTION

A unique control system was designed for a client who has significant cognitive and physical impairments. The purpose of the project was to increase the client's confidence by giving him independent control of a fan, lights, TV-VCR, and other devices. The project involved two phases:

- Phase I (client and system interface), and
- Phase II (system and control object interface).

The Information presented here pertains to Phase I development. The system was developed in Windows based Visual Basic.

SUMMARY OF IMPACT

In Phase I, a series of pictures related to the control objects are displayed on the screen. When the user selects a picture, a unique code (number) assigned to that picture is sent to the control box. Depending on the code sent, Phase II then activates the relay switches controlling operation of devices, such as a light, fan and TV–VCR.

Phase I begins by displaying pictures of appliances. The system provides voice feedback when a picture is displayed. When a picture is selected, (for example a fan) the item is indicated by voice response ("FAN"). The system then displays pictures related to the fan, like ON, OFF and EXIT. Figure 18.6 illustrates the overall description of Phase I. In general, Phase I familiarizes the client with the Environmental Control System. To simplify this process, additional pictures that interested the client were added.

TECHNICAL DESCRIPTION

Phase I was developed in Visual Basic 5.0 (VB). Figure 18.6 displays the flow chart for the entire process. The basic display frame is shown in Figure 18.7. The system is organized as a tree, with pictures displayed in the first loop that can be viewed as one
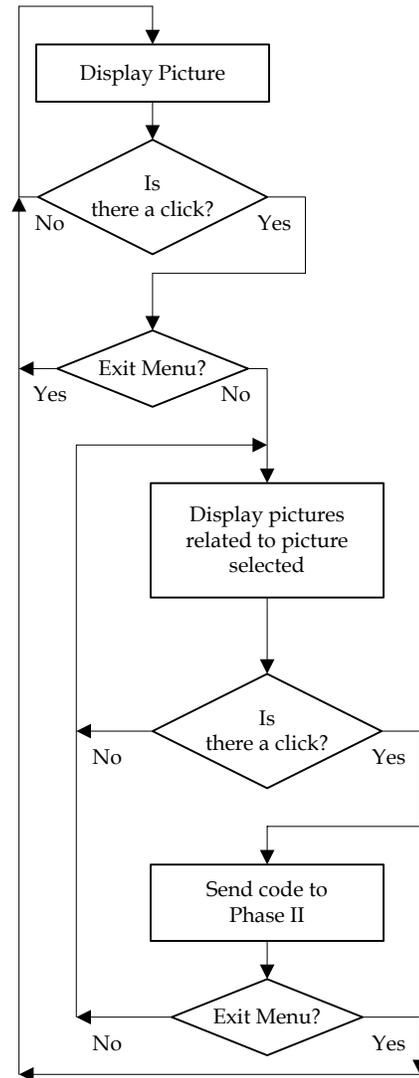

Figure 18.6. Phase I Flow Chart.

branch. Pictures displayed in the second loop are the stems of that branch.

Initially, a picture is displayed on the screen for an allotted time, as specified in the text box. In the meantime, the program waits for the user to select the picture. This can be accomplished by clicking

the right button of the mouse. If a picture is not selected, the next picture in the main loop is displayed for the same duration as the previous picture. If a picture is selected, pictures related to it (stems of the selected branch) are set for the display. All these pictures of the second loop are assigned a unique ID number.

When the stem of the selected picture is displayed, the system waits for the user's input. The system follows the same routine as described earlier except, now, if the user clicks on a picture, its unique code (ID number) is sent to the Digital I/O board. This in turn controls the relay switches of the control box.

Once again the system starts displaying the pictures related to Picture 1. Each branch has an "Exit" icon. If selected, the system will exit that branch and the user once again starts cycling in the first loop (main branch of the tree). The system follows the same routine until the user shuts it down.

Phase I prepares the user for Phase II; consequently, the pictures in Phase I are related to those in Phase II, as illustrated in Figure 18.7.

When the user clicks on the "Help" menu, the program stops displaying pictures and the user sees items 2, 3 and 4 displayed on the screen. When operating in the "Help" mode these conditions are helpful to remember:

- New pictures can be loaded by following the directions form the 'Help' menu;
- The timing interval between the displays of the two pictures must be defined in seconds in the text box;
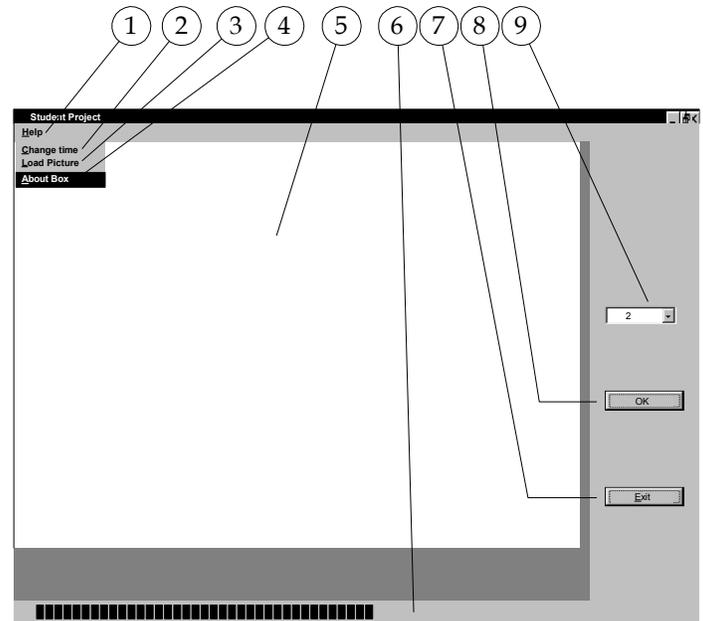
1) "Help"   2) "Change the time"
3) "Load the Picture"   4) "About Box"
5) Picture Frame   6) Progress Bar
7) "Exit" Button   8) "OK" Button
9) Text Box

Figure 18.7. Phase I Display.

- Once the time is defined in the text box, the system resumes displaying pictures by clicking the 'OK' button; and
- Clicking the 'Exit' button the system will stop running all the activities.

To use this program the user must have Visual Basic 5.0.

Estimated cost of this project is about $125.

PAUSE & PLAY VIDEO BOX

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INTRODUCTION

The Pause and Play Video Box is a cause and effect instrument designed to help children with physical and or cognitive impairments learn and use reflexive responses to audio and or visual stimuli.

This project is contained in a 6.5 x 8 x 3 inch prototype box with a 2.5 inch bright colored button fastened to its top. The system circuit design is centered on the dual non-triggerable one-shot DM74LS221 and the dual retriggerable one-shot with clear and complimentary outputs driving an LM556 dual timer. The combination of these devices and a nickel-cadmium rechargeable battery complete an inexpensive, low current, rechargeable circuit, which meets the need expressed by a social service facility.

SUMMARY

Students and participants at a school watch movies for enjoyment, stimulation or learning. This passive activity can become mundane and requires no participation or interaction on the part of the students. This Pause & Play Video Box will be placed under the hand of a student who has limited dexterity and movement. The student will be responsible for pressing the timed "PAUSE" button each time the video screen goes blank, or when other students direct him to reset the pause. Holding down the button will not result in the desired reset effect unless it is pressed immediately after the video is paused. Games can be created to employ the pause box so that the student must actively reset the video.

TECHNICAL DESCRIPTION

The system uses a 74LS122 (retriggerable) and LS123 one-shot because of their ability to generate an output pulse of 100% duty for long durations. Its DTL and TTL compatibility and input clamping diodes add stability needed in the low voltage, sensitive "remote control" environment. One of the standard four outputs from an opto-ioslator is used to trigger the first 555 which. This first timer is set to between 1 and 2 minutes, after which it uses a second opto-isolator to trigger the second 555 in order to acquire an extended pulse. This pulse drives the other pair of opto-isolator solid-state relays that are attached to the remote control button circuit pads. One relay resets the video player to "play". The other relay will set the video remote to command the VCR to stop when the timer runs out.

The circuit required a design such that if the button were held down it would not drain the nickel-cadmium battery. Still, the pulse needed to be long enough to trigger the opto-isolators and the 555s. The remote controls would only work when a diode was forward biased across the path created by the standard "play" and "stop" circuits on the remote circuit board.

There is a battery recharger included in this package so that the batteries can be recharged from a banana plug port on the side of the box. There is also a voltage check meter that plugs into this same port so that the charge of the battery can be tested at the beginning of each day. The meter clearly displays the OK zone and the zone where the unit needs a recharge.

Figure 18.8. Pause and Play Video Box.

HOME ENVIRONMENT CONTROL SYSTEM

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Supervising Professors: Prof. Donn Clark, Mr. Alan Rux
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INTRODUCTION

A home environment control system was designed for a person with quadriplegia. The home environmental control consists of two parts: the human-to-computer interface, and the computer control system. The human-to-computer interface is a circuit that consists of a pressure or force sensitive resistor that is connected to a level detecting integrated circuit. This circuit is developed for the special needs of the client, who has limited movement in his fingers. The computer control system is a Visual Basic program developed to control a wireless remote and X-10 module. When the user chooses an appliance function, the program will interpret this choice, such as "Turn on the TV," "Lights On," "Fan Off," and other choices, and interact with the X-10 package to execute the command.

SUMMARY OF IMPACT

The system is designed to involve the digital movement of this particular client, but is versatile enough to allow other means of human-to-computer interface. Through this system, the client will be able to involve other faculties as his rehabilitation continues.

TECHNICAL DESCRIPTION

The main requirements of the home environment control system are to:

- Take advantage of the limited mobility of the client,
- With consideration of mobility limitations, allow the client to interface with the PC in a comfortable and easy manner,
- Control common household appliances,
- Be portable and easy to connect and disconnect, and
- Be safe to use.

The system has three major components:

- A selection device,
- A computer system, and
- The control electronics.

The client hears sounds and sees pictures of different commands such as "Turn on the Lights," "Fan On," and "Play CD." The selection device is a level detector circuit connected to a force-sensing resistor. The force-sensing resistor is placed between the client's thumb and middle finger, and when this resistor is squeezed, it changes the level of voltage present at the input of the level detector circuit. When the maximum level is reached, the circuit activates a mouse button to indicate that a selection was made. The sensitivity of the selection device can be varied, as well as the time delay of its output pulse with the use of potentiometers incorporated into the circuit.

A customized Visual Basic program interprets this mouse click and matches it up to the scrolling picture and sound on the screen. By knowing what the picture represents, the program interprets as a certain command. This command is transformed into an instruction that is sent to a parallel I/O card integrated into the computer.

The parallel I/O card is connected to a Radio Shack remote control that will interpret the bit pattern, which will simulate pressure on the buttons. If the function activates anything connected to the X-10 modules, the X-10 module main controller will interpret the button sequence and make the desired appliance turn on or off.

Tests of the system were done at a university laboratory in addition to the home of the client. Continuous changes are being made, depending on day-to-day progress and special needs of the client.

Costs included:

- Approximately $50 for the selection device components (a force-sensing resistor, a

level detector chip and resistors, capacitors, opto-couplers and a 555 timer chip), and

- Approximately $150 for the X-10 components, the Radio Shack Remote Controller with X-10 compatibility, X-10 Controller, and individual X-10 module, and

The computer system, (for which the price may vary depending on the type of PC platform used).

A laptop computer was loaned to transport the project components between locations, but a low-end 32-bit system can be used, estimated at $500. A parallel I/O card was purchased for $50.
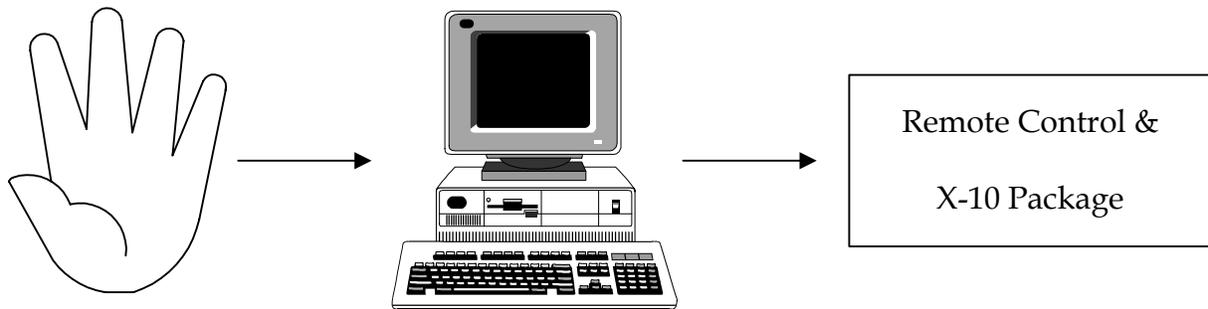

Figure 18.9. Symbolic Representation of the Home Environment Control System.

IN-HOUSE PAGING SYSTEM FOR INDIVIDUALS WITH HEARING IMPAIRMENT

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INTRODUCTION

A paging system was developed to assist two individuals with hearing impairment in an agency where they are employed. Their goal was to have a system that would enhance communication between the workers, which, in turn, would enhance the overall operations at the agency. The device was also expected to enhance the clients' independence.

Existing wireless technology was interfaced with digital technology. The original system uses a receiver tuned to 27.255MHz with a beeping sound to alert the individual when a message arrives. It was determined that the receiver should generate a warning light that would flash at a certain frequency and display a solid LED number (zero through nine) that would correspond to a specific task. The device would remain in this state until a worker with a hearing impairment had been alerted. Upon acknowledging the message, the circuit would allow the individual to reset the system.

SUMMARY OF IMPACT

This system is useful for individuals with hearing impairments. It allows them to work in a more relaxed, efficient and independent manner.

TECHNICAL DESCRIPTION

The overall circuit design is shown in Figure 18.10. The seven wireless receiver outputs corresponding to each of the bars on the LED display (common anode) are tied to the inputs of an eight-input NAND gate. The one unconnected input pin is tied to Vcc through a 1k pull-up resistor. The normal "on" resting state of the receiver (i.e., no signal is being transmitted or received) is active high at +3 Volts. When a message is received, the wireless receiver's outputs are approximately logic zero. Because the receiver required +3 Volts, the logic chips required +5 Volts. A 5-Volt 7805 voltage regulator with a resistor divider configuration was used (not shown in Figure 18.10) to obtain the different voltages. The entire system voltage source used is a 6-Volt AC adapter with a male interconnect that can be plugged in to the side of the receivers' outer metal casing. Because the resting state of the wireless receiver is logic one, all of the input pins of the eight input NAND gate are high. Thus the output of the eight input NAND is logic zero. The input pins of the 8-input NAND are also tied to seven inverters that feed seven positive-edge-triggered D flip-flops.

The output of the 8-input NAND gate is fed to one input pin of a 2-input OR gate. This OR gate is made using a three 2-input NAND gate configuration. The other pin of the OR gate is connected to a SPDT switch, which is at ground potential at rest. When a message, in the form of an LED number zero through nine, arrives this causes the output of the 8-input NAND to change its logic state, regardless of which LED number is being transmitted. Thus, the input of the OR gate is a logic one from the 8-input NAND gate and a logic zero from the SPDT switch position, so the output of the OR gate is a logic one. Consequently, this logic value at this output is fed to the clocks of the positive-edge-triggered D flip-flops. At the same instant the clocks are being enabled, data from the seven pins of the 8-input NAND are being fed through inverters that drive the positive-edge-triggered D flip-flops. Furthermore, the output of the flip-flops is taken from the Q' pins. This is done in order to accommodate the active low input of the new larger designed LED display (common anode).

The main reason that positive-edge-triggered D flip-flops are used in this design is to ensure that the received data does not blink or disappear, as in the existing wireless receiver, but to remain in a solid fixed state until the worker can manually reset it.

The two inputs of the LED display important for this design are pins/bars b and c. These pins are tied to an AND gate, which controls the circuit module for the flashing light. For this module, a 555 timer and LM3909 flashing circuit IC configuration was designed. For every number transmitted, bars b and/or c are always used. Using AND logic, this controls the timer, which drives the LM3909. The reset pins of the positive-edge-triggered D flip-flops are controlled by another timer circuit. This input is tied to the SPDT switch through an inverter imbedded into the OR configuration at the front end of the design. This timer is specifically calculated to have a delay of approximately 25 seconds. When the user resets the circuit, the switch goes high. This causes a logic zero to appear at the input of the 555 timer. The output thus resets the entire circuit through an inverter. This forces all of the Q′ output to a logic one. As a result, the flashing light will be turned off as the LED bars are turned off. The wireless transmitter is designed to continue transmitting for approximately 25 seconds. After the

reset button is pushed, the circuit ignores further transmissions for this amount of time. This is why a 25-second timer was used. Once the circuit is reset, it will remain clear and be ready for a new signal.

The cost of the parts/materials for the project totaled approximately \$206.
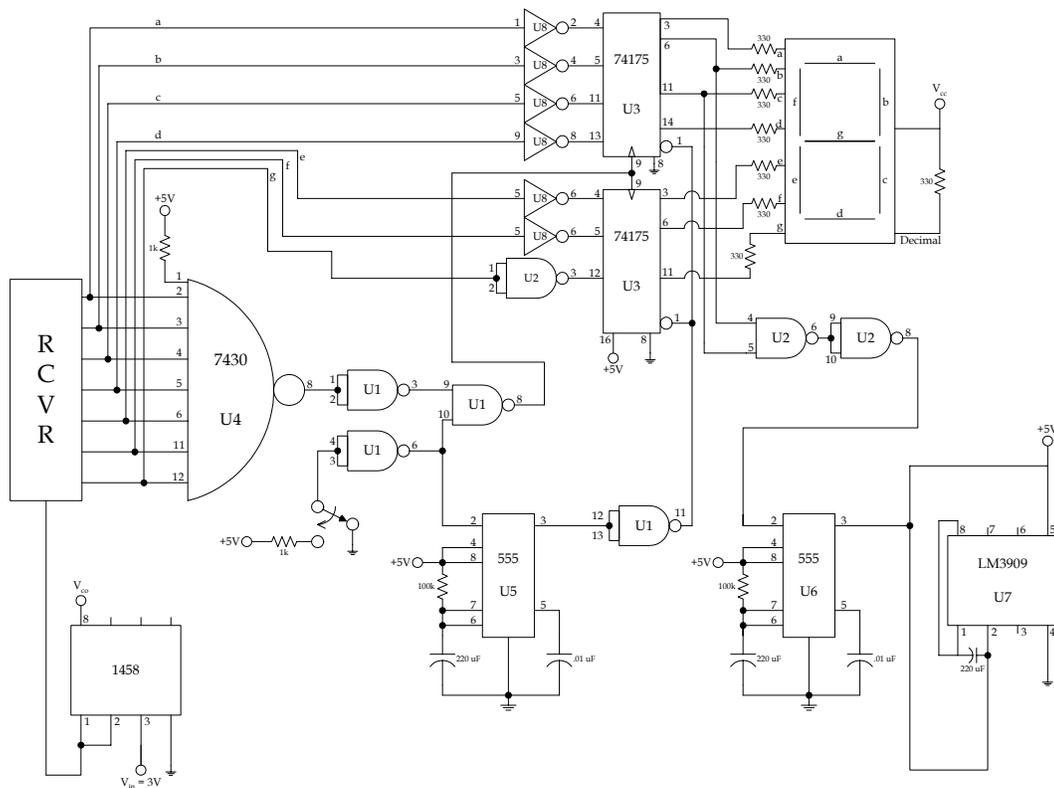

Figure 18.10. Circuit Diagram for In-House Paging System.

ACCESSIBLE RADIO

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INTRODUCTION

An Accessible Radio was designed for the children at school. It will allow children with disabilities to independently control a radio. This design features an acoustic effect (in addition to music) and a visual effect. These features were included in the design for entertainment, educational, and simulation purposes.

SUMMARY

The Accessible Radio was designed so that large area jellybean switches, string switches, or any plug-in type switch can be plugged into one of the sockets in the control box. The control box is designed so that the children will be able to control the POWER, PLAY, STOP, SELECT, VOLUME UP, and VOLUME DOWN functions of the radio. A voice response has been implemented for an acoustic effect using an ISD2590 IC. This will provide an audio description of one of the control buttons listed above.

The second main feature of this Accessible Radio is a visual effect. This is accomplished with an LED array box. This LED array box will light up as the music is played. This visual effect will provide visual stimulation as well as entertainment for the children. An LM3916 IC (LED display driver) was used to implement this effect.

TECHNICAL DESCRIPTION

The sequence for operating the radio follows:

- The control switch is pressed;
- A low pulse is sent to the ISD2590 circuit for activation;
- A low pulse is sent to the radio for activation;
- Music starts playing, and simultaneously the LED arrays begin to flash.

There are six function buttons built into the switchbox that control this radio. By directly addressing the ISD2590 integrated circuit, six different messages were assigned to their respective function buttons. Each switch makes a contact to ground (Pulse low). That low signal is conducted through a unique diode configuration. The configurations are characteristic of the binary address of each individual message. At the same time the ISD2590 is addressed through the diodes, the Chip Enable or CE pin (pin 23) is pulsed low by that same low signal. This activates the chip. Again, that same low pulse is sent through a logic gate configuration to enable control of the radio. When the music begins to play, the 6X10 LED array box begins to flash in red, green and yellow. To drive these LEDs, a LM3916 display driver is used. Each individual LM3916 IC can drive 10 LEDs; therefore six ICs were needed for the radio to function as designed.
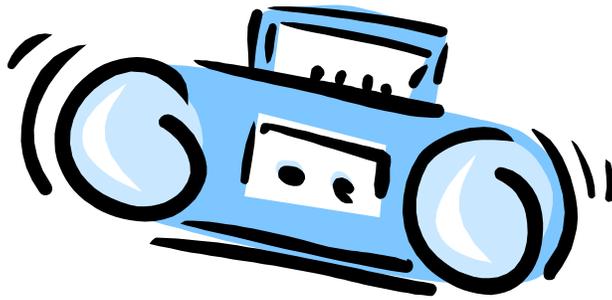
Figure 18.11. Elements of the Accessible Radio.

REMOTE HOME CONTROL KIT

Designer. Debra M. Lynch
Client: Joan Griffin
Supervising Professor: David Wade
Department of Electrical Engineering
University of Massachusetts- Lowell

INTRODUCTION

When used with compatible control modules, the RCA Home Control Kit is capable of controlling three video components and up to 16 uniquely coded devices, such as lamps and small appliances. Video components use infrared while the other modules use radio frequencies. With this kit, a person with physical impairment is able to better control her personal environment.

SUMMARY OF IMPACT

The client is in a wheelchair with limited use of her right arm. Her reaching range is approximately one foot. She enjoys reading and has been able to turn on her TV and radio without assistance, but depends on personal care assistants (PCAs) for many other activities.

Her PCAs visit many times a day. Still, she needed to wait until a PCA arrived should a sunny day become dreary or the morning attendant forget to put the shades up. Other inconveniences occurred when a PCA was delayed.

Installation of the remote home control kit enables her to turn on appliances when she wants. The remote is secured to a table using Velcro strips. Since the Home Control function uses RF, direction of the remote does not matter, nor does it matter if the infrared window is covered. She has some difficulty using the remote for TV functions since her hand usually covers the IR window. She is not concerned about this since she is still able to manually turn on the TV.

At the time the project was implemented, the remote control did not need any fine motor adaptations. Should the need arise in the future, the remote can be paralleled to use sensitive toggle switches.

Figure 18.12. Remote Home Control Kit.

A request to see if the air conditioner could also be controlled in this manner could not be met because electrical supply to the outlet was disconnected.

TECHNICAL DESCRIPTION

The basic kit consists of a multi-function remote control and one base module, as shown in Figure 18.12. The kit uses the preexisting electrical system. The remote is capable of controlling most brands of televisions, VCRs, and cable boxes, as well as the auxiliary module(s). Additional modules, wall switches, and even a key chain remote are available for purchase.

Four AAA batteries are needed to power the remote control. The base unit, lamp and appliance modules are plugged into the home electrical outlets. Devices to be controlled are then plugged into the base unit and other modules.

The base unit has a default house code setting of "A" and an unchangeable device code of "1". The other modules also have a default house code of "A" and the device code can be set from 1 to 16. The base unit and all modules must be set to the same house code. Device codes are set to the user preference.

Operation

After determining the number of devices to be controlled, each appliance needs to be coded according to usage. This client needed to control two lamps in one room, one lamp in an adjacent room, and a kitchen ceiling light. The house code was set on "A" for all devices. If all devices did not work with this code, then codes "B through P" were available. The room with the two lamps had the device code set to "1". The single room lamp was set to device code "2", and the kitchen ceiling light was set to device code "3". The client's television was already compatible with the RCA remote.

To turn on any of the devices, the following steps are used:

- Press the House symbol,

- Press the device code (such as the number 1), and
- Press Channel up.

To turn off and appliance the channel down or mute button is pressed.

The mute button, when used in the home control mode, functions as an "all modules off", regardless of the device code. The power button, when used in the home control mode, functions as an "all lights on" if lamp modules or wall switches are used, regardless of the device code. The TV button on the remote is pressed to control the television. Channel, volume, and mute buttons function normally. Pressing the power button shuts off the TV. To control the VCR, one needs to press the VCR button on the remote. All functions associated with a VCR operate normally.

TALKING BOX

Designer: Matthew Ciampaglia
Client. Doug Heifner Jr.
Supervising Professors. Donn Clark and Alan Rux
Department of Electrical Engineering
University of Massachusetts Lowell
Lowell, MA

INTRODUCTION

A programmable talking box has been designed for a teenage boy who cannot speak. The unit has the ability to record and playback 16 separate messages. Each message can be up to 4.8 seconds in length. Since the circuitry utilizes direct addressing techniques, the 16 messages can be recorded or played back in any order. A switch controls whether the box will play or record a message while a single key press initiates the action. Rechargeable batteries power the talking box. These batteries do not need to be removed to be recharged.

The talking box consists of three entities:

- The hex keypad,

- The microphone, and

- A 6x3x3 " box.

The box contains the speaker and electronics. The keypad connects to the box via an eight-wire-wide strand of ribbon wire. Messages relevant to the user's day can be recorded in the morning so the microphone can be detached from the box. As a recording safety feature, the microphone must be plugged into the box before a message can be recorded. The talking box, shown in Figure 18.13, is meant to be a portable communication device.

SUMMARY OF IMPACT

The talking box is ideal for a person who needs a small and convenient device to allow him to communicate without speech. The unit is smaller than many commercially available products. It can also record up to 90 seconds of sound, more than some commercially available devices. This talking box is convenient because the keypad is connected to the box by ribbon wire, rather than fused to the box. The ribbon wire connection allows the user to attach the box to his belt and put the keypad in a shirt breast pocket or another easily accessible place.

TECHNICAL DESCRIPTION

The circuitry inside the device includes the following four integrated circuits:

- A 7404 inverter,

- A 555 timer,

- A 74922 keypad decoder, and

- An ISD2590 voice record/playback chip.

These elements work together to communicate input data, from a key press and a microphone switch, and produce an output, a recorded or played back message.

The hex key press is decoded into a four-bit binary number by the keypad decoder. These binary digits are the address inputs of the ISD2590. The decoder also outputs a bit when any key is pressed. The bit controls the state of the voice chip's chip enable (CE) pin.

When the state of the CE pin changes from high to low, a record or playback cycle begins. The hex key press also triggers the 555 timer's timing cycle. While timing, the voice chip draws power from the batteries. When not timing, the unit powers down and enters a low power mode. Using the power down feature of the ISD2590 is important due to the fact that it draws 30 milliamps while powered up and only .01 milliamps while in the low power mode.

The ISD2590 is placed into the playback or the record mode by toggling a switch on the microphone. In the playback mode, a single key on the keypad must be pulsed to play back a message. In the record mode, the device will record when a key is held down. Since the microphone switch must be turned on and a key must be held down to record a message, it is unlikely that a message will be recorded accidentally.

The circuit runs on 4.8 volts supplied by four rechargeable batteries. These batteries are rated at 850 milliamp/hours. Though the amount of use determines how often the batteries must be charged, the batteries should last about four days per charge.

The charger produces 6 volts at 150 milliamps. One end of the charger plugs into a standard wall outlet. The other end plugs into the talking box. When engaged, current flows and the batteries begin to charge. The charger will charge the batteries in five hours and forty minutes.

The charging circuit consists of a diode, a 10-ohm resistor, and a 200 milliamp fuse in series with the charger and the batteries being charged. The diode prohibits current from flowing into the charger. The resistor absorbs the voltage differential between the charger and the charging batteries. If the leads of the recharging jack on the box were shorted, a loop circuit consisting of the batteries, the diode, the resistor, and the fuse would be created. The current created by this circuit would be significant. The current would be large enough to burn out the fuse and create an open circuit.

The cost of the material used to make this box is approximately $80. Much of the cost comes from a few expensive items, namely the rechargeable batteries, the speaker, and the ISD2590 voice/record playback chip.

Figure 18.13. Talking Box, Shown Without Charger.

VOICE COMMAND RESPONSE REPLY

Designers: Daniel Fernsebner, Roberto Bachman
Supervising Professor: Donn Clark
Department of Electrical Engineering and Computer Science
University of Massachusetts Lowell
Massachusetts 01854

INTRODUCTION

The purpose of this project was to enhance the independence of an eight-year-old boy with cerebral palsy by giving him the ability to control common devices in his home. These devices include lights, TV, VCR, stereo, and a front door. This project utilizes custom designed software and interfaces with existing software that recognizes speech. The software activates different peripherals that exist throughout the house through X10 technology.

SUMMARY OF IMPACT

The Visual Basic application listens for a command from the client. The client's speech pattern is recognized as a command by the voice recognition software, which in turn causes a bit stream to be transmitted to the COM port. From the COM port the bit stream is then transmitted to a X10 command center, which recognizes and toggles the correct unit and house code bits. The X10 module, with a house and unit code matching that of the bit stream, then receives and decodes this binary word, thus activating the desired device.

The Universal remote control was dismantled and hard wired into a logic box. This logic box or remote control interface is wired to a bi-directional X10 module. This module receives the initial house and unit code signal to identify that the signal being transmitted from the command center is for the remote to perform an action. The logic box circuitry deciphers the bits transferred from the command center. Through this logical decoding the command stream triggers the correct output state and activates the remote to send an infrared signal to stimulate the desired device. See Figure 18.14.

TECHNICAL DESCRIPTION

This system utilizes X10 technology, first developed by Pico electronics in 1970. It is a communications "language" that allows compatible products to communicate with one another through the existing 110V electrical wiring found most homes. It eliminates the need for expensive rewiring.

The following are the principal system components:

- Visual Basic application,
- Microsoft Speech SDK 4.0,
- An Interfaced Universal Remote,
- A CP290 Command Center, and
- Assorted X10 modules (TW 523).

The Visual Basic application is the "center" or brain of the system. It handles the entire drop down menu operations and command/module editing. It also makes "queries" to the Microsoft Speech SDK 4.0 recognition software to listen for commands, and to pass the "recognized" words back to the Visual Basic application. If a command is recognized, the Visual Basic application then sends a binary stream through the COM port to the CP290 command center. As long as the bit stream is valid, the CP290 will than transmit a thirteen-bit word, which consists of a house, unit, start, and command codes. If the associated binary stream is directed to a device (light, door, etc.) the corresponding module will activate the desired device, thus toggling the light or activating the door mechanism. If the associated binary stream is directed to the remote the X10 TW523 module will wait for a recognized bit pattern to be transmitted.

Once the TW523 recognizes a correct bit pattern from the given house and unit code identified in the bit stream it is then passed to the logic box. The logic box will then decipher the bit stream and trigger the appropriate final state. Once the state has been set to active the remote will emit an infrared signal to either the TV, stereo, or VCR, thus toggling the device.
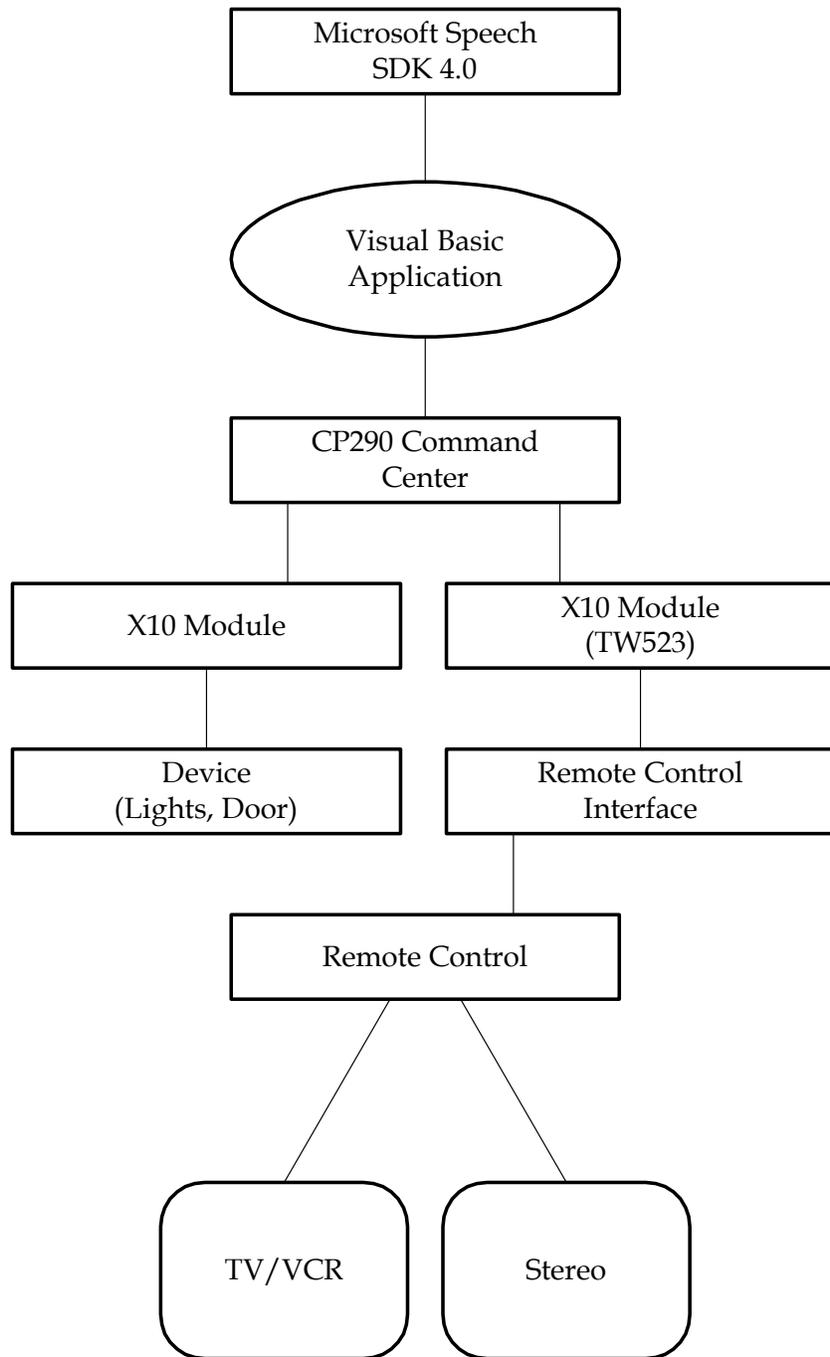
```
        ┌─────────────────────┐
        │  Microsoft Speech   │
        │     SDK 4.0         │
        └─────────────────────┘

           ╭───────────────╮
          │  Visual Basic   │
          │  Application    │
           ╰───────────────╯

        ┌─────────────────────┐
        │  CP290 Command      │
        │     Center          │
        └─────────────────────┘

  ┌──────────────┐   ┌──────────────┐
  │  X10 Module  │   │  X10 Module  │
  │              │   │   (TW523)    │
  └──────────────┘   └──────────────┘

  ┌──────────────┐   ┌──────────────┐
  │   Device     │   │ Remote Control│
  │(Lights, Door)│   │  Interface   │
  └──────────────┘   └──────────────┘

        ┌─────────────────────┐
        │  Remote Control     │
        └─────────────────────┘

     ╭──────────╮   ╭──────────╮
     │  TV/VCR   │   │  Stereo  │
     ╰──────────╯   ╰──────────╯
```

Figure 18.14. Flow Chart.

DIGITAL RECORDING ODOMETER

Designer: Ed Peek
Client: Scott McBay
Supervising Professor: Professor Donn Clark
Department of Electrical Engineering
University of Massachusetts Lowell
Lowell, Massachusetts 01854

INTRODUCTION

The Digital Recording Odometer is designed for a person, who has the ability only to move the neck and head, to measure, read, record, and reset distances. The device is single switch reset activated, with voice sensed record activation. It is completely portable and can be turned on and off when desired.

The Digital Recording Odometer is compact and includes multiple components so that the odometer display is the only piece of device visible to the user. The rest of the Digital Recording Odometer can be mounted on the back of the wheelchair, completely out of the user's sight (Figure 18.15).

SUMMARY OF IMPACT

The Digital Recording Odometer (DRO) is designed for a man who has quadriplegia due to a motorcycle accident. He is employed for a paving company and his job requires him to measure the dimensions of driveways. The DRO allows him to measure, read, and record the distances accurately and independently. Without the DRO he has to rely on his nurse to help him with his everyday job duties.

TECHNICAL DESCRIPTION

The Digital Recording Odometer consists of four main sections:

- An odometer box,
- A rotary network,
- A recorder, and
- A power supply box.

It runs off the 12-volt battery that is used to power the wheelchair motor, and will not consume more than 500mA of current.

The odometer box displays the distance of the measurement traveled in feet, and is reset to 000.0 with one touch of the normally open tongue switch. The odometer circuitry is comprised of logic chips.

The first set of logic chips converts 5-volt pulses to BCD numbers and the second set of logic chips converts those BCD numbers to seven-segment numbers. The output is then displayed through common anode, seven-segment LED displays.

The rotary network is comprised of a rotary encoder, two logic chips, and customized metal wheel. The rotary encoder supplies 128, 5-volt pulses per rotation. Used along with the metal wheel, it converts the spinning of the wheelchair wheel to pulses. These pulses are then sent through two logic chips that are each set up for divide-by-five logic. By doing this, the signal drops to a usable 5.12 pulses per rotation. With the odometer count measured in feet, each pulse must equal 1.2 inches, which forces one rotation to be 6.144 inches per rotation. The wheel can then be customized to a radius of .978 inches to produce the effect of one pulse equaling 1.2 inches.

The recording of measurement is done verbally through a digital micro cassette recorder. The recorder is voice sensed; it records when the distance is verbally stated, and goes into pause mode after four seconds of non-verbal use. The recorder is also manipulated so that an LED on the odometer box is on when the recorder is recording, off when the recorder is off, and flashes when is recorder is in standby mode.

The final segment of the Digital Recording Odometer is the power supply box. The supply box houses the power supply and the logic of the rotary network. The power supply converts the 12-volt power supplied by the battery to 3 volts for the recorder, and 5 volts for both the odometer and rotary network logic. This is done by first sending the voltage through polarized capacitors. Next the signal is sent to a 5-volt regulator and an adjustable voltage regulator set at 3 volts. The 5-volt bus, ground bus, and 5-volt pulse are all sent to the odometer box using 9-pin connectors and cable.
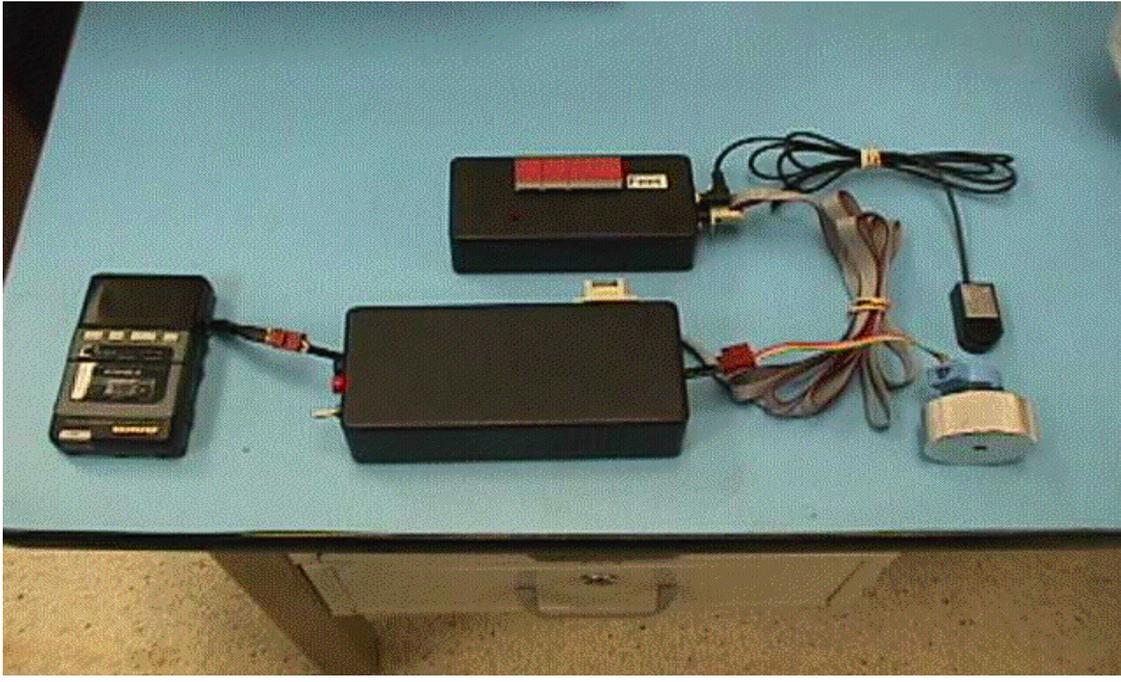
The total cost of parts and materials was $250.

Figure 18.15. Digital Recording Odometer.

SINGLE MESSAGE RECORD/PLAYBACK BOX

Designer: Robert Embt
Supervising Professor: David Wade
Electronic Engineering Technology Department
University of Massachusetts at Lowell, Division of Continuing Education
Lowell, MA 01854-2881

INTRODUCTION

A single message record/playback device was designed to assist non-verbal individual with poor motor control by giving him or her a way to communicate. The non-verbal person must first have assistance from a teacher or parent to record a message into the device by pressing the record button and speaking into the microphone on the bottom of the box. The message can then be played back any number of times by the individual simply by pressing the large playback button attached to the outside of the box plugged into the playback jack. The device can record up to a twelve-second message, and is powered by four internal nickel-cadmium batteries. An external DC power adapter is provided to recharge the batteries when plugged into the DC power jack on the back of the box.

The goal of this project was to design for mass production so that 50 to 100 of the boxes could be easily produced. The ISD1012 chip was used for the speech record and playback, and a printed circuit board was designed. The circuit board is packaged within a low cost case with battery power, record switch, playback switch, and DC power adapter to be used for charging the internal batteries.

SUMMARY OF IMPACT

The Single Message Record/Playback Box gives a non-verbal persons a chance to communicate. Since the goal of the project was to design for mass production, it will be possible to give clients several of these boxes, each programmed with a different message, which yield them several phrases to use when they need something.

TECHNICAL DESCRIPTION

The Single Message Record/Playback Box consists of:

- a double-sided circuit board, approximately four inches by four inches, with two integrated circuits,
- two switches
- a speaker connection, and
- a microphone connection.

There are approximately 14 discrete components.

The discrete components and integrated circuits were soldered to the board. Wires were soldered to the circuit board to connect the switches, microphone, and speaker that are mounted to the enclosure. Four nickel-cadmium batteries are plugged into a battery clip that is attached to the back of the enclosure, and wired into the DC power jack. This is in turn wired to the power and ground terminals on the circuit board.

The DC power jack has three terminals, two of which are connected by a 20-ohm resistor. When the DC power adapter is plugged into the jack, 6 VDC is applied to two of the terminals. Since the nickel-cadmium battery pack is wired to the third terminal on the other side of the 20-ohm resistor, and the DC power adapter always supplies more voltage than the nickel-cadmium batteries, so current will flow through the batteries and charge them. Since the circuit board power is drawn from the battery terminals, it will never exceed the maximum voltage of the 4 nickel-cadmium batteries (1.2 volts times 4 batteries or 4.8 volts), which is an acceptable level to power the circuit board.

The ISD1012 chip mounted on the circuit board will be used as the record/playback chip. Since the entire family of chips is pin compatible, any other chip from the family could be substituted to shorten or lengthen the maximum message size. This chip will provide a 12 second message. A Schmitt trigger input quad 2-input NAND gate is used as the power down circuit that drives the PD pin of the ISD1012. The inputs to the NAND gate are pulled up +Vcc that will draw very little current due to the high impedance. When either the record or playback switch is pressed, the inputs to one of the gates will be pulled to ground, causing the ISD1012 chip to

activate and perform either the record or playback function then shut off.

The approximate cost is $50.