CHAPTER 22

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Software Improvement of Smart Switch A Training Controller for Disabled Students

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INTRODUCTION

Many students at Fircrest School are severely physically disabled as well as profoundly mentally retarded. Teachers at the school frequently use microswitch training devices to help students interact with their environment by communicating their needs or controlling events in their daily life. For example, pressing an adapted microswitch can allow the student to activate a tape player, radio, or other desired electronic equipment. While the goal of training is independent student operation, progress is often very slow and requires careful data collection and monitoring to document the student's learning. Training occurs in both an independent condition (where the student has free access to the switch and reinforcer) and a prompted condition (where staff cue or encourage the student to interact with the switch).

An earlier training support device (the "Smart Switch") accepted inputs from a variety of microswitches, counted the number of switch closures and the total duration of switch activations, and provided DC power to a variety of electronic reinforcers. Summary of median switch-press duration and the upper and lower quartiles of this distribution were calculated and displayed on LCD.

However, it did not provide a good user interface to meet staff training needs. For example, the user was required to view and respond to six LCD menus to obtain data from the prompted training condition. Also, the software used in the earlier project was too complex for effective staff training, and its use was too slow for efficient operation. After software revisions, staff can now obtain the same information using only two menu screens. The new software is

intended to motivate staff involvement in managing student training programs by facilitating ease of use, reducing errors, and providing simple progress summaries.

SUMMARY OF IMPACT

The software design of the Smart Switch revolves around the Intel 8031 microcontroller. The 8031 is a complete 8-bit microprocessor and I/O system integrated onto a chip. There are three switches on the device, two pushbutton switches (A & B) and a toggle switch to allow the user to choose the desired mode of operation or statistical display.

When the battery is connected to the Smart Switch, the default screen for the independent mode will be displayed. Data will be collected whenever the external microswitch is activated. The number of events that have occurred and the elapsed time for the current microswitch event will be displayed. When the microswitch is released, the total elapsed time for all events will be displayed.

When the toggle switch is hit, the operation will change from independent to prompted mode and the screen will display the number of the current prompted trials. A clock that counts backwards is also displayed, and if the student activates the microswitch within the allowed learning period (30 sec.), then this is considered a successful learning trial.

When button A is pressed, the independent mode statistics (median, upper and lower quartile) are displayed. When button B is pressed, the percentage of the successful trials of prompted mode is displayed. The system can be reset by pressing buttons A & B simultaneously. The display switches back to the default screen if no user activity has occurred for fifteen seconds.

No additional cost is add to this project (the original Smart Switch cost $145.00), and the new version of the software is considerably simpler for the user to operate.

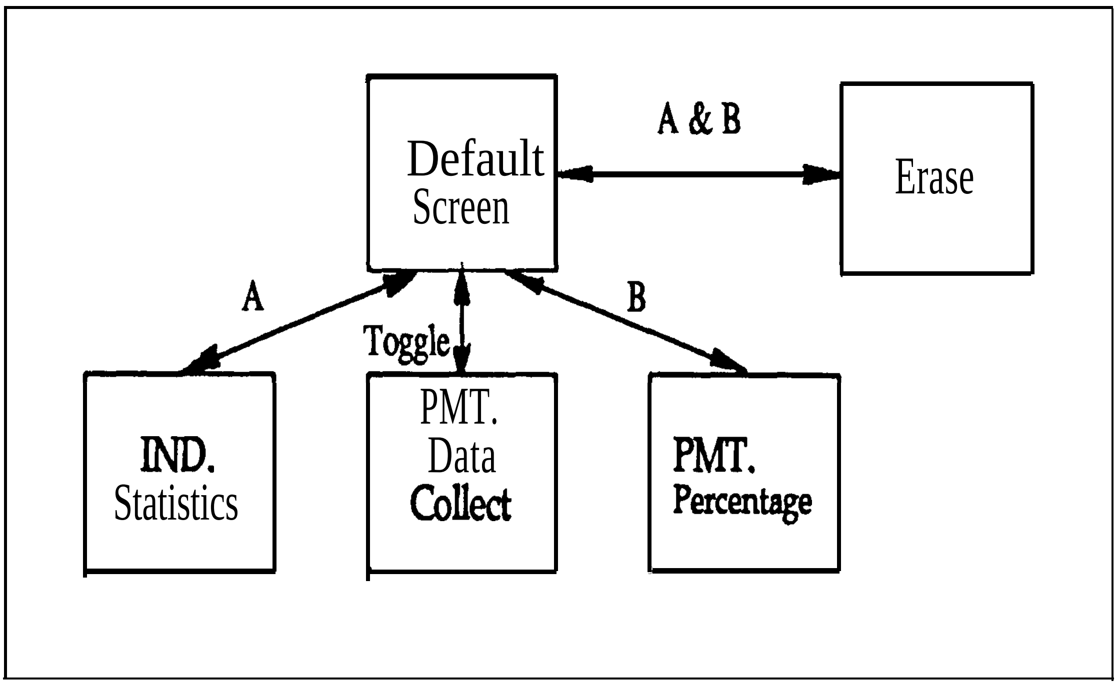

Fig. 1. Function flow chart of smart switch.

Vocational Production Monitor A System for Monitoring the Productivity of Mentally and Physically Disabled Workers

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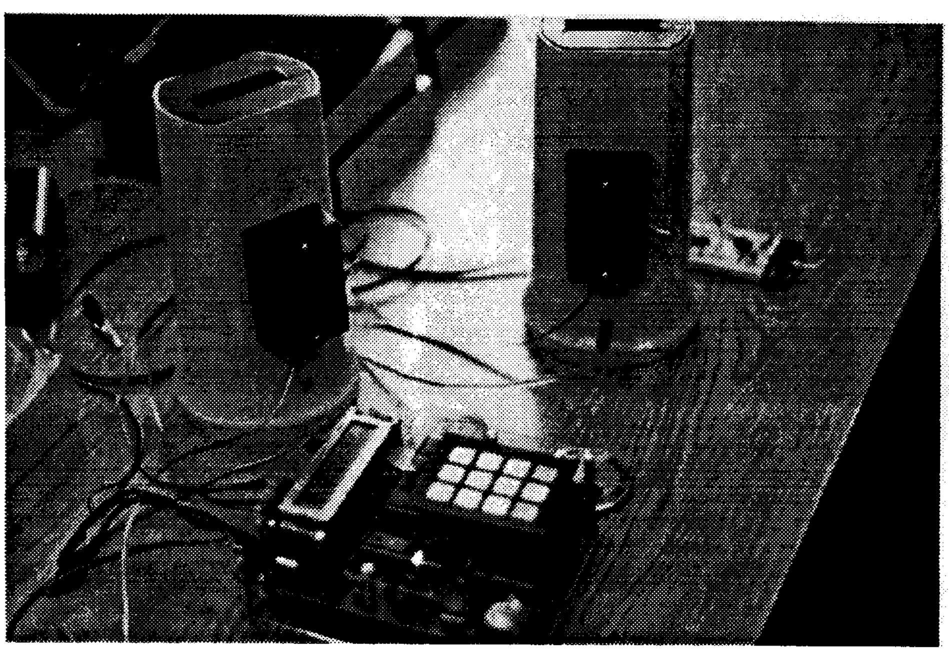
INTRODUCTION

The Vocational Production Monitor (VocMon) system monitors the production rate of physically and/or mentally disabled students in a sheltered workshop setting. The VocMon counts the items each student produces and generates a signal to produce a reward when a certain threshold is reached. The type of reinforcement is determined by the supervisor. Any device such as a radio or a tape player that may be switched on and off by a relay may be used as a reinforcer. The VocMon can display the work progress of each student such as the number of items produced (I), the production rate (PR), the total elapsed time (TET), and the total work time (TWT). In addition, it is programmable, allowing the supervisor to easily change the default reinforcement conditions. The VocMon also provides the capability to communicate with a computer to transfer the student information for further processing and evaluation. The VocMon is made up of two separate units, the Sensor unit and the Data Collector (microcontrol) unit. The microcontrol unit is capable of processing data for four different sensor units.

SUMMARY OF IMPACT

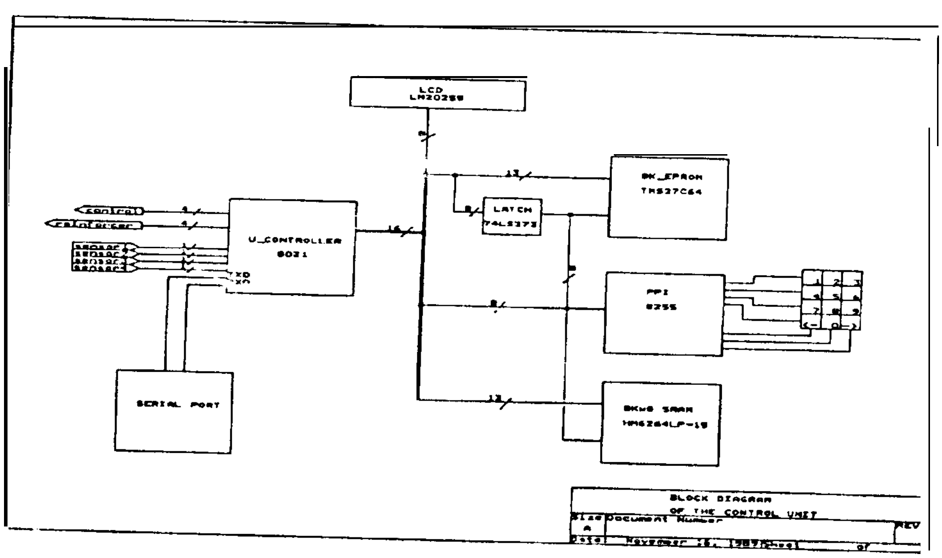
The VocMon system was first conceived at the Fircrest School in Seattle, WA, which is a residential treatment facility for the developmentally disabled. The VocMon system monitors the productivity level of such handicapped individuals in a sheltered workshop environment. The VocMon system can be helpful is raising the productivity levels of handicapped workers by providing tangible rewards for greater efficiency.



TECHNICAL DESCRIPTION

The VocMon design centers around the Intel 8031 8-bit microcontroller. The main unit consists of the microcontroller, support chips (EPROM, latches, ect.), a 20 x 2 LCD display, and a 3 x 4 numeric keypad. Each sensor unit is enclosed in a 1 foot high, 4 inch diameter cylindrical chute. The sensors are an infrared emitter/detector pair mounted across from each other on the circumference of the pipe. Digital outputs are provided to control external electrical devices used as reinforcers. A single VocMon unit can accommodate up to four sensors and four individually controlled reinforcers. Object detection at the sensor station is accomplished by pulsating the IR emitter using a 555 timer and observing the signal received by the detector. The output signal of the detector is amplified and filtered for transmission to the microcontroller unit. An object dropped in the chute will block the path of the emitted signal and the expected pulse pattern will not be received by the detector. The Data Collector unit uses four I/O ports for the microcontroller to provide internal communication with the support chips and I/O devices (LCD, keypad), and external communication with the four sensor units and a computer. Two o the ports are multiplexed to interface with the EPROM, SRAM, LCD, and Intel 8255 Parallel Input/Output chip. The other two ports are used to receive inputs from the sensor units and provide reinforcer outputs and RS-232 serial output. The built-in serial port of the microcontroller is used to provide serial communication with an RS-232 port of a computer. A MAX232 signal level converter is used to convert RS-232 level signal to TTL level as it is received from the computer and vice versa for signals transmitted to the computer. The serial communication capability allows student information to be downloaded to the Data Collector unit to individualize the reinforcement schedules. The work progress of the student ca be stored in the SRAM and uploaded to the computer for processing and evaluation.

The VocMon software consists of two main programs, a foreground program that monitors the user's inputs through the keypad and displays the student progress through the LCD screen, and a background interrupt driven program to monitor the status of the sensor units. The timer interrupt service routine is required to monitor the object drop and keep track of the total elapsed time, the total work time, and the production rate for each sensor station. In addition, the routine also performs the comparison and computation to generate a reinforcement signal when all reinforcement conditions have been met. The conditions for reinforcement, threshold production rate, and reinforcer duration can be programmed individually for each work session. The approximate cost of the VocMon and four sensor units is $200.00.



Single User Remote Switch A Device to Provide the Disabled Student With Control of Positive Reinforcers

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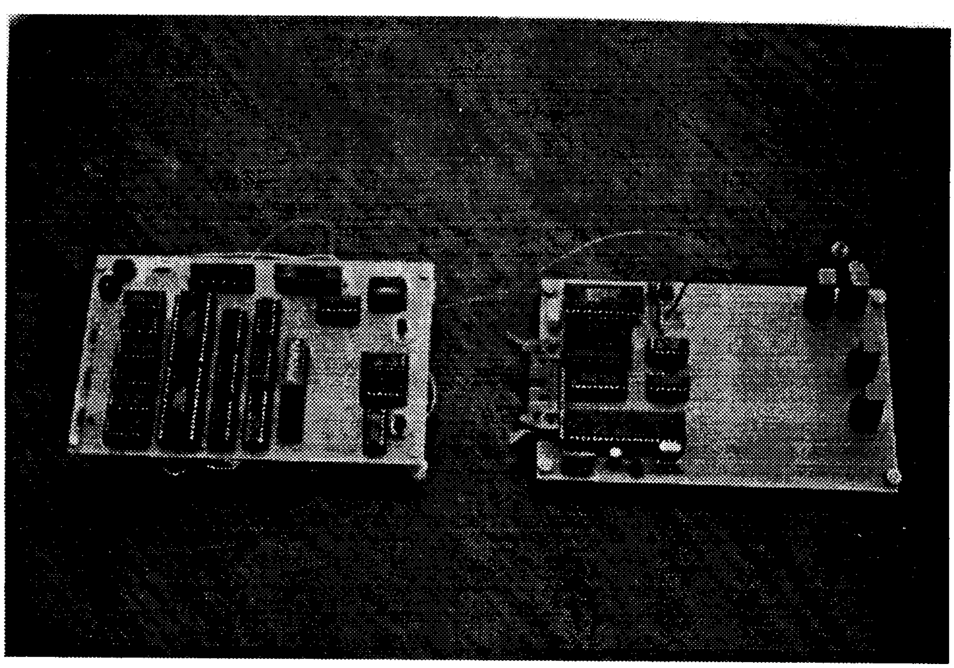
INTRODUCTION

The Single User Remote Switch gives developmentally disabled students on-off control of positive reinforcers such as music, lights, or motorized devices. Each switch consists of a battery powered remote control unit (the master) and an AC outlet powered unit (the slave). The power cord for the radio, light, or other device to be controlled is plugged into the slave unit, while the master unit with its single button is given to the student. In its most basic level of operation, the controlled device (radio, light, or other) will be "on" while the button is being pressed, and "off" when the button is not being pressed. Implemented with the radio frequency (RF) transmitters and receivers, these instruments provide omnidirectional control without students directly operating a device plugged into a wall outlet. Up to thirty-two of these switches can be implemented in the same locality without conflict, allowing for switches to be placed at each student's bedside. Circuit schematics and printed circuit board (PCB) layouts have been developed to facilitate small scale production.

Enhancements to the basic switch operation include battery saving low power consumption after four minutes of idleness, procedures to handle simultaneous button presses of different master units, automatic shut off of the controlled device after the button has been pressed for four continuous minutes, and disregard for accidental button presses lasting one tenth of a second or less.

SUMMARY OF IMPACT

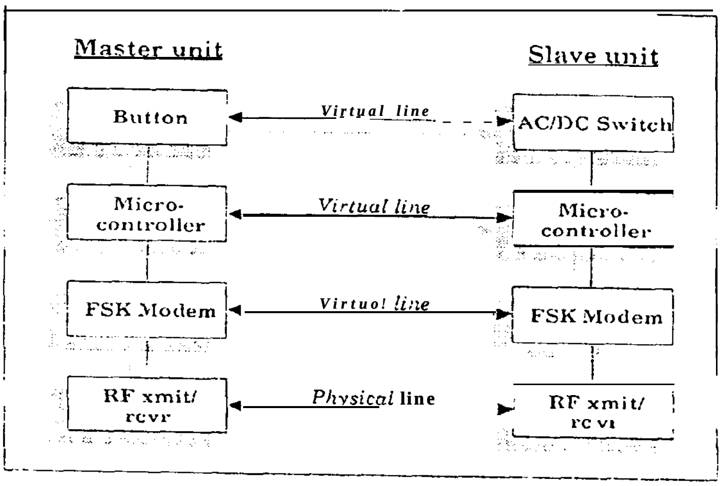
The Single User Remote Switch system was developed for the Fircrest School in Seattle, WA, which is a residential treatment facility for the



developmentally disabled. It consists of four levels of communication: button power, microcontroller, modem, and FM radio receiver/transmitter.

TECHNICAL DESCRIPTION

At the highest level, the button on the master unit has direct control over the power output on the slave unit, causing the output to be a powered AC or DC source when the button is depressed, or not powered when the button is released. This button is configured as a pin input to a Motorola MC68HC705C8 microcontroller within the master unit, and the AC or DC power supply is controlled by a pin output of a microcontroller within the slave unit. The microcontroller in the master reacts to button transitions in software, performing a software debounce, executing bus collision avoidance procedures, and sending “on” and “off” commands in the form of serial data to the slave microcontroller. The slave microcontroller in turn responds to appropriate commands by operating the power supply and sending acknowledgements to the master. Between the microcontrollers are a pair of modem chips, which translate the serial messages between the masters and slaves into 1200 baud FSK signals. These signals travel via FM radio transmitters and receivers, which are cut up versions of Radio Shack walkie-talkies. To ensure robustness and avoid conflict between master and slave pairs, a two-byte, two-way protocol is implemented between microcontrollers. When a valid button transition has been established, the master polls the squelch of the walkie-talkie to test for other units sending messages. When the airwaves are found to be empty, the master waits a random amount of time (25 to 100 ms) and sends a two-byte message if the airwaves remain empty. The first byte consists for a 5-bit identification (ID) number and a 3-bit command code (only “on” and “off” are given in this version), and the second byte is the one's complement of the other. The 5-bit ID is uniquely determined by DIP switches within each unit. Once these two bytes have been sent, the master waits for an acknowledgement from its slave unit. This acknowledgement consists of the same two bytes being sent back by the slave. If the master fails to receive an acknowledgment, it retries to send the message. If after five tries the master still does not receive an acknowledgement, the master stops trying to keep the airwaves free. All of the enhancements described in the introduction are implemented by the microcontroller. Low power consumption is obtained by using a power MOSFET as a power switch for the walkie-talkie and placing the microcontroller in a low power mode after four minutes of inactivity. Button debounce, disregard for accidental depressions, four minute automatic shutoff, and the two-byte protocol are all implemented in the software of the microcontroller. The cost for producing a single master and slave pair is approximately $170.



Steering Indicator An Aid to Communication for Mobility Impaired Students

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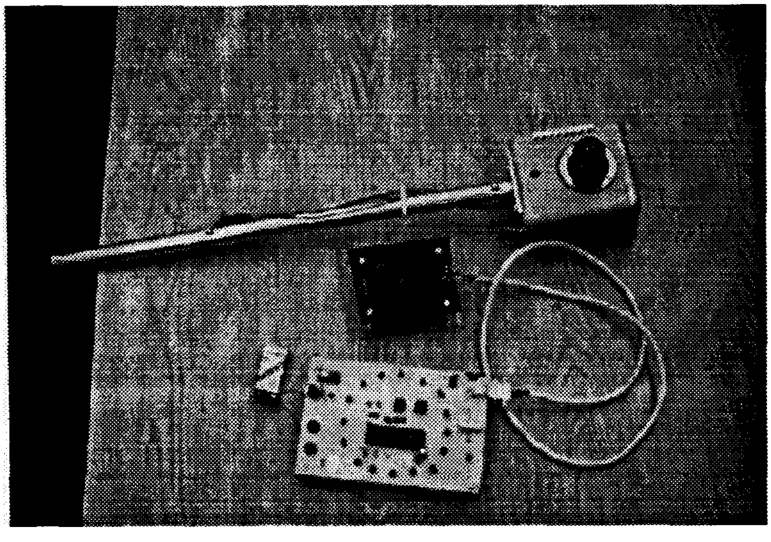
INTRODUCTION

The Steering Indicator was implemented as an aid to communication for developmentally disabled students who are unable to move independently. The steering indicator is mounted on the back of a wheelchair, and provides the student with either analog or digital joystick on the right arm rest of the chair seat to indicate which direction and motion he/she wants the teacher to push the wheelchair.

An enhancement to this application would use a standard Fircrest joystick that transmits directional information to sixteen LED's arranged in a circle and one more LED in the center to indicate neutral, which is mounted to a clamp-on steering handle behind the wheelchair. The blinking rate of the LED indicates how hard the student is pushing the joystick, and the brightness of the LED can be adjusted by a teacher. The Steering Indicator project is based on a microcontroller, and this typical MCU application involves hardware development, software development, and mechanical development, with all the elements working together as a system. The software program allows the MCU to perform the desired function to control peripheral devices, and the flexibility of the software-driven MCU simplifies the connection for external circuitry. The hardware design consists of connection peripheral devices to general purpose I/O lines.

SUMMARY OF IMPACT

The Steering Indicator was devised for Fircrest School in Seattle, WA, which is a residential treatment facility for the developmentally disabled. Training these disabled clients in the use of electrically-powered wheelchairs is the objective of this project. These wheelchairs are expensive and cannot be easily obtained by clients without prior demonstration of their ability to use them properly. The training method consists of using a non powered wheelchair with a mounted joystick similar to that used on powered versions. A school staff member pushes the wheelchair in the desired direction.

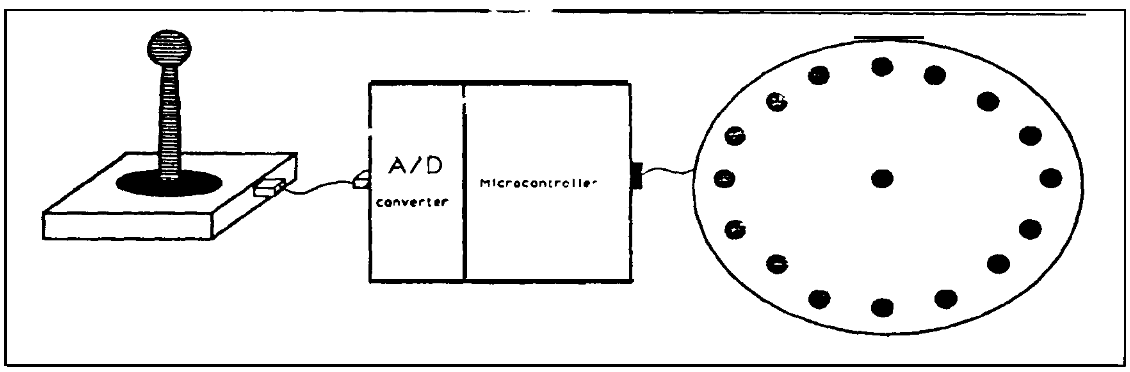


The Steering Indicator provides directional and force information to the person pushing the wheelchair, eliminating ambiguities in determining the precise position of the joystick by eyesight alone. This method provides a safe method for clients to learn the use of a motorized wheelchair and increase their level of independence while still being supervised by their teachers. Also, the method is inexpensive to apply.

TECHNICAL DESCRIPTION

The Steering Indicator design is based on a Motorola 68HC705 microcontroller. It is composed of three major blocks: the joystick and its interface, the microcontroller, and the LEDs and their drivers. The device is battery powered and a printed circuit board was designed to allow the device to be easily added to the back of a standard wheelchair frame with the joystick attached to the right arm. The interface between the joystick and microcontroller supports both an analog as well as a digital interface.

The 68HC705 MCU was selected because it integrates input/output ports within a single package. The outputs of the joystick go directly to an I/O port (through an A/D converter first in the analog case). The microcontroller must then compute the position of the joystick based on the X-Y values and decide that of the 16 LED's to light to indicate direction. The magnitude of X and Y is used to determine the blinking rate for the 17th LED in the center of the circle (to indicate the force with which the user is pushing the joystick). The computation of the direction is based on a table lookup method so as to avoid multiplication, division, and trigonometric function calculations. To compensate for jitter on the joystick due to rapid hand motions on the part of the client, the direction displayed on the LED is a time average of eight samples over a 100 ms interval. This solves the problem of oscillation between adjacent LED's so that neither is visibly on. The LED's are driven directly from a parallel I/O port on the microcontroller and the blinking rate is set by using an internal timer to generate interrupts at the appropriate rate. The approximate cost of the project is $100 including the joystick.



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

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INTRODUCTION

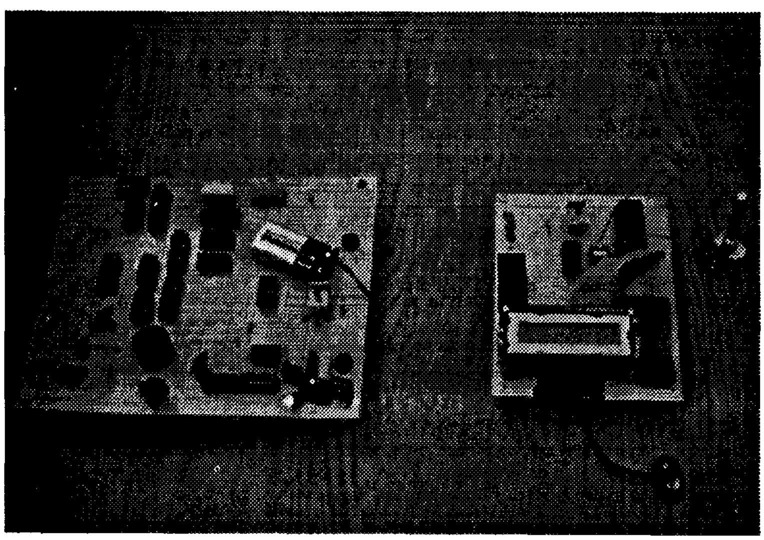
The Communications Switch is a device designed for speech pathologists to monitor the progress of physically and mentally disabled individuals who have impaired verbal communication abilities.

The communications system consists of two battery operated devices, namely the icon switch and the downloader. The icon switch, a data collection device, is a simple one-button device that keeps track of the number of times the button is pressed. Since this device is battery powered and remains on at all times to keep the data in the register, a lot of effort was spent on minimizing power consumption. Once a week, the data in the icon switch is transferred to another device, the downloader, via infrared transmissions. The downloader is basically a software driven device that receives data from the icon switch and then transmits it to a personal computer through ES232 serial communications. The downloader is built around a Motorola microcontroller that controls all the data flows as well as driving a LCD screen for data display purposes.

The icon switch deals mainly with hardware design, such as PAL, whereas the downloader is driven by an assembly program. This project involves two different data transmission mechanisms, infrared and serial communications.

SUMMARY OF IMPACT

The Communications Switch was designed for use at Fircrest School in Seattle, WA, which is a residential treatment facility for the developmentally disabled. By making such a system available, the progress of the residents whose verbal communication is impaired, can be monitored more easily and efficiently.



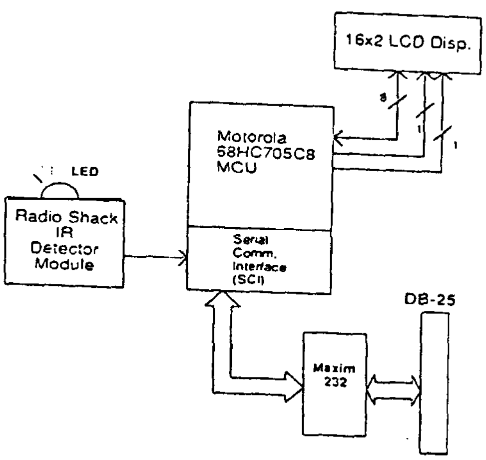
TECHNICAL DESCRIPTION

The project consists of two parts: a wall mounted switch and a downloader unit that can also be interfaced to a personal computer. Both devices are battery powered and were designed for low power consumption. This was especially true for the icon switch that must be on continuously over an entire week. The switch consists of a simple debounced switch and an asychronous counter that keeps track of the number of times a switch was pressed (up to 65536 separate presses). A PAL in the device implements a state machine that controls .ie interface to the downloader. A Reed switch is used to indicate that the downloader is nearby and ready to communicate. When this occurs, the PAL sends the value of the counter serially to an infrared LED that will be sensed by the downloader. A simple error checking protocol is used that sends the complementary value of each counter byte immediately after each of the two bytes. This allows the downloader to check for proper transmission. The protocol also includes start and stop bits to frame the 32 bits (16 bits of data followed by 16 bits with the complement) being transferred.

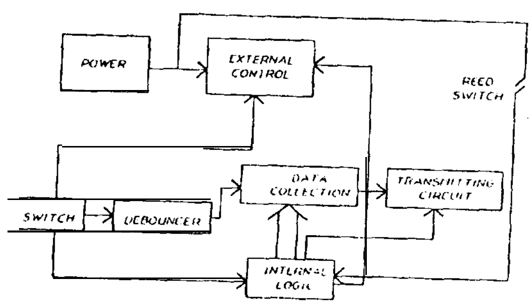
The downloader is based on a Motorola 68HC705 microcontroller that integrates parallel and serial I/O ports and includes on-board EPROM to store its program. The infrared detector is interfaced to the parallel I/O port and a built-in USART handles communication with a personal computer. The downloader is carried to each of the icon switches and used to collect the number of switch presses (the switches can then be reset by the downloader). Once this collection phase is completed, the downloader is collected via a RS232 link to a personal computer that can take the data collected and perform statistical processing and display. The downloader includes a two-line 32 character LCD display for user interface and displays the data as it is collected.

The approximate cost of this project is $100 for both units. The replication cost of the icon switch is less than $20/unit. The downloader is more expensive due to the microcontroller and infrared receiver circuitry and costs about $80.

DOWNLOADER



ICON SWITCH



Variable Interval Timer
A Random Timing Device for Reinforcement Training Programs of the Mentally and Physically Disabled

Designers: Kraig Brockschmidt and Khai Trinh
Disabled Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Dr. Yongmin Kim
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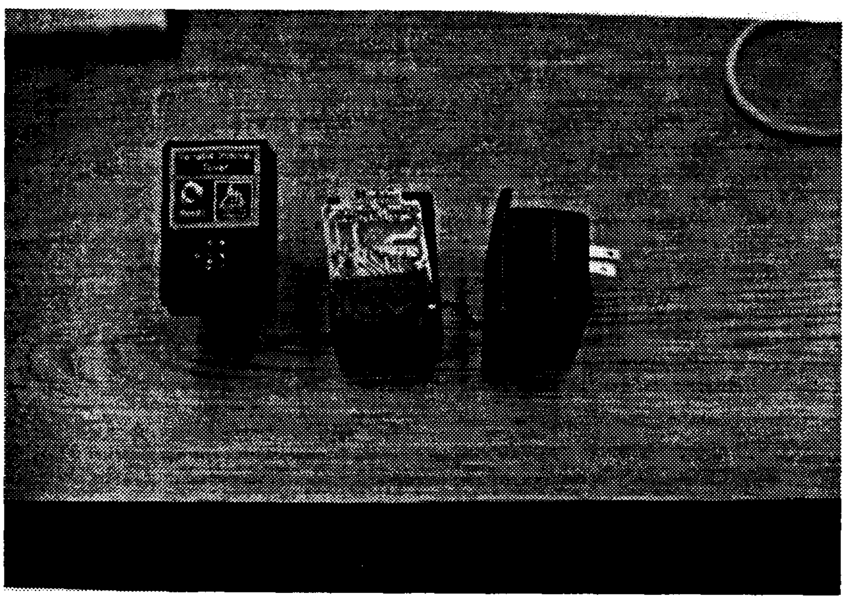
INTRODUCTION

The Variable Interval Timer is a device capable of generating visual and audible alarms on both fixed and variable intervals. Fixed intervals are periodic alarms whereas the variable intervals are random alarms that occur on a given uniform distribution, i.e., occur in some *range* after a fixed delay. Users can select one of thirty-two fixed intervals, as well as specify the audible signal generated when the alarm begins.

The Variable Interval Timer will replace a design currently in use at Fircrest, as the latter has shown some reliability and accuracy problems. The replacement design allows many more options and much improved accuracy.

SUMMARY OF IMPACT

Fircrest School is a residential treatment facility in Seattle, WA, for the developmentally disabled. In their "Reinforcement Density" program, staff members monitor the behavior of patients and reinforce them for adaptive behavior. In order for these behavioral training programs to have full impact on the patient, the staff must monitor and reinforce the patients randomly. If the disabled person is checked regularly, he or she will begin to modify their behavior just before they are checked again, as they learn to anticipate the next check. The Variable Interval Timer can be used as a staff queuing device to remind the staff to monitor and



reinforce the patients randomly so that the program has the proper effect on the patients.

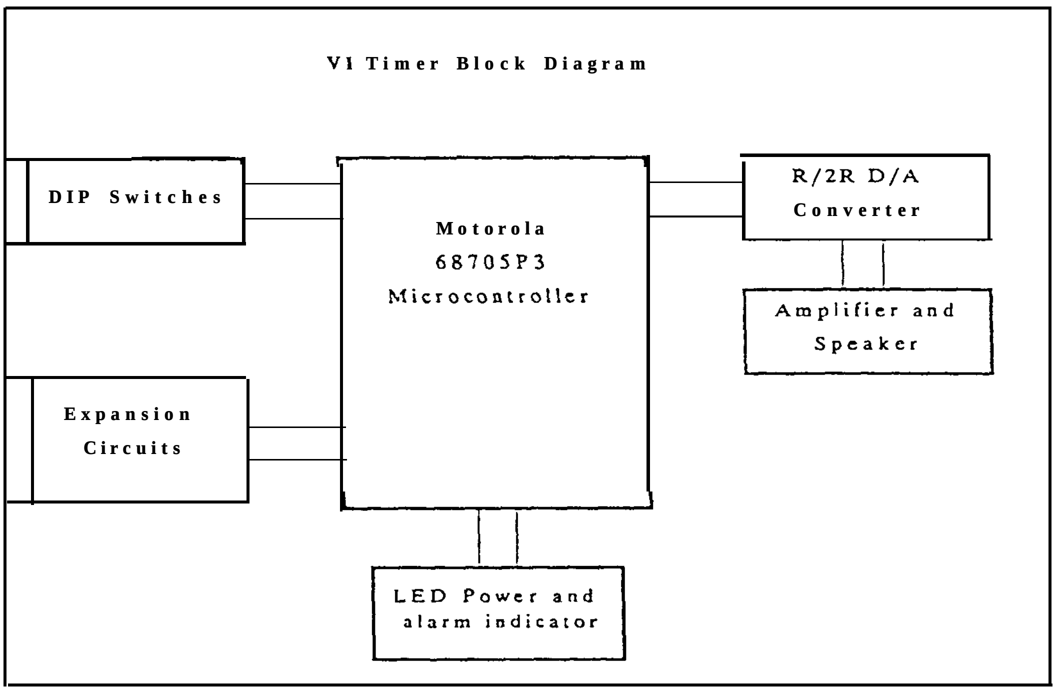
TECHNICAL DESCRIPTION

The VI Timer is housed in a 1.5” x 2.5” x 1" plastic box mounted on the back of a plug-in wall transformer, which serves as the power supply to the unit. A power/alarm LED and a reset switch are mounted on the front side of the device above several holes that compose the speaker vent. The VI Timer is activated by plugging the unit into any standard wall outlet. When plugged in, the LED glows to indicate power.

Seven DIP switches mounted on the printed circuit board control the timing and other important aspects of the VI Timer Operation. One switch specifies the operation mode, either the fixed interval operation or the variable interval operation. Another switch selects the alarm sound, ranging from pleasant to noxious. The remaining five switches select the time interval, which is interpreted differently in each mode.

In the heart of the VI Timer is a Motorola 68705P3 microcontroller, which generates time intervals and sounds, as well as controlling the reset button. The microcontroller also checks the setting of the DIP switches and decides which timer interrupt will be used to measure the interval. After the interval has elapsed, the alarm sound is generated. The alarm sound can be a bell, a sine wave, or the sound of a phone left off-hook, depending on the mode of operation.

The waveforms of these sounds are stored in the memory of the 68705, and written to the port where the R/2R ladder networks transform the waveform into an analog output. The output is then amplified by two MOSFET's and fed to the speaker. While the alarm is sounding, the LED flashes at a 2 Hz rate to provide a visual indication. The user must press the reset button to stop the alarm and set a new interval (except in fixed interval mode where the alarm is a short bell after which the new interval is started automatically). The time it takes to press the reset button is used to randomize the next variable interval. An optional connector can be added to the VI Timer, allowing the unused I/O ports of the 68705 to control many external devices with minimal software modifications. The approximate cost of the VI TImer is $50.



Choice Selection Module
A Device to Aid Communication
By the Mentally and Physically Disabled

Designers: Joan Anastasio and Qian Wen
Disabled Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Dr. Yongmin Kim
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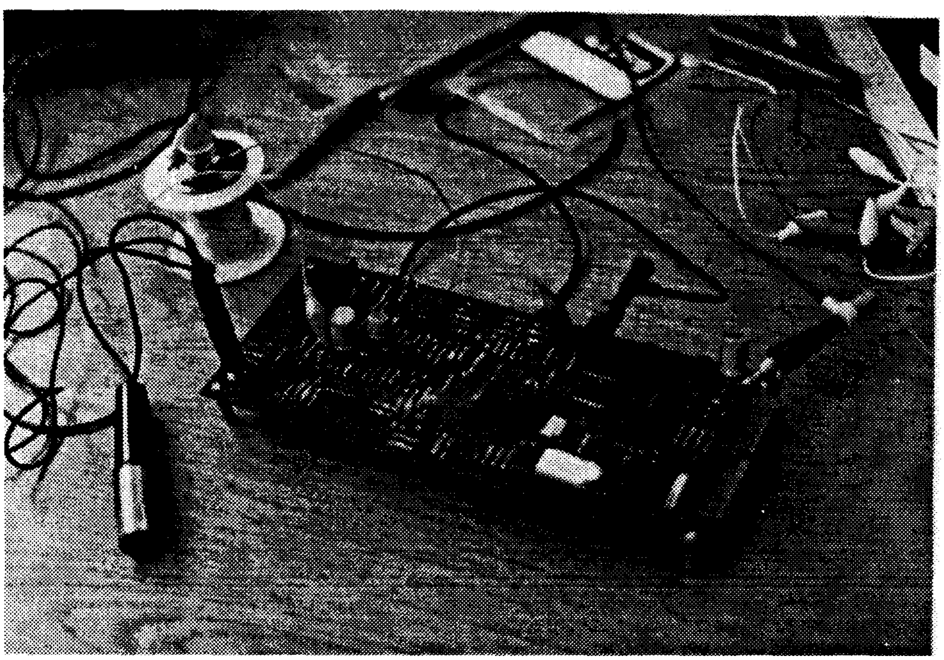
INTRODUCTION

The Choice Selection Module is a small, battery powered device that records and plays short sound segments, initiated by a single switch depression. This device allows individuals who have difficulties communicating to audibly express a need or desire in a manner that can be easily understood by others.

The record and play functions are initiated by the same switch, for ease of operation. Insertion of a microphone into the jack changes the operation from play to record. To ensure timely maintenance, the device monitors the battery voltage level. When a low battery level is detected, operation is inhibited and an indicator flashes briefly, upon switch depression, to alert staff to the need for a battery change.

SUMMARY OF IMPACT

The Fircrest School in Seattle, WA, is a residential facility for the developmentally disabled. Many residents have limited communication capabilities, and consequently, have difficulty expressing needs and desires to others. The Choice Selection Module provides these residents with a means of communicating through representative sound segments.



TECHNICAL DESCRIPTION

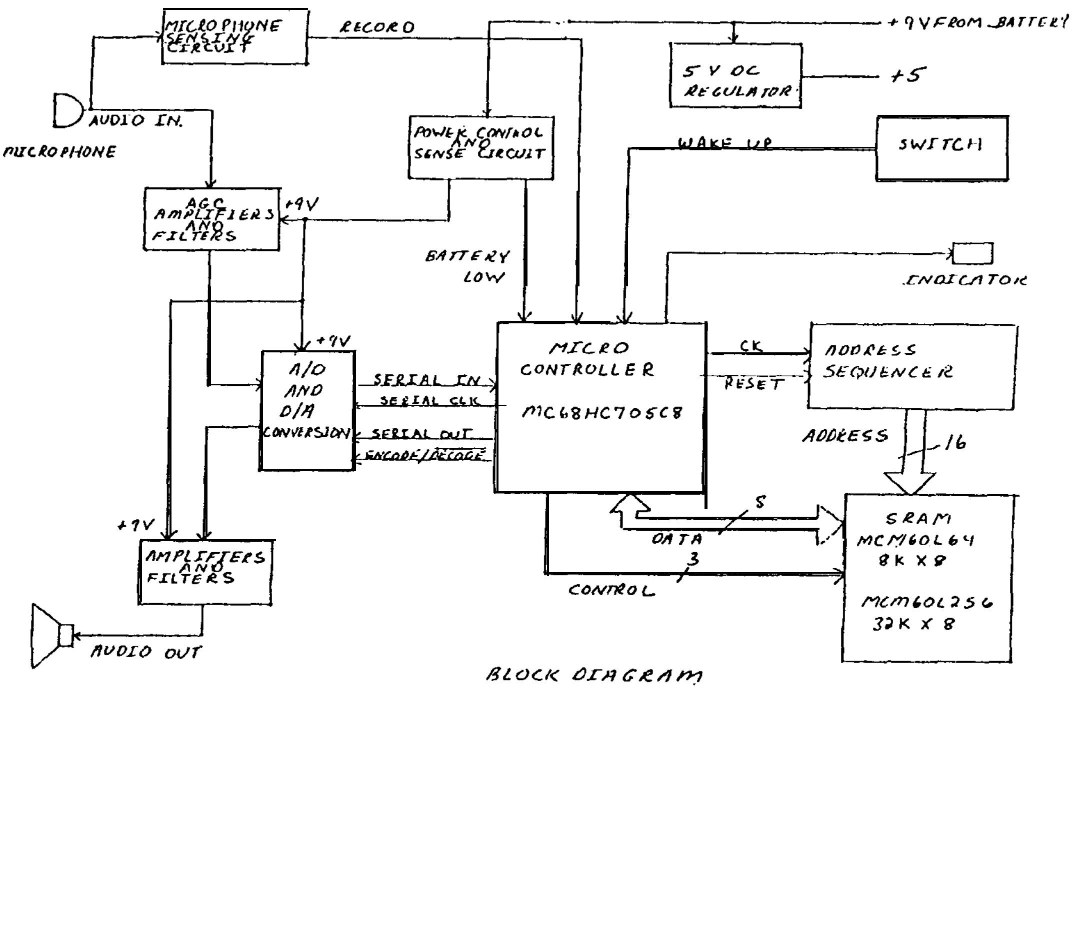
The Choice Selection Module employs a delta modulation scheme for A/D and D/A conversion. A CMOS microcontroller with on-board EPROM performs all the monitoring and controlling tasks and provides the sampling clock to the delta modulator. The sound samples are stored in the' CMOS SRAM, which is accessed via an address sequencer, controlled by the microcontroller.

Power consumption is a primary consideration for this device, and many design parameters were influenced by this constraint. CMOS parts were used in all of the digital circuits. Power to the analog circuit is turned off during idle state and applied only when conversion is required. To ensure data retention in the SRAM, if battery voltage drops below 6.0 volts, operation is inhibited, and an indicator flashes to indicate a low battery condition.

Record and play operation is initiated by depression of a single switch. The presence of a microphone in the jack is checked and a signal is sent to the microcontroller. Upon switch depression, the microcontroller checks for a low power condition, and if the battery level is sufficient, checks for the presence of the microphone. If the microphone is present, then the record function is initiated, otherwise playback is performed.

The length of the sound segment is determined by the size of the SRAM installed. If and 8K x 8 SRAM is used, the sound segment is two seconds in length. With a 32K x 8 SRAM, the sound segment becomes eight seconds long.

The estimated cost of the Choice Selection Module is $100.



BLOCK DIAGRAM

Smart Switch
A Device To Educate and Monitor the Mentally or Physically Disabled in Cause and Effect Relationships

Designers: Chris W. Fleming and Doug R. Huard
Disabled Coordinator: Dr. John Eiler of Fircrest School
Supervising Professor: Dr. Yongmin Kim
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INTRODUCTION

The Smart Switch is a device that monitors switch closures by physically or mentally disabled people, and controls a reinforcer device associated with the switch. The Smart Switch collects data on the number and duration of switch closures, and activates the reinforcer device that can be any electro-mechanical device operating and a voltage of 12 volts or less, such as a radio or a tape player. It displays the number of switch closures, the total duration of switch closures, and the median and the interquartile range of the switch closure durations. The Smart Switch operates in two modes: independent and prompted. Normally, the Smart Switch is in the independent mode where the disabled user is operating the switch without and supervision. The prompted mode is used to record the success rate of the instructions to operate the switch. The data for each mode is maintained separately, and can be displayed at any time. The Smart Switch is a small, independent, portable device, designed to operate and battery power. It can monitor one switch unit and control one reinforcer device.

SUMMARY OF IMPACT

The Smart Switch device was conceived at the Fircrest School in Seattle, WA, which is a residential facility for the treatment and education of the developmentally disabled. The Smart Switch monitors the behavior of the handicapped in both supervised and unsupervised environments. Using

this device, the handicapped can learn the relationship between the operation of the switch and the effect of the reinforcer. It is also useful in monitoring the progress of responses to the instruction from the supervisor. The Smart Switch is a complete redesign of an older switch monitor that contained only a timer and a counter.

TECHNICAL DESCRIPTION

The Smart Switch is designed using the Intel 8031 CMOS 8-bit microcontroller. The control and the power circuits are on separate PC boards, and the design is intended to be modular so that the AC power circuit can be added in order to operate the Smart Switch from an AC wall outlet.

The control circuit consists of the 8031 microcontroller, EPROM SRAM, 16 x 2 LCD display, and support parts (discrete IC's, crystal, ect.). There are three switches mounted on the Smart Switch implementing the supervisor interface - two momentary pushbuttons and one momentary toggle switch used to control the mode of operation (prompted or independent). To minimize the size of the control circuit, the LCD timing and interface is implemented in software. The internal timer of the 8031 microcontroller is used to measure the duration of the external handicapped user's switch. The input and output lines are directly connected to the microcontroller's I/O pins. The duration data of the switch closures are saved in the SRAM, which is 8 kbytes in size. The control program polls the I/O lines that are connected to the switches and the power circuit, calculates the median and interquartile range of the durations, measures the switch closure durations, controls the LCD display, and processes the input from the supervisor interface. Data collected by the Smart Switch is maintained in the SRAM until the supervisor resets the Smart Switch through the supervisor interface or removes the power source.

The power circuit has several functions. First it monitors the condition of the battery and displays it though two LED's mounted on the front of the Smart Switch. It also notifies the battery condition to the microcontroller so that the power to the reinforcer device can be turned off in order to save the collected data for as long as possible. The power circuit also contains a circuitry to recharge the battery through an external transformer. The battery is rechargeable even during the operation of the Smart Switch. The power circuit maintains proper voltage for the reinforcer device via a sense resistor and an adjustable voltage regulator, provides proper voltage to the control board, and converts the DC current into high voltage AC for the backlighting of the LCD display.

Hardware flexibility is limited due to constraints in the physical size imposed in the design, but the software is reconfigurable with the extra program memory left available for the future expansion.

The cost for the device is approximately $145.00

Functional Block Diagram