CHAPTER 19
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Choice Selection Module
A Device to Improve Communication for the Physically and Mentally Disabled

Designers: Jon Chinn and Wilfred Wong
Client Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Dr. Yongmin Kim
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INTRODUCTION

The Choice Selection Module is a simple battery-powered device which records and plays back sound stored digitally in flash memory. Since disabled individuals are often limited in their abilities to audibly express their needs, this unit will allow a user to vocalize a request simply by pressing down on a user switch.

This electronic device provides record and playback functions, both of which are initiated by a single switch. By inserting a microphone into the unit and pressing the switch, a facility staff member can record a message that is stored in nonvolatile memory. When the microphone is removed, the user can initiate playback by pressing the switch. In this way, the human communication problem is minimized by relaying a prerecorded message from user to staff.

SUMMARY OF IMPACT

The Choice Selection Module has been designed specifically for residents of the Fircrest School in Seattle, Washington. Since many of these developmentally disabled individuals have impaired communication capabilities, this module will aid these residents in their ability to communicate verbally.

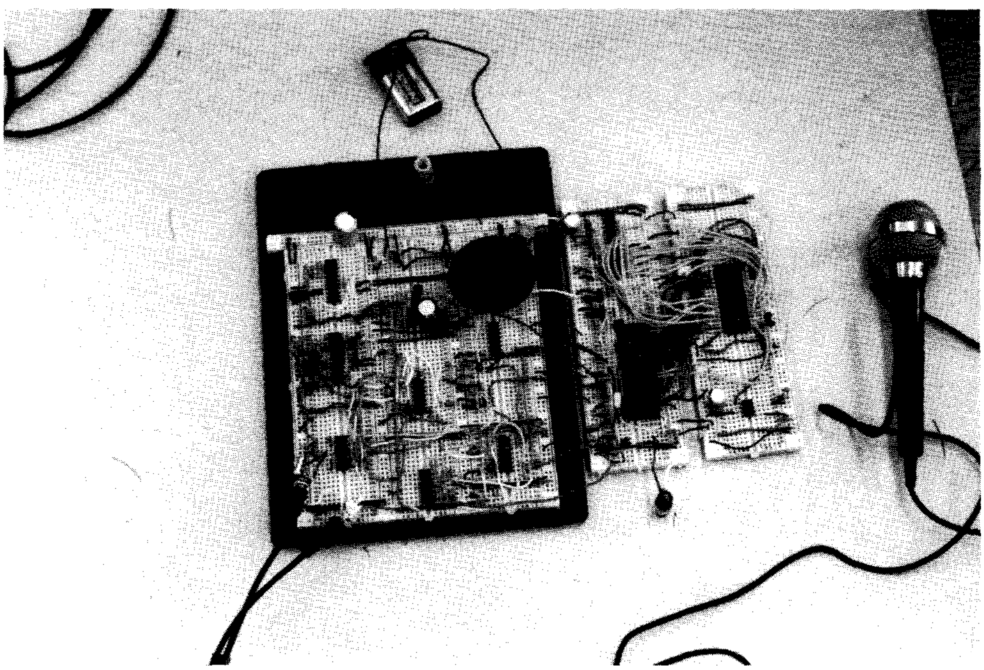

Fig. 19.1. Choice Selection Module

Each user may be trained in a number of Choice Selection Modules. To provide a greater range of expression, each easy-to-operate unit may be programmed for a different need, and the user would be able to communicate a variety of desires to staff members simply by pressing the switch on the appropriate module. In this way, the Choice Selection Module provides a viable solution for reducing communication problems between disabled individuals and facility staff members.

TECHNICAL DESCRIPTION

The container for the Choice Selection Module (CSM) is 5” long, 4” wide and 1" deep. The front consists of a photo-mount lexan-plate switch, LED, and battery cover. There are standard 1/8" and 3/32" microphone jacks mounted on the left side of the module. The 9 V battery compartment and the electronics of the CSM are all located inside the container.

There are three modes of operation: play, record, and idle. Using a 68HC705C8 microcontroller, play is initiated with a logic high on Port C bit 1 and the user switch pressed. The lower fifteen bits of two 8-bit synchronous counters are used to sequentially address the memory in 32 Kbyte pages. Port B of the 68HC705C8 receives the data and transmits it through its Serial Peripheral Interface (SPI) to the D/A converter. Since the D/A converter is using 9 V power, the data must be converted to 9 V logic levels. This is done using a CD4050 buffer. The clock for the D/A conversion is supplied by the SPI and the data rate is 64 Kbits per second. The resulting analog signal is transmitted to a bandpass filter with cutoff frequencies of 300 Hz and 2500 Hz and sent to an 8-ohm speaker with audio amplification.

Record is initiated by using the microphone to send a logic low to Port C bit 1 and pressing the user switch. The input signal is amplified with a gain of 21 and filtered with cutoff frequencies of 220 Hz and 3500 Hz. The signal is then transmitted to the SPI port for storage on memory.

The data conversion portion of this device is relatively easy to design using an MC3418 Delta Modulator, performing A/D and D/A on a single IC. The value of the digital data is determined by the slope and the frequency of the input analog signal and is well suited for human voices because of its bandwidth compression property. A logic low from Port C bit 3 will set the MC3418 to D/A and a logic high will set it to A/D mode.

Intel Flash memory ICs are used for nonvolatile data storage. To write, each byte must be cleared with ØØH, verified, and erased with FFH each time. A MAX632 voltage regulator is used to supply a +12V Vpp to the Flash EPROM and it is critical to have a 22 μF tantulum bypass capacitor at this input. The user must configure two jumpers for memory size used. Four, eight, or sixteen second data samples can be stored depending on the memory size.

The Choice Selection Module costs about $90 to build and will be very helpful in aiding **many** speech impaired people to communicate.

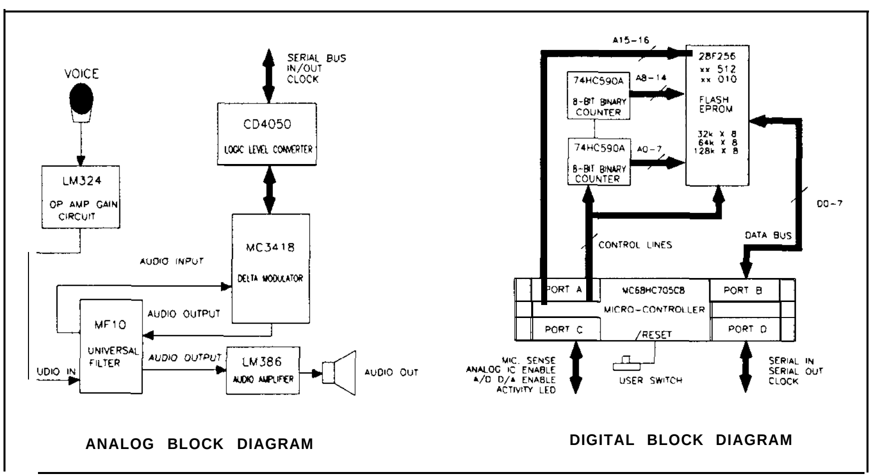

Fig. 19.2. Block Diagrams of the CSM.

A Communication Switch Downloader A Device for Monitoring the Progress of Disabled Students with Impaired Communication

Designers: Anthony Wong and Adam Lew
Client Coordinator: Dr. John Eiler of Fircrest School
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INTRODUCTION

The Communication Switch Downloader (CSD) is a device designed to enable speech pathologists to monitor the progress of physically and mentally disabled individuals who have impaired verbal communication abilities.

SUMMARY OF IMPACT

The CSD was designed for clinical application at Fircrest School in Seattle, Washington, which is a residential facility for the disabled. With the CSD, the progress of the students can be monitored more easily and efficiently. While students are developing their verbal abilities, a communication switch can be left with them over a period of time. Since the communication switch is a relatively inexpensive device, each student can have more than one communication switch. After a period of time, the CSD is used to retrieve the data from the multiple communication switches and transfer the data to a computer. As a result, the speech pathologists can use a computer to monitor the progress of many students by examining the data collected from each communication switch.

TECHNICAL DESCRIPTION

The CSD is a two-button battery-powered device that retrieves data from the communication switches and transfers the data to a computer for further analysis. There are two types of communication switches, simple (SCS) and complex (CCS), which are both described in separate reports. In addition, the DSC has a Liquid Crystal Display (LCD) to display information. In order to keep track of the current time, the CSD contains a real-time clock.

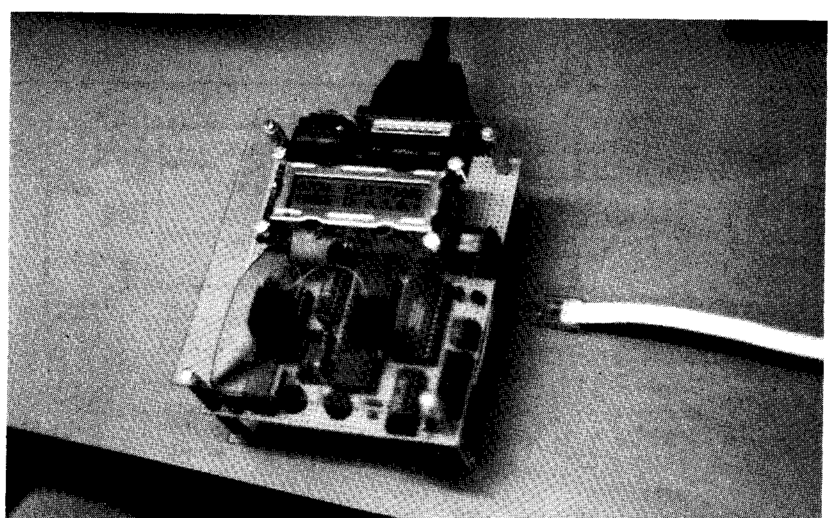

Fig. 19.3. A Communication Switch Downloader.

The CSD has three major functions: switch transfer, data scroll, and computer transfer. The CSD retrieves the data from both the SCS and CCS. Using the two buttons, the corresponding student ID numbers and names of the data retrieved can be displayed. The data contained in the CSD can then be transferred to a computer and displayed on a terminal. Also, data can be transferred to the CSD via the computer for initialization purposes.

The CSD has three major design objectives: power consumption, simplicity, and cost. Because the CSD is battery-powered, CMOS devices are used to save power. Since the CSD has many complex functions, a microcontroller is used to minimize the complexity of the design.

The CSD hardware consists of four major blocks: control, storage, user interface, and power. The control block consists of the Motorola MC68HC705C8 8-bit Microcontroller. A 4 MHz clock is used as the system clock. The microcontroller interfaces to the communication switches through a synchronous serial port, the Serial Peripheral Interface (SPI). The SPI also interfaces to the real-time clock. The microcontroller interfaces to the computer through an asynchronous serial port, the Serial Communications Interface (SCI). A Maxim 236 is used to convert the TTL/RS-232 logic levels. Two transparent latches are used to multiplex the parallel ports in order to provide additional control signals. A PNP bipolar transistor is used to detect if the CSD and a communication switch are connected. When a communication switch is connected, the PNP will turn on and a logic high will be detected.

The data is stored in a 32K x 8 static RAM; the data and address are multiplexed via one of the latches. The user interface consists of two SPST switches and a 16 x 2 LCD. The two SPST switches are used so the user can select the different modes of operation. Information is displayed on the LCD. The power block consists of a 9 V battery and a voltage regulator. The voltage regulator converts the 9 V into 5 V which supplies the power to the chips.

The CSD software consists of four major modules:

1. SIMP_SW,
2. TIME-SW,
3. XCMP-MAIN
4. SCR-MAIN

SIMPSW handles the data retrieval from the SCS. TIME-SW handles the data retrieval from the CCS. XCMP_MAIN handles the data transfer between the CSD and computer. SCR-MAIN handles the scrolling of the data on the LCD. Basically, the software is a large interrupt routine. When the CSD is not being used, the CSD is in a low power mode. However, when a button is pressed or connected to a communication switch, an interrupt is generated and the interrupt routine is executed.

The approximate shelf-life of the CSD is one year. The estimated cost to manufacture the CSD is $80.

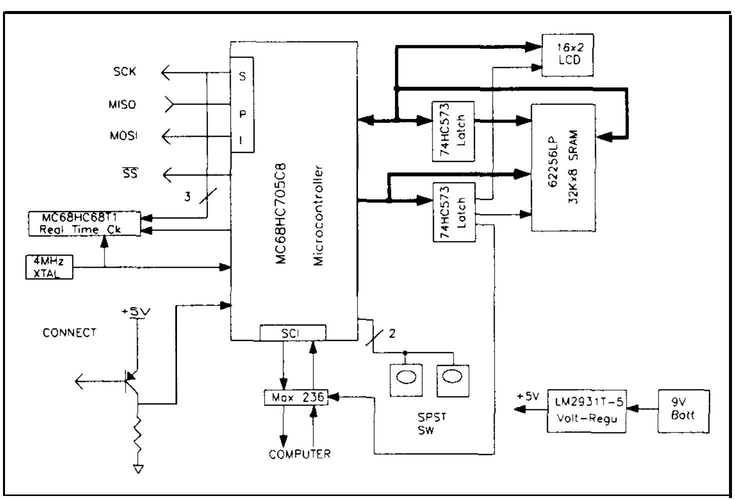

Fig. 19.4. Downloader Hardware Design.

A Simple Communication Switch A Device for Monitoring the Progress of Disabled Students with Impaired Communication

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Client Coordinator: Dr. John Eiler of Fircrest School
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INTRODUCTION

The Simple Communication Switch (SCS) is a device designed to enable speech pathologists to monitor the progress of physically and mentally disabled individuals with impaired verbal communication.

The SCS is a one-button battery-powered device that keeps track of the number of button presses. The SCS emits a light and tone when the button is pressed. A removable lexan plate is placed over this button, and each lexan plate has a different icon imprinted on it. Therefore, the SCS can change its identity by simply changing the lexan plate. For example, a SCS with a smiling face imprinted on it can be used to communicate happiness.

SUMMARY OF IMPACT

The SCS was designed for clinical application at Fircrest School in Seattle, Washington, which is a residential treatment facility for the developmentally disabled. Training can be facilitated by a signal device that performs two basic communicative functions: 1) to gain a listener's attention, and 2) to communicate a message. The SCS alerts the listener by emitting a light and tone when a switch is pressed, and various messages are communicated by a graphic icon printed on the switch plate. Messages can be readily changed by replacing the removable lexan switch plate. For example, a student can ask for assistance in bathing by pressing the switch with a bathtub icon, or request a soda by pressing the switch with a soft drink icon.

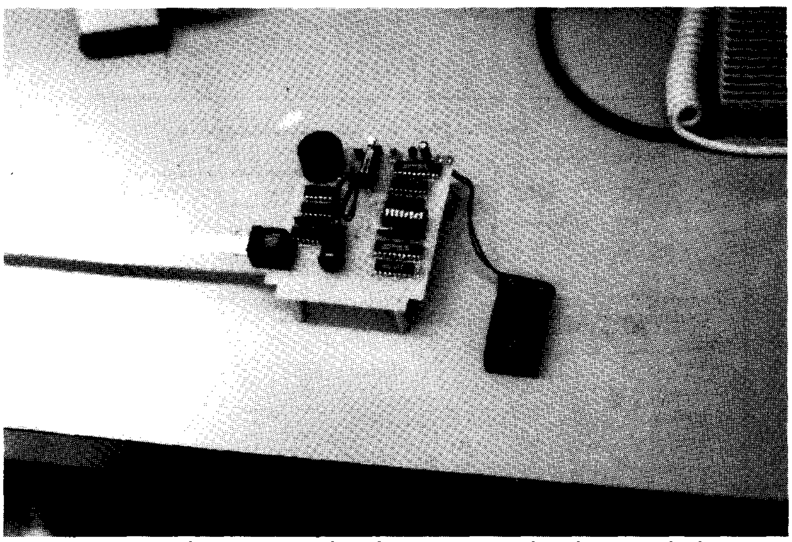

Fig. 19.5. Simple Communication Switch.

TECHNICAL DESCRIPTION

The SCS has three major design objectives: size, power consumption, and cost. The device is packaged in a plastic case that measures approximately 4" x 5" x 1". Because the SCS is battery-powered, CMOS devices are used to save power. Since the SCS will be a multiple production device, the cost must be minimal and thus, discrete logic devices are used.

The SCS consists of four major blocks: user interface, storage, control, and power. The user interface block consists of a SPDT (single-pole, double-throw) switch, lamp, and piezo buzzer. NAND gates are used to debounce the switch. When a switch is pressed, a power MOSFET allows a light and tone to be emitted. The storage block consists of two 8-bit synchronous and two 8-bit buffers. Two 8-bit counters are cascaded to form a 16-bit counter that stores the number of button presses. A button press will provide the clock for the 16-bit counter. Two 8-bit buffers are used to hold the device type and serial numbers. The control block consists of a decade counter, a shift register, and an NPN bipolar transistor.

The control block interfaces directly with the CSD; or more specifically, the Serial Peripheral Interface (SPI) on the Motorola MC68HC705C8 Microcontroller that controls the CSD. The decade counter controls which 8-bit data (device type, student ID, MSB of count, and LSB of count) is to be transferred. Four outputs of the decade counter are used to control the output enables of the counters and buffers. The CSD provides the clocks for the decade counter and the shift register. The data is transferred to the CSD through a parallel-in serial-out register. The NPN bipolar transistor is used to detect if the SCS and CSD are connected. When the CSD is connected, the NPN will turn on and a logic low will be detected. The power block consists of a 9 V battery and a voltage regulator. The voltage regulator converts the 9 V into 5 V that supplies the power to the chips.

The SCS can also help monitor a student's progress in functional communication training by counting the number of times the switch is pressed and saving this data in memory for further analysis. In order to differentiate itself from other devices, the SCS stores a device type number. In addition, a serial number is stored in the SCS so the student and the number of presses can be correlated. Since multiple SCSs will be used by different students, and one student may use several SCSs, the serial number is configurable on the SCS.

While students are developing their verbal abilities, a SCS can be left with them over a period of time. Since the SCS is a relatively inexpensive device, each student can have more than one SCS. After a period of time, the CSD is used to retrieve data from the multiple SCS's and transfer the data to a computer. As a result, the speech pathologists can use a computer to monitor the press of many students by examining the data collected from each SCS.

The SCS has an approximate shelf-life of one year. The estimated cost to manufacture the SCS is $30.

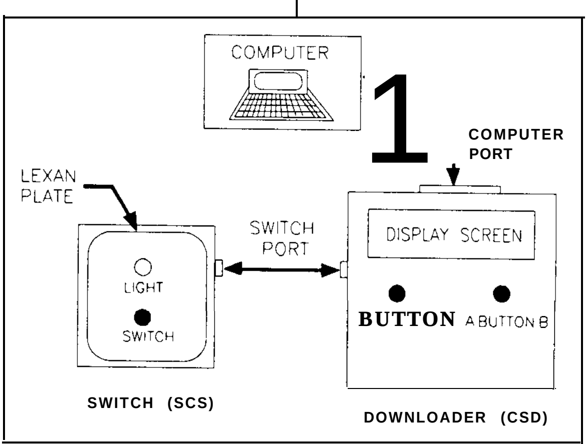

Fig. 19.6. Communication Switch.

Improvement of the Communication Switch Downloader
A Device for Monitoring the Progress of Disabled Students with Impaired Communication

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INTRODUCTION

The Communication Switch Downloader (CSD) is a device designed for speech pathologists to monitor the progress of physically and mentally disabled individuals with impaired verbal communication. The details of the CSD are described in a separate report.

SUMMARY OF IMPACT

The CSD was designed for clinical application at Fircrest School in Seattle, Washington, which is a residential treatment facility for the disabled. With the CSD, the progress of the students can be monitored more easily and efficiently. While students are developing their verbal abilities, a communication switch can be left with them over a period of time.

Since the communication switch is a relatively inexpensive device, each student can have more than one communication switch. After a period of time, the CSD is used to retrieve the data from the multiple communication switches and transfer the data to a computer. As a result, the speech pathologists can use a computer to monitor the progress of many students by examining the data collected from the communication switch.

TECHNICAL DESCRIPTION

The improvement of the CSD has the following design objectives: to change the CSD/computer data transfer format and to implement a packaged printed circuit board. The format of the data transferred from the CSD to the computer is converted and manipulated by an existing software package. This format is shown below. In the previous design, the data format did not contain the tailer. By making a software change, the tailer was added.

In order for the CSD to be a manufacturable product, a printed circuit board (PCB) was implemented. Due to limited board space, the memory address lines were swapped around to create parallel buses. However, this change does not affect the functionality of the CSD. The software package OrCAD was used to produce a PCB layout. A lithographed version of the PCB layout was then used to etch the board. The PCB was put into a 4" x 6" plastic enclosure.

No additional costs were added to the CSD and the original total cost was approximately $80.

```
H                                                          header
19910418120000                                             date/time of
transfer
19910417080000  002  00005  007  John Doe                  data
00000000000000  001  00001  010  Jane Doe
T                                                          tailer
```

Fig. 19.7. Example of CSD Data Format.

Improvement of the Simple Communication Switch A Device for Monitoring the Progress of Disabled Students with Impaired Communication

Designer: Adam Lew
Client Coordinator: Dr. John Eiler of Fircresf School
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INTRODUCTION

The Simple Communication Switch (SCS) is a device designed for speech pathologists to monitor the progress of physically and mentally disabled individuals with impaired verbal communication abilities. The details of the SCS are described in a separate report.

SUMMARY OF IMPACT

The SCS was designed for clinical application at Fircrest School in Seattle, Washington, which is a residential treatment facility for the disabled. With the SCS, the progress of the students can be monitored more easily and efficiently.

While students are developing their verbal abilities, a SCS can be left with them over a period of time. Since the SCS is a relatively inexpensive device, each student can have more than one SCS. After a period of time, the CSD is used to retrieve the data from the multiple SCS's and transfer the data to a computer. As a result, the speech pathologists can use a computer to monitor the progress of many students by examining the data collected from each SCS.

TECHNICAL DESCRIPTION

The improvement of the SCS has two major design objectives: to emit a brighter light when the switch is pressed and to package the SCS into an enclosure. When the SCS is pressed, a light and tone are emitted. However, the light in the previous design was too dim; not enough current was provided to the lamp. In the improved design, a P-channel Power MOSFET was replaced with an N-channel Power MOSFET, and an NPN transistor and 10K resistor were added. As shown below, the 9 V from the battery is used to supply more current to the lamp. The NPN transistor and 10K pull-up resistor are used as an inverter (note the 10K pull-up is a spare from the resistor SIP package).

Another 10K resistor is used to limit the current to the transistor. When the switch is pressed, the NAND gate outputs a low that is then inverted to a high. The high will turn on the N-channel Power MOSFET and thus emit a stronger light.

Also, the SCS was packaged into a 3” x 4” plastic enclosure covered with a removable lexan plate. To make it easier to change the student identification number, a rectangular hole was made on top of the plastic enclosure.

Only $.20 was added to the total cost and the final total cost of the SCS is still around $30.

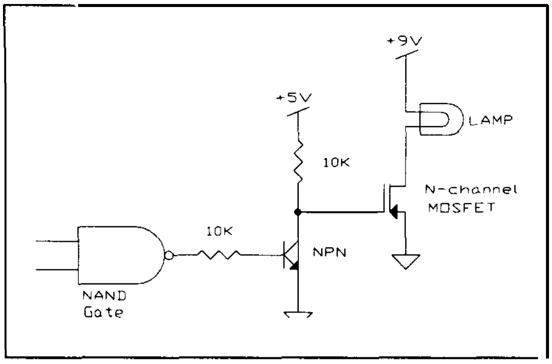

Fig. 19.8. Diagram of Change in SCS to Emit Brighter Light.

Mobility Training Simulator
A Training Device for Mobility Control

Designers: Chuong Dinh Nguyen and Hung Vo
Client Coordinator: Dr. John Eiler of Fircrest School
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INTRODUCTION

The Mobility Training Simulator is designed to allow mentally or physically disabled students to experience and practice the control of the motion of an object before being able to operate a wheelchair on their own. Since most of the time, the wheelchair will be moving forward, the simulator will have to demonstrate that the students can be trained to sustain this motion without veering sideways. If the student manages to stay within a preassigned region, he or she will be rewarded by having a stereo or other device turned on (positive reinforcement). If the student gets out of this preassigned region, the reinforcement will be turned off. The teacher can adjust to different levels of speed suitable to an individual student's ability. The Mobility Training Simulator uses a standard Fircrest joystick that sends the direction and magnitude to drive the stepping motor. The speed of the carrier shows how hard the user is pushing the joystick.

SUMMARY OF IMPACT

The Mobility Training Simulator is designed for the purpose of teaching mobility control at the Fircrest School in Seattle, Washington, which is a residential treatment facility for the developmentally disabled. The device can be used instead of a power wheelchair, which is too expensive to use for training. The Mobility Training Simulator demonstrates that the disabled students can be trained to control their power wheelchair using positive reinforcement to encourage students' desired interaction with the control of the chair.

The training staff can adjust the levels of speed to the students' best comfort and plug in an external audio or visual device for positive reinforcement. The design allows for training with low cost, independence, and portability.

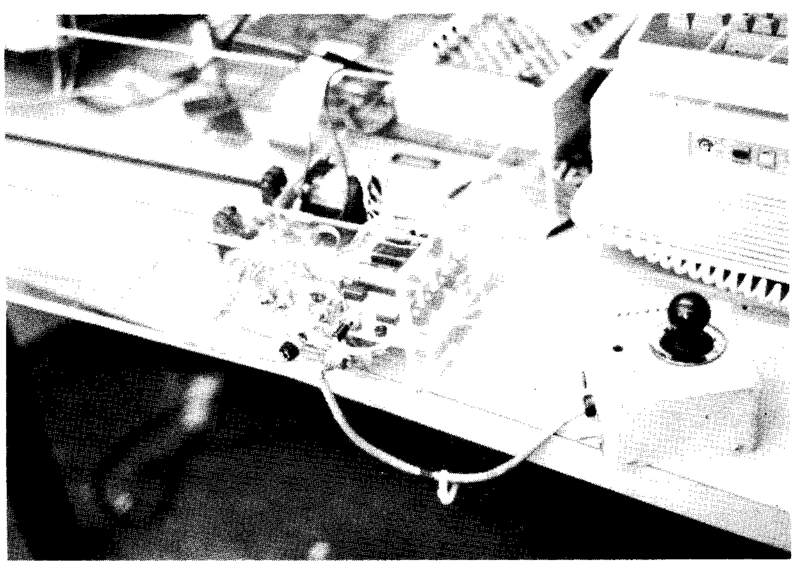

Fig. 19.9. Mobility Training Simulator

TECHNICAL DESCRIPTION

The Mobility Training Simulator design is based on a Motorola 68HC705 microcontroller. The analog input from the joystick and potentiometer knob is digitized by a TI ADC0809, 8 bit A/D converter, and fed to the input ports of MCU. The 500 kHz clock signal from the A/D converter is derived from the MCU clock signal through a modulo-8 counter implemented by the 74LS161 4-bit counter. There is an optocoupler mounted on the carrier to signal the reinforcement boundaries set by the two indicators. The two level switches are at the two ends of the shaft setting the limits of moving boundary. The input from the optocoupler and debounced inputs from the level switches are also fed to the input ports of the MCU.

The MCU computes the speed and direction for the carrier based on the X-Y values of the joystick and generates the next pulse pattern to drive the stepping motor. The speed for the carrier is controlled by the five lookup tables that contain ten different speeds from slowest to fastest. The lookup tables correspond to the value of the potentiometer adjusted for different levels of speed. The value from the lookup table is then used for delay time before generating the next pulse pattern.

The MCU also interprets the position of the carrier with respect to the reinforcement boundaries and the traveling limits to determine whether it should turn on a reinforcement or not. The reinforcement flag is implemented by complementing itself as the carrier passes through the optocoupler once. The previous direction and status of the optocoupler are kept track of to distinguish the situations when the carrier moves to the middle of the optocoupler and moves back instead of moving through to another region.

The MCU allows the carrier to move backward only as it hits either the left or right end of the shaft set by the two level switches. By keeping track of the previous direction of the carrier, the MCU stops the motor if the user tries to move left or right at the left or right boundary respectively; otherwise, the motor is driven backward.

The driver of the stepping motor is designed using four N-channel power transistors IRF 510 connected in series with a center-tapped 4-phase stepping motor. The four diodes V2210 are put across the transistor drain-source pins to protect the circuit from reverse current discharged from the motor's coils. The reinforcement signal turns on the external stereo or other devices through a relay.

The approximate cost of the Mobility Training Simulator is $300 excluding the joystick.

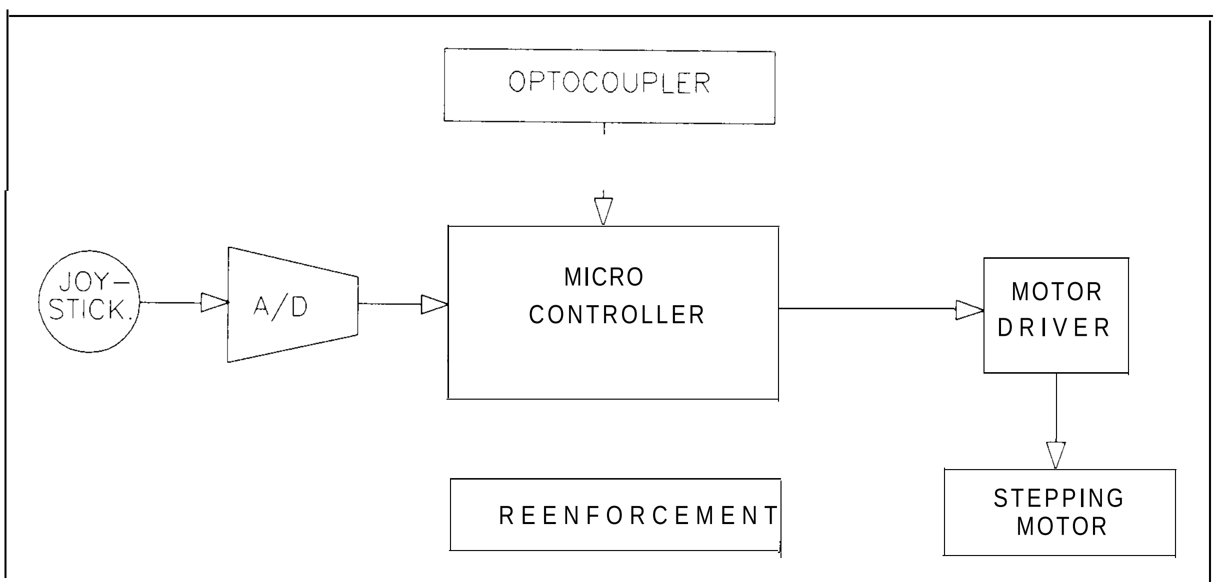

Fig. 19.10. Block Diagram of Mobility Training Simulator.

Revising the Choice Selection Module A Device to Improve Communication for The Physically and Mentally Disabled

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INTRODUCTION

The Choice Selection Module is a simple battery-powered device which records and plays back sound stored digitally in flash memory. Since disabled individuals are often limited in their abilities to audibly express their needs, this unit will allow a user to vocalize a request simply by pressing down on a user switch. This document describes some of the enhancements made to the Choice Selection Module. These enhancements were made to better suit the needs of the residents at Fircrest School.

The basic operation of this electronic device is the same, providing record and playback functions, both of which are initiated by a single switch. Staff members can record a message by simply inserting a microphone into the unit and pressing the switch. This message will be recorded on nonvolatile memory. Playback is initiated simply by pressing the switch. The human communication problem is minimized by relaying the prerecorded message from user to staff.

SUMMARY OF IMPACT

The Choice Selection Module has been designed specifically for residents of the Fircrest School in Seattle, Washington. Since many of these developmentally disabled individuals have impaired communication capabilities, this module will aid these residents in their ability to communicate verbally.

Each user may be trained to use a number of Choice Selection Modules. To provide a greater range of expression, each easy-to-operate unit may be programmed for a different need, and the user would be able to communicate a variety of desires to staff members simply by pressing the switch on the appropriate module. In this way, the Choice Selection Module provides a viable solution for reducing communication problems between disabled individuals and facility staff members.

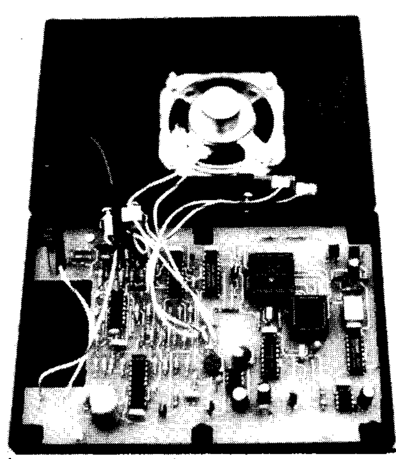

Fig. 19.11. Choice Selection Module.

TECHNICAL DESCRIPTION

The revised dimensions for the Choice Selection Module (CSM) are 6.876” long, 4.876” wide, and 1.5” deep. The front consists of a photo-mount lexan-plate switch, LED, and a battery cover. There are standard 1/8" and 3/32" microphone jacks mounted on the left side of the CSM. The 9 V battery compartment and electronics are all inside the container.

There were a number of revisions made to the Choice Selection Module, the major being the creation of a printed circuit board using a PCB layout program called OrCAD. This was done to increase the sturdiness of the device, which will result in better reliability. Since durability is important, the enclosure is carefully chosen to maximize life. The enclosure is made from ABS GSM UL Rated 94 HB plastic and has excellent resistance to heat distortion as well as toughness and rigidity properties.

Since the printed circuit board developed was only two sided, space was very limited due to the size constraints given. PLCC versions of the MC68HC705C8 microcontroller and 28Fxxx (where xxx is 256, 512, or 010) flash EPROM were used rather than the DIP versions, saving more space.

In converting 5 V logic level to 9 V logic level, a CD4050 buffer was previously used. Instead, an MC14049 inverter was used, eliminating two NMOSFETs in the process. This not only resulted in space saving, but cost savings as well.

In the previous design, the volume was permanently set at a predetermined level. On the PCB, two 1K trimmers (potentiometers) were placed. One is for speaker impedance matching and the other is to control the gain of the LM386 audio amplifier varying it from 20 to 200. These trimmers can be used in tandem for volume control. This will give the staff member the freedom to set the volume while still maintaining security from the user.

The staff member also has the freedom to choose the memory size for either 4, 8, or 16 second messages by setting the jumpers to notify the MC68HC705C8. These jumpers are also located inside the enclosure, so access can only be limited to the staff member at Fircrest.

The revised Choice Selection Module costs about $88 and will prove very helpful in aiding many speech impaired people to communicate.

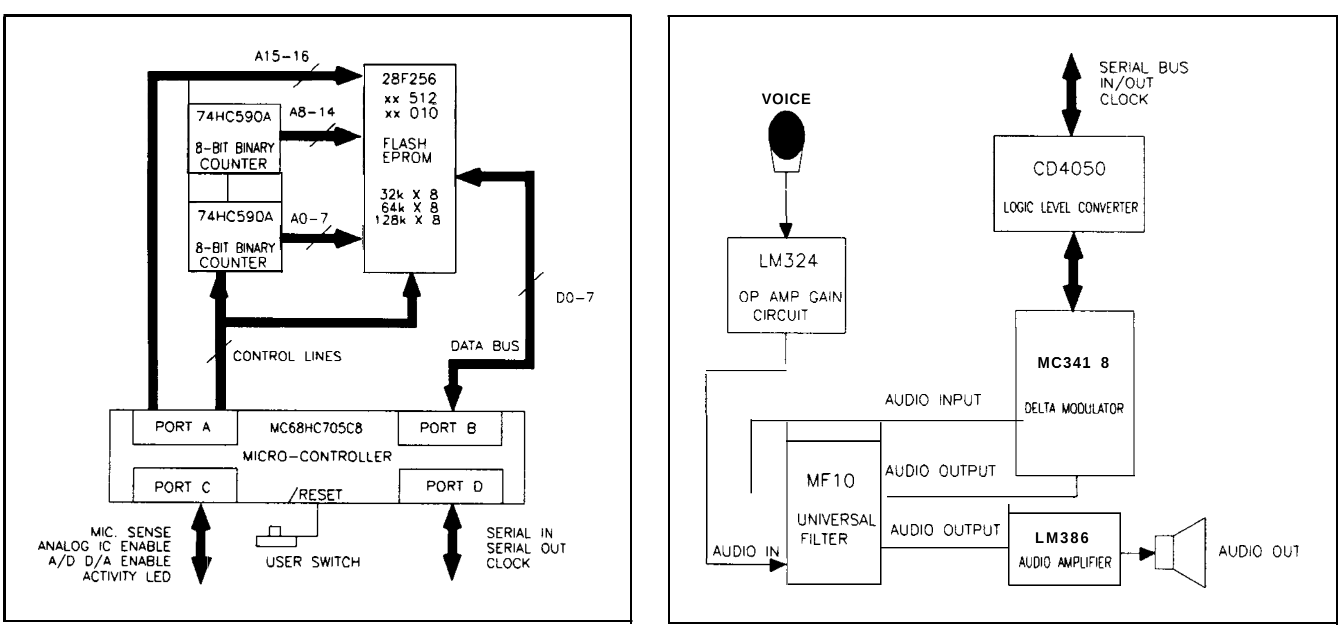

Fig. 19.12. a] CSM Digital Block Diagram b) CSM Analog Block Diagram.

Smart Switch
A Training Controller for Disabled Students

Designers: Rolf S. Mogster and John Ware
Client Coordinator: Dr. John Eiler of Fircrest School
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INTRODUCTION

The Smart Switch is an important learning tool used by therapists to train students who have severe learning disabilities. The Smart Switch is used to teach the students cause and effect. If they push a button, they can affect their environment, e.g., push a button and a radio turns on. The Smart Switch is designed to gather data. It basically has two buttons. One, called a user button, is used to record the time when the button is pushed, and the time when it is released. While the user button is held down it must also turn on a device called a "reinforcer." The other button is called the "prompt" button. It is used by the therapist any time he or she prompts the user to push the button. The Smart Switch records the time when the prompt button is pushed.

SUMMARY OF IMPACT

By comparing the time elapsed when the prompt button and user button are pushed, the student's progress can be measured. To be useful in therapy, the Smart Switch must record the data it collects, and transfer it to a PC. The reason long-term data storage is important is that, for some students, it can take up to two years for any improvement to be measured.

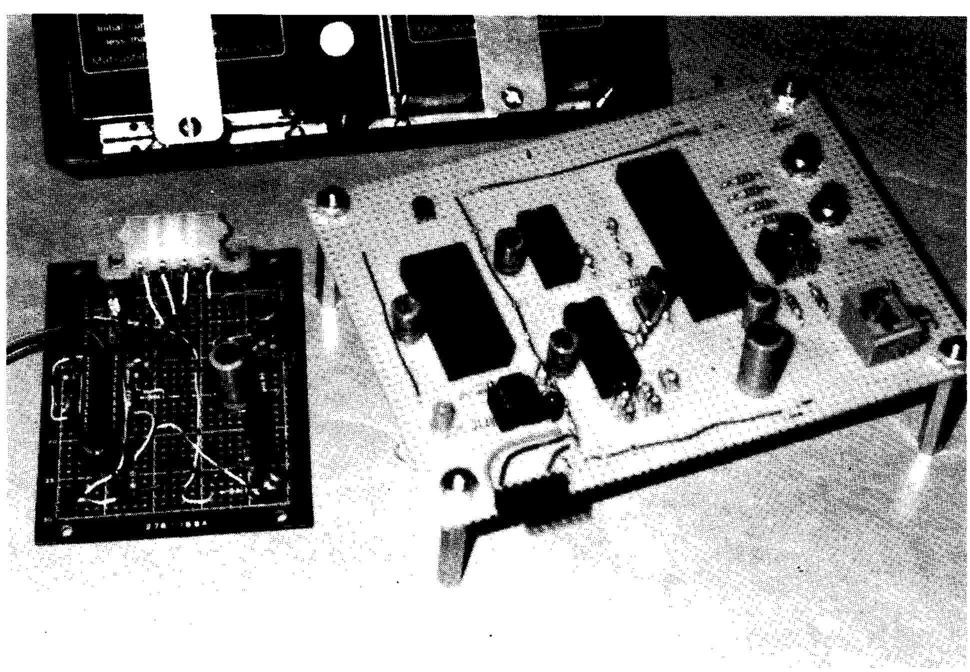

Fig. 19.13. Smart Switch.

TECHNICAL DESCRIPTION

The brain of the downloader is the Motorola MC68HC705 Microcontroller. This chip is used to gather the data needed, and to turn on the reinforcer. The reason for using this chip is that it has a built-in serial communication port. Also, it must transfer its' data to a device (the downloader) that uses this part. In order to record the time the switch is pressed, we have to know the time and date. To achieve this end, we used the Motorola MC68HC68T1 real-time clock. This chip also has the feature of a built-in serial port, and it was designed to talk to the microcontroller we used. This greatly simplified the designs of the hardware and software. The time and date, including year, are set by the downloader.

The data that the Smart Switch collects is stored in an 8K x 8 RAM. This data is transferred to a PC by using a device called a Downloader. When the user switch is pressed, the Smart Switch must turn on the reinforcer. To turn on the reinforcer, the microcontroller sets a pin high. This pin is connected to the gate of an N-channel FET. This FET controls a switching power supply, used to power the reinforcer.

The power supply for the reinforcer was designed around a switching regulator circuit. The switching regulator was chosen for two reasons. One was for efficiency. The switching regulator circuit we used is 85% efficient. This means that 85% of the power that comes from the battery is delivered to the load. Our load, the reinforcer, was by far the biggest drain on the batteries. The load was to consume 250 mA. We wanted its power supply to be as efficient as possible. The second consideration was heat. If we delivered 3 V to a load with a voltage divider type of arrangement, we would waste 75% of our power. This power is dissipated as heat. 9 V at 250 mA is 2.2 W, which represents a high level of heat, and this heat can adversely affect the components, especially in a sealed box.

The switching power supply we designed was based on the Motorola MC34063 switching regulator. This is an 8 pin IC that performs as a buck or boost regulator with minimum external parts. The output voltage is controlled by a resistor voltage divider on the output. The voltage from the divider is 1.25 V. The value of R2 will depend on the desired output voltage. The value of R1 was selected to be 12K. This value was agreed on by both groups using switching regulators to power reinforcers. It was selected because the calculated and available values of R2, needed for the desired voltages, are very close.

The approximate cost of the Smart Switch is $27.

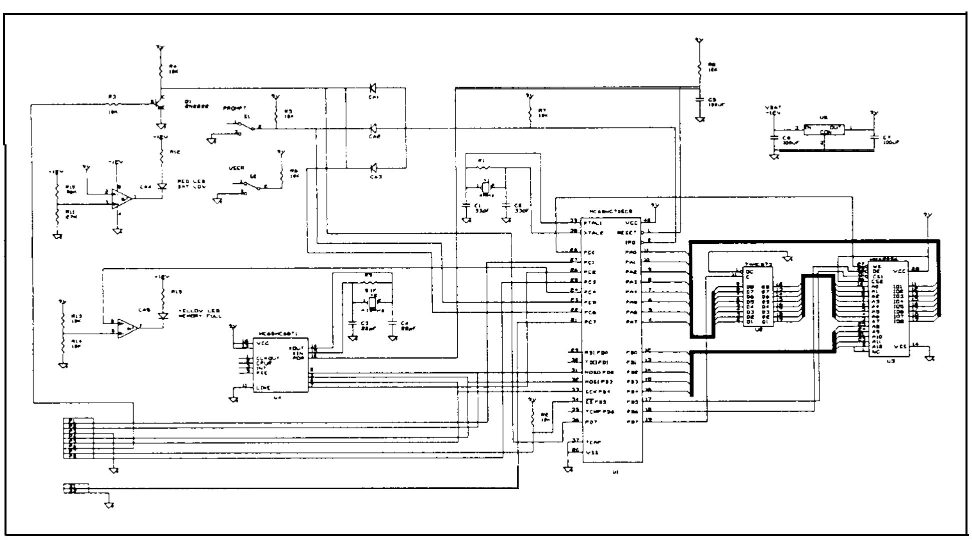

Fig. 19.14. Circuit Diagram of Smart Switch.

Vocational Production Monitor Printed Circuit Board Fabrication and Keypad Improvement

Designer: Radwan Faraj
Client *Coordinator:* Dr. *John Eiler* of *Fircres t School*
Supervising Professor: Dr. Yongmin Kim
Department of Electrical Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

The Vocational Production Monitor (VocMon) is a reinforcement device that gives a disabled student time for listening to a radio, a television, or any other reward and encouragement that is electrically controlled. The amount of reward and amount of work required to attain the reward is programmed by the user. The reward is usually a radio or television being turned on. The overview and requirements of the system include utility and handling of the hardware that supports it, as well as user interface. A more robust prototype than the present wirewrap form of the VocMon is preferred. A printed circuit board layout of the VocMon using the CAD program OrCAD is built. This printed circuit board implements the above requirements and improves the VocMon's reliability.

SUMMARY OF IMPACT

The Vocational Production Monitor will be used at Fircrest School, a residential facility for the developmentally disabled. The VocMon monitors the production of workers helping in the tabulation of work done by a student using the VocMon. Since the work environment will probably be unsuitable for a wirewrap form to be used as the working prototype, the printed circuit board prototype could be used with more reliability. Since it will be easy to incorporate a PCB using the OrCAD produced layout, a printed circuit board would be much more preferable than a wirewrapped form of the device.

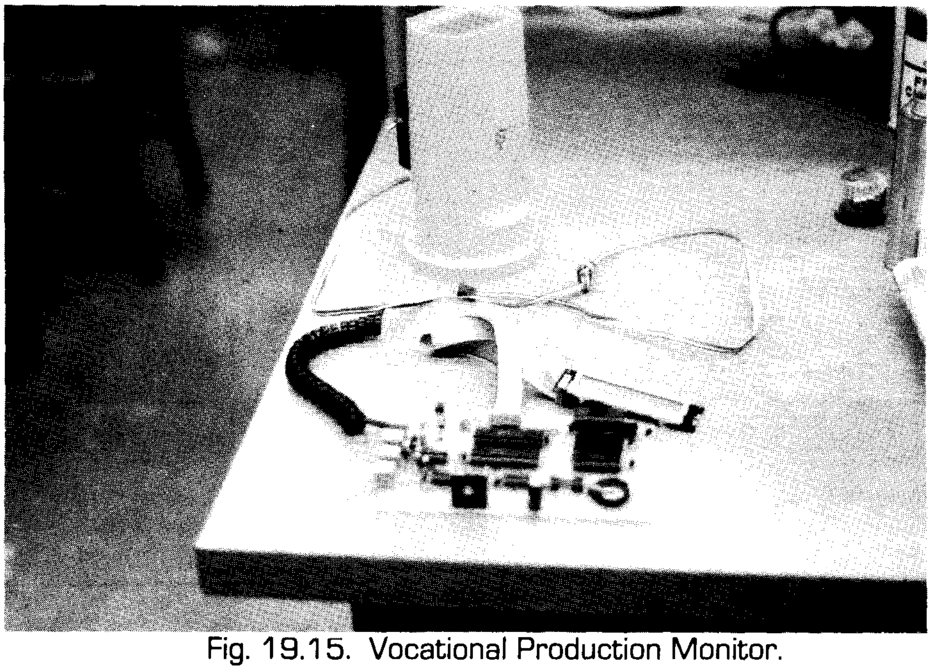

Fig. 19.15. Vocational Production Monitor.

TECHNICAL DESCRIPTION

The Vocational Production Monitor is a device that contains ten chips, six connectors, and a 3 V battery. It weighs about ten ounces and is enclosed in a box that has openings for the connectors, a 2X20 Liquid Crystal Display and a 4X3 keypad. The design of the hardware centers around the Intel 8031 Microcontroller, which controls the communication between the memory and the mechanical and visual part of the device. The memory parts are the Intel 2764 EPROM and the 6264 SRAM, and the visual and mechanical part is the combination of the Liquid Crystal Display (LCD) and the keypad. The communication is done through an Intel 8255 parallel peripheral interface. External communication is also provided with the sensor station and computer terminal. Communication with the four sensor stations monitors work progress and dispenses reinforcement.

There are three signals required for each station: power on, reinforcement, and sensor object detect (to detect an object in the path of the detector). The detector for object drop through a clearly identifiable yellow chute is mounted on the inside of the chute. The LED, which is used for indicating reinforcement (via TV, radio, etc.) is mounted on the other side of the chute. The LED and detector setup are built on one circuit board and VocMon main circuit is built on another circuit board.

The 7.7” x 5.1” VocMon printed circuit board contains the necessary connections for the circuit to be functional, along with sockets and the connectors, capacitors, diodes and resistors. A board layout containing the route and pads placement is produced by the appropriate use of pad size of integrated circuit chip pins and vias, the library utility in OrCAD, and the creation of modules. The default was used for everything else in the layout, such as track width and design conditions. The OrCAD library utility was useful for its contents, such as the Intel 8031 microcontroller. The Computer Aided Design creation of layouts would be the technology that has been replacing the use of stickers to layout traces and other layout techniques that rely on the careful use of hands. The layout and subsequent etching of the board (thus the fabrication of the printed circuit board), could only be as accurate as the layout techniques. Using OrCAD, the industry standard for producing layouts was useful. If Fircrest were to produce more VocMons, then it would be relatively easy to make one using the layout and just fabricating it, rather than using wirewrapping techniques.

The board is laid out by using a combination of auto routing and manual routing techniques. The net list is used and checked from the original schematics for verification. Also, the placement of the modules is done so that it could be fabricated and understood relatively easily. The chips are placed all facing one direction and the connectors are all on the edge of the board. The differences in parts between the PCB and the wirewrap form are a phone jack for the connection to each workstation, double-sided male connector for the LCD and a better packaged design for the printed circuit board. An efficient use of space is incorporated when laying out the printed circuit board. The VocMon costs about $175 to build a first PCB prototype.

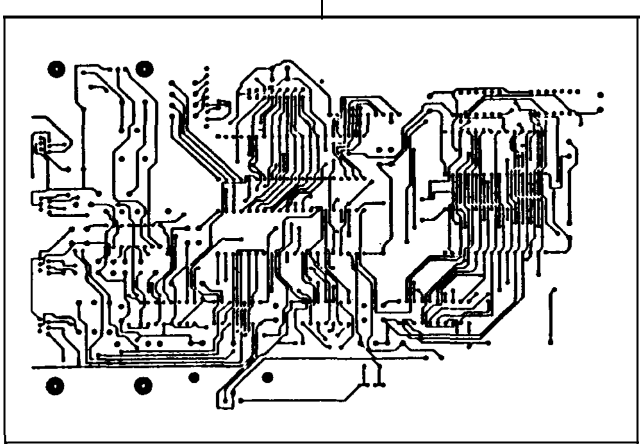

Fig. 19.16. Printed Circuit Board Layout.

X-10 Remote Control Interface
A Device to Assist the Developmentally Disabled in Everyday Activities

Designers: Minh H. Phan and Ngoc-Cuong Hua
Client Coordinator: Dr. John Eiler of Fircrest
Supervising Professor: Dr. Carl Ebeling
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INTRODUCTION

The X-10 remote control system is the leading standard for home automation. An inexpensive ($50) Radio Frequency remote control is available for push button latch controls up to 16 AC modules. However, the operation of the transmitter requires very precise motor skill that prevents the disabled users from operating the system successfully. A user interface device that provides a one-switch operation would be more favorable. A version of this interface device is commercially available. Unfortunately, the price of $525 is prohibitively expensive for most disabled users.

The design of the user interface device has been based on the following factors: User friendliness, cost, reliability, and low power consumption. To provide a high level of user friendliness, we have come up with a one-switch operation scheme. The design uses high speed CMOS MSI parts for low power consumption. It uses a 9 V battery that is shared by the original remote control.

SUMMARY OF IMPACT

The need for a remote control interface to the X-10 Home Automation System was realized at the Fircrest School for the developmentally disabled. Using this device, a student can have a higher level of interaction with his/her environment. This device along with the X-10 system provides the students with the ability to control their lights and home appliances. The students can learn to be more independent and self-sufficient by having better control over their everyday activities.

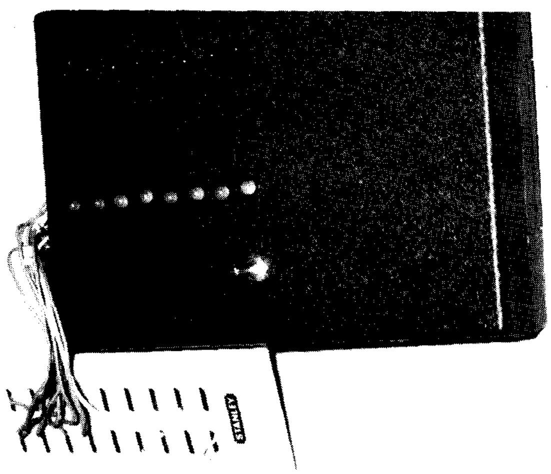

Fig. 19.17. X-l 0 Remote Control System.

TECHNICAL DESCRIPTION

The main task is to build an interface device that is affordable, easy to operate, compact enough to be mounted on the wheelchair and consume the least power possible. The cost of the device should be as low as possible. At $35 for parts, this interface can be built in quantity for less than $70. This is only a fraction of the $525 retail price for the commercially available unit on the market now.

The interface device will operate on battery. Therefore, its power consumption has to be minimal. Only high speed CMOS parts are used. At idle state, the device consumes 18 mA and during operation, it consumes 25 mA. In order to accommodate different users, the scanning rate must be adjustable from 1 to 5 seconds. This is done using a potentiometer-controlled variable resistor. The scope of the device is to change the 16-switch matrix into a one-switch operation that works as follows:

- From the non-operating mode, if the switch is pressed and released, it will make the system enter the scanning mode. The scanning rate is adjustable and the scan sequence always starts at module one.
- In the scanning mode, the LED's will be turned on successively to denote the module selected.
- While in scanning mode, if the switch is pressed, then the selected module (denoted LED) will be activated accordingly.
- After the switch is released, all of the LED's will be turned off and the system is reset back to the non-operating mode with module one.

The main function of the interface is to simulate a closing of the original X-10 remote's switches. This is done by using two analog multiplexers. Since the X-10 remote stays in sleep mode until it senses a current flowing through one of its 16 switches, digital multiplexers would not be appropriate. The scanning operation is controlled by a 16-state counter. This counter keeps track of which module can be selected. It cycles from 0 to 15 representing eight ON and eight OFF states for 8 modules. If the user activates the switch when the counter is at state 3, for example, then module two will be turned on. If he activates the switch when the counter is at state 4, then module two will be turned off.

The heart of the interface is the PAL. The state machine implemented by the PLD is an eight-state Moore machine. There are two clocks for the system, one is for the PAL and the other is for the counter. The latter is controlled by a variable resistor mounted on the interface panel.

The approximate cost of the X-10 Remote Control Interface is $35.

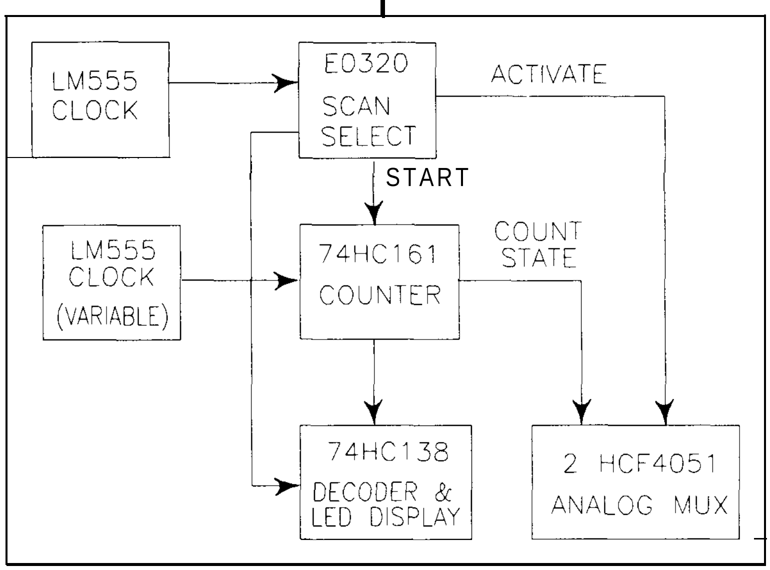

Fig. 19.18. Block Diagram of the X-l 0 Interface Device.

A Complex Communication Switch A Data Collection and Signaling Device for the Verbally Impaired

Designers: Christopher Chan-Nui and Quinn Howard
Client Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Dr. Yongmin Kim
Department of Electrical Engineering
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Seattle, WA 98795

INTRODUCTION

A new augmentative communication device has been developed which serves as both a signaling device and a data collection tool for developmentally disabled students. The simple, flexible design minimizes power consumption and allows the device to be configured for individual communication training needs. The device provides a flexible interface that allows the staff to customize the device to an individual student's needs and has an active life of several months. Therapists can access each student's time and type of communication via a companion downloading device, which retrieves the data, displays an LCD summary and transfers the information to a personal computer for analysis.

SUMMARY OF IMPACT

Functional communication training for severely and profoundly developmentally disabled students focuses on a means to convey basic wants and needs. Staff at Fircrest School in Seattle have been using a simple signaling device that emits a light and tone to gain a listener's attention, and communicates a message by a picture or icon printed on the switch plate. Speech pathologists at the school felt that the ability to maintain accurate records of the requests made by each student would enable them to better analyze the effects of their communication training.

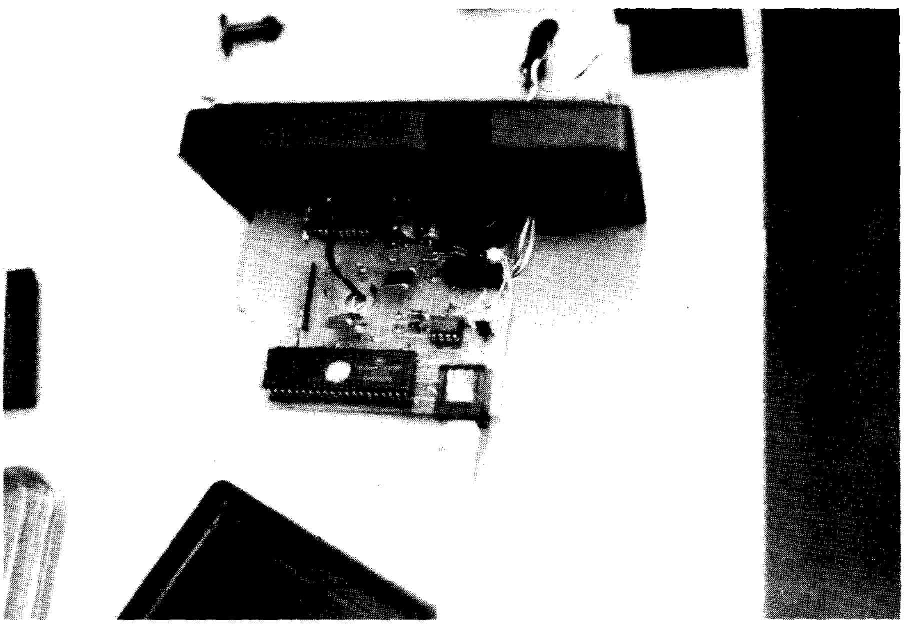

Fig. 19.19. A Complex Communication Switch.

Therapists for the mentally handicapped often use signalling devices to establish communication with their non-verbal students. These devices vary in range and ability from the simplest bell to dedicated banks of switches. They allow the student to alert the staff of a particular need, reducing the amount of monitoring the student requires. Usually each device is associated with a particular need by means of a picture or icon, on or near the switch.

This device is designed to serve both as a signalling device and a data collection device. The device is flexible, allowing the therapist to select a number of settings to customize the switch for an individual student. It is also expandable, allowing easy addition of extra storage and/or function. Finally, the cost of the device is low, allowing multiple devices to be used with each student. This device provides substantial clinical benefits over existing equipment by allowing the speech pathologists a reliable means to monitor the progress of many students in functional communication training programs.

TECHNICAL DESCRIPTION

A block diagram of the signalling device is shown in Figure 19.20. The device is designed around a highly integrated microcontroller in order to reduce the number of components in the device and to increase the flexibility of the device. The EEPROM, real-time clock and serial ports were connected directly to the microcontroller ports. This allowed access to be completely software controlled, minimizing the number of discrete hardware components.

The selected EEPROM uses a serial interface, reducing the space occupied by the chip and allowing different sizes of memory to be used with no hardware and very little software modification. Using the minimum data storage size, the device is able to hold approximately 60 entries. If the data storage requirements are higher, the data buffer may easily be increased in size by utilizing a larger EEPROM and changing a hardcoded value in the program. This allows the flexibility of selecting an EEPROM that is the correct size for a given situation. Nonvolatile memory also has the advantage that in the case of power loss or damage to the device, the data will still remain intact.

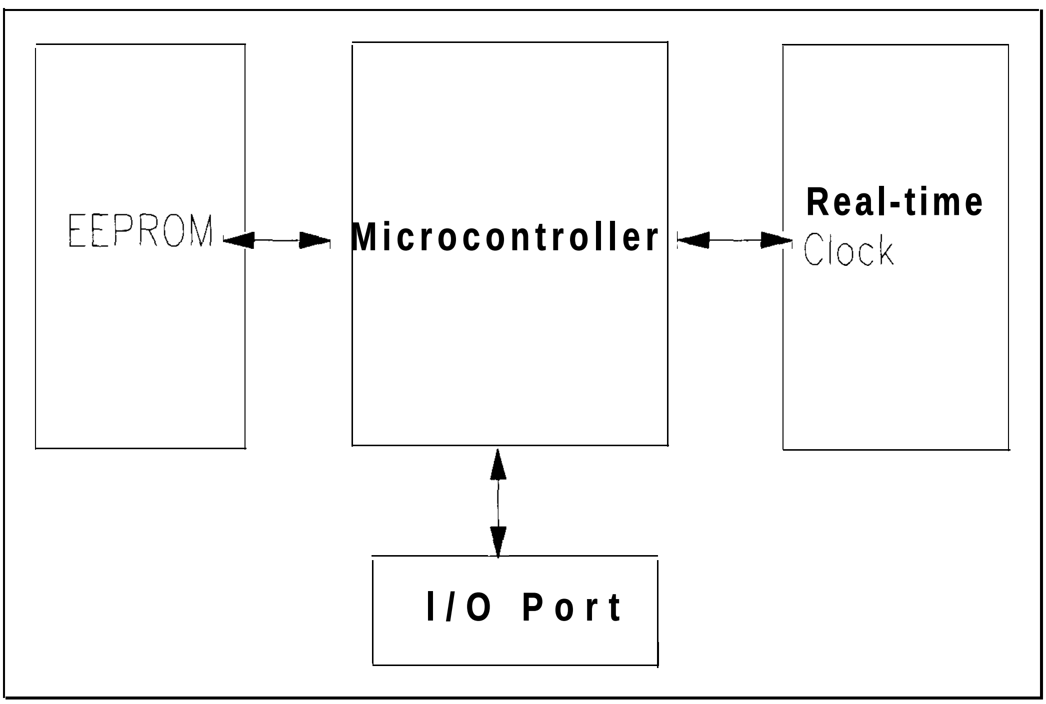

Fig. 19.20. Block Diagram of Hardware.

The I/O interface to the downloader is provided using the serial communication feature of the microcontroller. Extra lines were added in order to control data flow, connection information and a soft reset in case of error. The connection used for communication with the downloader is an 8-pin modular jack. This was chosen because it was the most ergonomically fit connector we could acquire which can easily be inserted and removed multiple times.

The real-time clock is used in order to keep accurate time with a minimal power drain. All of the chips may be placed in their respective low-power consumption modes by toggling their appropriate control lines from the program. The switch press and the connection line from the I/O port are both routed to the interrupt line as well as a microcontroller port. This arrangement allows the software to power down all of the ICs while it is waiting for a switch press, consuming as little power as possible. The microcontroller will be activated when the interrupt line is activated. The software may then wake up the other chips as necessary, perform whatever tasks are necessary, then return all of the chips to their power-down state.

When the battery is inserted, the microcontroller will jump to a power-up routine that initializes its temporary variables. One important variable it initializes tells the switch that the value in its real-time clock is no longer valid.

When the switch is pressed, the program will first check to see if the real-time clock holds a valid time. After this, the program verifies that there is room left in memory for the switch press to be stored. If either of these two conditions fail, then the switch will beep, using an intermittent beep rather than a continuous beep. This alerts the attendant that the switch has a problem that requires the interaction with the downloader. The downloader automatically sends the correct time and tells the device to clear its memory in the course of the download procedure.

If the checks described above are successful, the device will use its internal timer to see how long the switch is depressed and filters out any bouncing caused by the switch or the actions of the person pressing it. If the switch press passes all the selectable criteria for acceptance, the program then wakes up the real-time clock and the EEPROM. It gets the time, stores it in the EEPROM, then it shuts down all of the ICs in order to wait for the next switch press.

When the downloader is connected to the device, the program completes any pending operations with the real-time clock or EEPROM and then verifies that the downloader remained connected. When this is done, it then asserts a signal to the downloader in order to indicate that it is ready to accept commands. The downloader then has access to an l&command application programming interface. The downloader may pass a one-byte command to the device. Upon receipt of the command, the device will either accept additional parameters or send back the requested data. The commands perform a variety of functions from identifying the device type to modifying the device's operating parameters. Because the microcontroller requires the device to be in a wait mode rather than a standby mode while communicating, the device utilizes a time-out feature to prevent excessive battery drain. If no command is issued for approximately 30 seconds, then the switch will drop the ready line informing the downloader that it must wake the device up again.

The complete device measures approximately 5 1/2" x 3 1/2" x 1 1/2". The case of the device is a standard Radio Shack housing with a 9 V battery compartment. A Lexan plate that is the same length and width as the compartments, is fastened to the case using a Dzus-type fastener. The Lexan plate serves as both an extension of the switch and a place to affix the icon identifying the switch. Because it is fastened with a Dzus-type fastener, the plate may be easily swapped with other plates bearing different icons. The lamp on the device protrudes through a case into an opening in the Lexan plate, serving as a fulcrum for the Lexan plate. Finally, the actual microswitch projects out of the case near the bottom of the casing. This arrangement allows the student to apply only a modest amount of pressure anywhere on the lower half of the plate in order to activate the switch. Another advantage of this layout is that the screws and battery may not be removed without first removing the Lexan plate. While this may easily be done with a coin or an Allen wrench, depending on the fastener used, it prevents the students from inadvertently injuring themselves or disabling the device.

An augmentative communication device has been built that can help non-vocal developmentally disabled students begin to acquire functional communication skills by: 1) alerting a listener with a light and tone, 2) communicating a message using a graphic icon, and 3) collecting accurate data on the use of the device. Therapists can access each student's time and type of communication via a companion downloading device, which retrieves the data, displays an LCD summary and transfers the information to a personal computer for analysis. This device provides substantial clinical benefits over existing equipment by allowing the speech pathologists a reliable means to monitor the progress of many students in functional communication training programs.

The approximate cost of the Complex Communication Switch is $30.

DC Multistep Timer
A Device to Teach the Developmentally Disabled the Concept of Cause and Effect

Designers: Garr Godfrey and David Huang
Client Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Dr. Carl Ebeling
Department of Computer Science and Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

The DC Multistep Timer is a battery-operated device that controls a reinforcer such as a radio or an electronic toy, for teaching the concept of "cause and effect" to developmentally disabled persons. The DC Multistep Timer will respond to the user's actions by providing power to an external device. The DC Multistep Timer is functionally equivalent to an AC version currently in use, but is a completely new design, is portable to allow students to carry it around with them, and contains a battery charging unit to recharge its battery.

SUMMARY OF IMPACT

The DC Multistep Timer was conceived at the Fircrest School in Seattle, Washington, which houses, treats and educates the developmentally disabled. The DC Multistep Timer reinforces the concept of "cause and effect" for the seriously developmentally disabled. By turning on the reinforcer, the developmentally disabled person can learn the relationship between their actions and the consequences. The external device should be turned on long enough for the students to notice a response to his or her actions. The response duration of the DC Multistep Timer must be adjustable because of the vast differences in students' abilities.

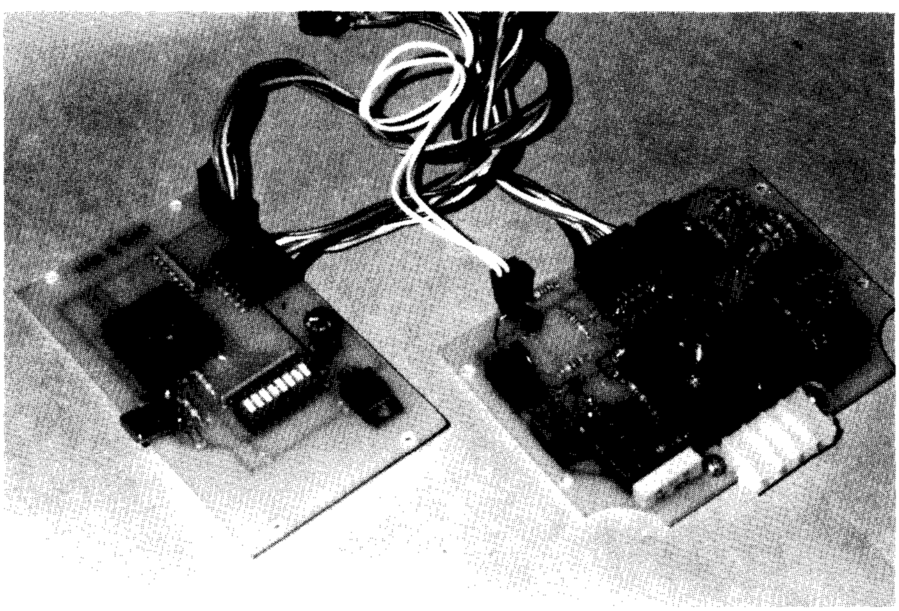

Fig. 19.21. DC Multistep Timer.

TECHNICAL DESCRIPTION

In addition to adjustable response duration and device portability, the timer also must not be prohibitively expensive and must interface to many electronic devices, the reinforcers. The response duration switch must be simple and self-explanatory. The pinouts of the input and output connectors must be consistent with other devices in use at the Fircrest School in order to provide compatibility and to minimize cost.

The digital portion of the DC Multistep Timer is designed around the Motorola MC68HC705C8 CMOS microcontroller. The power portion is designed on a separate board and is centered around the Linear Systems LT1070 switching voltage regulator. The boards have been designed so that they are interchangeable with other power and controller boards in use at the Fircrest School.

The microcontroller reads the switch input and the time setting to determine when the reinforcer should turn on and off. A signal from the microcontroller to the power board turns on the voltage regulator to provide power to the reinforcer.

The voltage regulator uses a resistor on the connector to the reinforcer to determine the voltage to supply. A switching regulator works by providing a modulated current to an LC circuit. The voltage in the LC circuit is fed back into the regulator and used to determine the duty cycle of the modulated current. When the feedback voltage is below the desired voltage, it increases the duty cycle, and conversely, it reduces the duty cycle when the voltage is too high.

The desired feedback voltage is 1.244 V for the LT1070. The resistor in the connector to the reinforcer provides half of a voltage divider, which divides the output voltage, to feedback 1.244 V.

The power board provides two other functions. One is a battery recharge circuit, which uses the Unitrode 3904 chip to recharge the lead acid batteries. The second is a low battery detector, which turns on an LED when the battery drops below a certain voltage.

The total cost of this device is approximately $90.

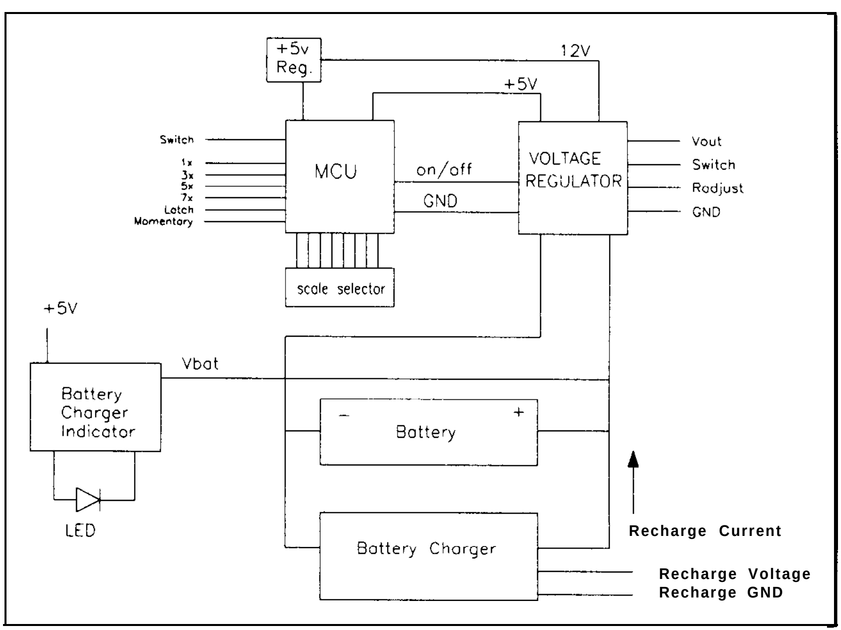

Fig. 19.22. Block Diagram of DC Multistep Timer

Variable Interval Timer

Designers: David D. Siek and Dun Nguyen
Client Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Carl Ebeling
Department of Computer Science and Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

The Interval Timer is a device used in reinforcement training programs at Fircrest School, which is a residential training facility for the developmentally disabled. The purpose of this device is to generate an audible alarm on random intervals in a given distribution. Staff members operating these programs need to observe and collect data on students' behavior. Using a fixed time interval on which to base observations does not work, as students learn the pattern of the alarm and change their behavior just before any observation is made. The Variable Interval Timer is designed to give an alarm on random interval, therefore, eliminating any behavioral changes that may result. This design is a replacement for the existing AC NMOS Version. The new Variable Interval Timer takes advantage of the low power feature of the CMOS microcontroller.

SUMMARY OF IMPACT

The Variable Timer is used in Fircrest's Reinforcement Density program. In order to affect behavioral changes in students, staff members monitor the behavior and provide reinforcement. The program is called Reinforcement Density because the monitoring and reinforcing are done at intervals of a few minutes. The VI Timer is used by the staff members as a queuing system, at which time they observe and record the behavior of students to determine their progress and problems and the necessary reinforcement.

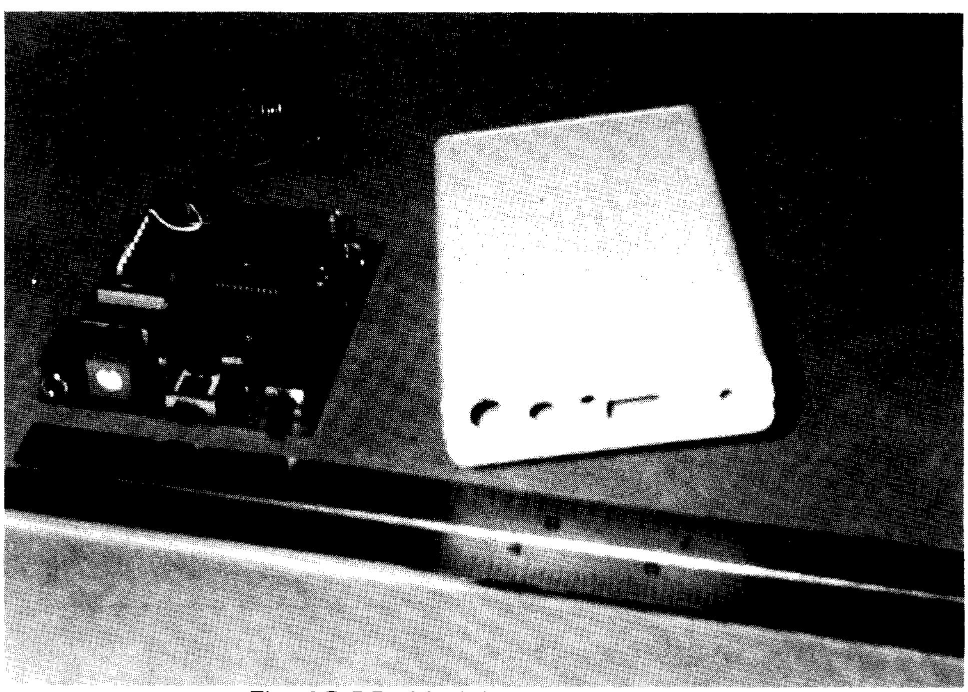

Fig. 19.23. Variable Interval Timer.

Variable intervals are needed primarily because the students, over the course of a few days in the program, become accustomed to fixed intervals. Once they become accustomed, they learn to anticipate the next alarm, and change their behavior just before they are observed. Thus, data collected with fixed intervals is more or less invalid.

TECHNICAL DESCRIPTION

The software is the driving element of the new VI Timer design. It handles all the DIP switch interpretation, timing, interrupt servicing, sound generation, low power detection, and controlling LED blinking rate. The extensive use of software limits the number of hardware components needed and thus PC board space, which is a critical factor in the design. The features supported by the new VI Timer include: fixed interval mode, variable interval mode, test mode, low power detection, optional vibrator, and LED off.

The new VI Timer is intended to overcome the problems of the existing timer which Fircrest School currently has, and enhance the capability of the old timer. It uses a CMOS MC68HC705C8 microcontroller and operates on a 9 V battery. The enhanced features include on/off switch, low power detector, earphone jack, and optional vibrator. The printed circuit board and the battery are packaged in a small case approximately 2.25" x 4.1" x 0.5" in size. MC68HC705C8 is chosen because of its low power consumption, multiple I/O ports, and a built-in timer. Multiple ports are used for many programmable functions. Eight inputs of Port A are used for programmable switches. Eight I/O pins of Port B are used for LED indicator and generating digitized audible signals. A 44-pin PLCC microcontroller package is used due to limited spacing for the final product.

The estimated cost of the Variable Interval Timer is approximately $50.

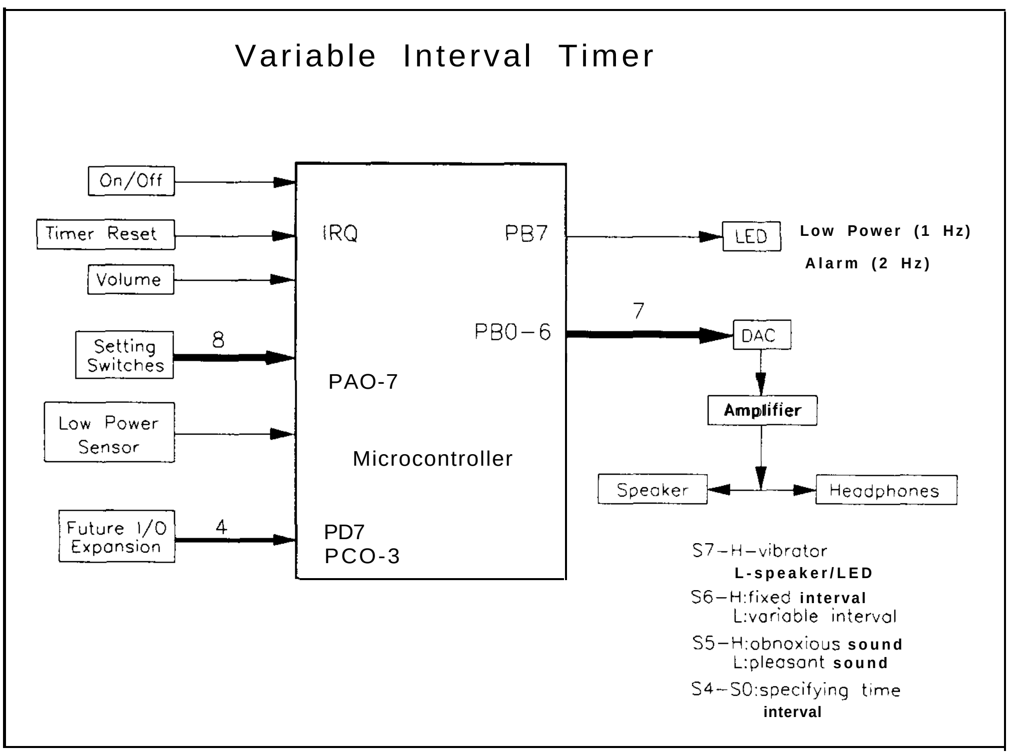

Fig. 19.24. Programmable Switches of Variable Interval Timer.